

Different Flavors of the Marchenko-Equation-Based Internal Multiple Elimination Methods: the Trade-off between Fidelity, Computational Cost and Ease of Use

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Abstract

In seismic exploration, the overburden generates a large amount of internal multiple energy, potentially leading to imaging artefacts at target level which can impact the interpretation. In such cases, the conventional methods such as the inverse scattering series (ISS) or the Jakubowicz method are not as successful as the Marchenko equation-based suite of approaches. We provide a comprehensive overview and analysis of all new flavors of the latter, including their practical advantages and disadvantages, such as computational cost and ease of use in practice.

The Marchenko equation allows us to calculate an inverse transmission operator, including all possible internal multiple generation mechanisms, through any desired section of the medium, without any a priori knowledge of the subsurface. The inverse transmission operator can be used for internal de-multiple in numerous ways, which typically are a trade-off between complexity, computational cost, expected outcome and fidelity of the result.

For a target-oriented approach, one can show that the target primaries are dressed with a convolutional filter representing the total overburden transmissions. Therefore, convolution with the inverse transmission operator can remove source- and receiver-side internal peg-leg multiples. With some modification, the same inverse transmission can be used (albeit at slightly higher computational cost) to remove multiples generated by reflections from below the overburden.

The most computationally expensive approach by far, finds the inverse transmissions for each depth level and uses them to determine the primary reflection for each point in the medium. It also has the advantage that the pseudo-boundary no longer needs to be specified. This method also generates a very large amount of auxiliary wavefields which may require a large amount of memory and user intervention to quality control. We explain why this last flavor of the Marchenko suite of methods, in its current form, is not compatible with short-period internal multiple suppressing feedback loop.