An interferometric interpretation of Marchenko redatuming

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Recently, a novel iterative scheme was presented to retrieve the Green's function as if there were a receiver at an arbitrary location X in an unknown heterogeneous medium. The scheme requires as input the reflection response at an acquisition surface at one side of the medium and an estimate of the direct wavefield between the acquisition surface and X. The output Green's function contains - besides the direct arrival - all internal multiple reflections in the medium. The Green's functions are retrieved by a so-called focusing function that acts directly on the reflection response. At each iteration, the focusing function is updated by a multidimensional crosscorrelation of a previous estimate of the focusing function with the reflection response. As in seismic interferometry, raypaths should be stationary to achieve correct results, which is obtained by integration over the surface at each iteration. We interpret each multidimensional crosscorrelation by subtracting traveltimes along these stationary raypaths. In this way, we obtain a physical understanding of the way in which internal multiples are retrieved by the scheme. An example is provided in Figure 1. Initially, the estimate of the direct field (being the initial focusing function) is crosscorrelated with the reflection response to obtain an event whose traveltime equals the difference of the traveltime along the red and green raypaths in Figure 1a. In the final step of the scheme, this event is crosscorrelated with the reflection response again to construct downgoing internal multiples, as shown in Figure 1b. A single iteration is already relatively accurate in predicting the most dominant internal multiples in the system. Accurate amplitudes and higher-order internal multiples require (only) a few more iterations. We provide a comparable interferometric interpretation for the retrieval of various other events by the scheme.
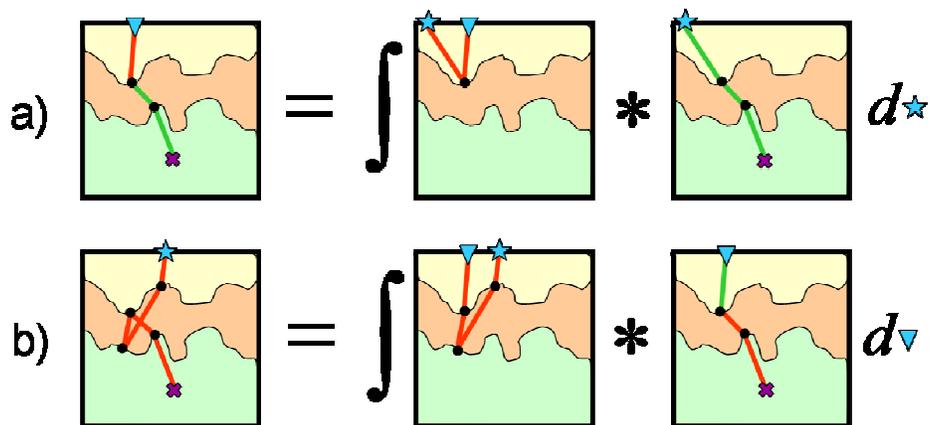

Figure 1: Example of the retrieval of a downgoing internal multiple reflection. Red rays have positive traveltimes. Green rays have negative traveltimes. a) In step 1, the initial focusing function is crosscorrelated with the reflection response, yielding the event in the left panel. b) In step 2, this event (shown here after time reversal in the right panel) is crosscorrelated with the reflection response again to produce an internal multiple reflection. Blue stars and blue triangles represent sources and receivers at the surface. The purple cross is the focal point X. Each step requires integration over sources or receivers the surface, where the relevant stationary points should be sampled.