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Pushing the limits of the Marchenko method

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In recent years, the Marchenko method has proven to be a viable tool to create virtual seismic sources and receivers in the subsurface from reflection measurements at the surface. Applications range from suppressing internal multiples in seismic imaging to forecasting responses to induced seismic sources. One of the attractive aspects of the Marchenko method is that no detailed subsurface model is needed; a smooth background model suffices. All information needed to treat the internal multiples correctly comes from the reflection measurements at the surface.

One of the underlying assumptions of the Marchenko method is that the seismic wave field can be decomposed into downgoing and upgoing waves at any position in the subsurface where one wants to create a virtual source or receiver. Although in many situations this implies no significant restrictions, it may hamper the imaging of steeply dipping flanks and it prevents the treatment of refracted and evanescent waves.

It can be shown that the Marchenko focusing function (the nucleus of the Marchenko method) can be expressed in terms of the so-called propagator matrix. The propagator matrix, which was introduced in geophysics in the nineteen-sixties for 1D systems and developed further in the nineteen-seventies for laterally varying 3D media, 'propagates' a wave field from one depth level to another. It does not rely on up-down decomposition and it accounts for propagating waves at all angles and for evanescent waves. By exploiting the link between the Marchenko focusing function and the propagator matrix, the applicability of the Marchenko method can be expanded. In the presentation we will review the underlying theory and discuss the potential application of the Marchenko method for refracted waves.