Pushing the limits of the Marchenko method

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At the first EAGE data processing workshop (Caïro, 2024) I addressed the question: given the developments in full waveform inversion (FWI), is there still need for the Marchenko method? The Marchenko method is designed to suppress internal multiples (either as a preprocessing step or as an integral part of the seismic imaging workflow), without needing a detailed subsurface model. FWI can, at least in principle, also suppress internal multiples, but it requires an accurate estimation of the multiple-generating interfaces and the velocities between them. I proposed to combine the best of both worlds: use the Marchenko method to suppress the internal multiples as much as possible (in particular overburden-related multiples) and continue with FWI to resolve the detailed subsurface parameters (for example in a target zone below the overburden). In the presentation I will briefly review these arguments.

Next, I will discuss how to push the limits of the Marchenko method. Almost all current implementations of the Marchenko method rely on the assumption that the seismic wave field can be decomposed into downgoing and upgoing waves at those positions where one wants to create virtual sources and/or receivers (for example at the top of a target zone). This may hamper the imaging of steeply dipping flanks and it prevents the treatment of refracted and evanescent waves. In the presentation I will show that the up/down decomposition in the subsurface can be avoided by using Marchenko focusing functions which have their focal points at the acquisition surface instead of in the subsurface. These focusing functions allow retrieval of the full (i.e., non-decomposed) wave field at any desired position in the subsurface, while correctly dealing with internal multiples, refracted and evanescent waves. This forms a basis for extending the Marchenko method to improve the imaging of steeply dipping flanks and to use refracted waves.