Controlled-source seismic interferometry with one way wave fields

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In Seismic Interferometry we generally cross-correlate registrations at two receiver locations and sum over an array of sources to retrieve a Green's function as if one of the receiver locations hosts a (virtual) source and the other receiver location hosts an actual receiver. One application of this concept is to redatum an area of surface sources to a downhole receiver location, without requiring information about the medium between the sources and receivers, thus providing an effective tool for imaging below complex overburden, which is also known as the Virtual Source method. We demonstrate how elastic wavefield decomposition can be effectively combined with controlled-source Seismic Interferometry to generate virtual sources in a downhole receiver array that radiate only down- or upgoing P- or S-waves with receivers sensing only down- or upgoing P- or S-waves. For this purpose we derive exact Green’s matrix representations from a reciprocity theorem for decomposed wavefields. Required is the deployment of multi-component sources at the surface and multi-component receivers in a horizontal borehole. The theory is supported with a synthetic elastic model, where redatumed traces are compared with those of a directly modeled reflection response, generated by placing active sources at the virtual source locations and applying elastic wavefield decomposition on both source and receiver side.