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Abstract

Augmented Marchenko equation based demultiple – a way to address the gaps in Marchenko redatuming

Marchenko equation based de-multiple is the most promising data-driven algorithm to attenuate all overburden-borne internal multiples in one go. The aim of this paper is to explain the assumptions and the resulting gap in the conventional Marchenko demultiple/redatuming algorithm. The gaps can be pictured by an under-constrained linear inverse problem, and we show that appending the conventional algorithm with additional relations closes this gap.

Already in the 1950s a single-mode 1D scattering region characterization was suggested using the so-called Marchenko equation. In 2D and 3D geophysical setting this was re-derived in 2010s by splitting the medium into the (closer) overburden and a (further away) target, and temporally separating with a mute the information due to the former from the later. Its solution, the inverse transmission through the overburden, is obtained by means of a series of convolutions and correlations with the surface reflection data further concatenated by aforementioned temporal mutes. This inverse transmission is the cornerstone of the all-in-one-go overburden internal demultiple scheme.

The method requires the surface reflection data and a non-backscattered component of the desired solution on input to calculate the rest of the solution - the coda wavefield accounting for the multiple scattering. For a 1d single mode setting, this is simply given by an appropriately timed spike. In practice when the reflection data is band limited, said spike and the coda also are band limited, can overlap, and a part of said overlap is required on input. Moreover any forward scattered wavefield components (diffractions, reflections of salt flanks, forward mode conversions) need to be included too, and since these are typically unknown this amounts to solving a one linear inverse problem with two unknowns leading to a need for one more equation.

The other equation is obtained from using properties of the solutions: that they have to obey energy conservation condition, and that the solution is stable and causal with a stable and causal inverse (minimum phase relation). These conditions have already allowed for solving the some gap-resulting problems in 1.5d media and understanding generalization of minimum phase to matrices will allow to do elastic internal demultiple in complex geologies, for which we had no remedies in the past.

Even though the first work on Marchenko equation based algorithms dates back to 1950s, it was introduced in geophysics in 2D and 3D in the 2010s, including notable field data application attempts. First signs of augmented Marchenko had been presented at 2018s EAGE, and the first paper tackling applications to short period demultiple was published in Jan 2019.