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Grouping of complex-valued frequencies in the Laplace-Fourier domain waveform inversion

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Full waveform inversion is a method to estimate subsurface physical properties by iteratively minimizing the differences between observed and modeled seismic data. The waveform inversion can be implemented in the time, frequency, Laplace or Laplace-Fourier domain. Laplace-Fourier domain waveform inversion has an advantage in that it can recover long-wavelength and medium- to short-wavelength velocity models despite the lack of low frequency components in the data. For the Laplace-Fourier domain inversion, we deal with angular frequencies and Laplace damping constants which constitute the real and imaginary part of the complex-valued frequencies, respectively.

Since the objective functions for low angular frequencies are less nonlinear with the model, frequency domain waveform inversion is usually implemented sequentially from low to high frequencies in order to mitigate the nonlinearity of the seismic inverse problem. For the Laplace-Fourier domain inversion, we propose a method of grouping complex-valued frequencies as an approach to optimize the usage of the complex-valued frequencies. Grouping of complex-valued frequencies is a strategy for selecting angular frequencies and Laplace damping constants in the Laplace-Fourier inversion problems. Its concept comprises sequential inversion and simultaneous inversion. The grouping method in the Laplace-Fourier inversion can be implemented by inverting grouped complex frequencies simultaneously while inverting each group sequentially.

We applied three Laplace-Fourier inversion algorithms - simultaneous, sequential, and grouping - to synthetic seismic data and compared the inverted velocity models to find strengths and drawbacks of each inversion methods. The examples show that the grouping method can enhance the Laplace-Fourier domain inversion results.