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Estimating resolution in full waveform tomography

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Interpreting seismic tomography results requires the knowledge of resolution. The resolution is a linearized concept and most often looked at from the point of view of averaging kernels or point-spread functions. While resolution is easily computed for small systems, for large systems it remains a computational challenge. Therefore numerous resolutions test have been proposed, all of them suffering from ambiguities in their interpretation. When inspecting resolution operators for a reasonably well-posed problem, the important information is found along diagonals and not along rows (averaging kernels) or columns (point-spread functions). The main diagonal carries information on how the amplitude of the parameters is recovered, while the secondary diagonals inform us on the spatial averaging involved in the recovery of the parameters. Matrix probing techniques are very efficient in estimating diagonals.

Matrix probing is a collective term for randomized algorithms designed to analyse matrices. They are most useful when explicit representations of the matrix are unknown or to expensive to be computed (full wave form inversion). We propose a simple method where the inversion of synthetic data, corresponding to a zero-mean random input vector, is used to infer the average horizontal and vertical resolution lengths of tomographic models. The method works well if the resolution operator has a diagonally dominant structure. This assumption, although often verified in seismic tomography, can be tested by simply cross-correlating the input with the output of the synthetic simulation. The method is as efficient as a single checker-board test, but reveals more easily interpretable information. If the resolution is not diagonally dominant, more time consuming methods are needs (i.e. more probes or parametrized techniques).