

Green Function Retrieval Versus Interferometric Imaging

Kees Wapenaar and Deyan Draganov

In the past couple of years it has been shown by various authors that the cross-correlation of wave fields observed at two receiver points yields the Green function between these two points. Several quite distinct derivations exist for this phenomenon. On the one end of the spectrum is the theory pioneered by Weaver and Lobkis (PRL, JASA, 2001), in which the main assumption is that the wave field is diffuse; the diffusivity can be due to the irregularity of the enclosure or to the presence of random scatterers. On the other end there is the approach based on the Rayleigh reciprocity theorem for an arbitrary inhomogeneous open configuration (Wapenaar et al., SEG, 2002; GJI, PRL, 2004). Here the main assumption is that there are sufficient independent sources, which emit either transient signals that are well separated in time or noise signals which are mutually uncorrelated. The reconstructed Green function contains the ballistic wave as well as the coda due to multiple scattering in the inhomogeneous medium.

Once the Green functions are retrieved for a sufficient range of receiver positions at the surface of the earth, they can be used to form an image of the subsurface, using any standard seismic reflection imaging algorithm. Schuster (EAGE, 2001; GJI, 2004) coined this interferometric imaging. Intuitively one would expect that the same assumptions should be fulfilled as for Green function retrieval, however, a more careful analysis proves this wrong. Consider the subsurface of the earth as a fully deterministic open configuration and assume that there is only one noise source present in this subsurface. Although for this situation it is not possible to reconstruct accurate Green functions as an intermediate result, it can be shown that interferometric imaging still maps the primary reflection response (i.e., the ballistic wave) to its correct scattering origin in depth as long as the specular reflection point at the surface lies within the array of receivers. Hence, compared with the theories for Green function retrieval, interferometric imaging is less restrictive with respect to the assumptions about diffusivity or the distribution of sources. On the downside, interferometric imaging requires a background velocity model; moreover, it incorrectly handles multiple reflections, which are mapped as unwanted ghost images.