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Monte Carlo method for coupled earthquake locations and 1D velocity structure determination: 'Minimum' models with constant velocity gradient layers

Einar Kjartansson and Ingi Thorleifur Bjarnason
Institute of Earth Sciences, Science Institute, University of Iceland, Reykjavík, Iceland, eik@hi.is

Ray-tracing through a one dimensional earth model, consisting of layers of constant linear velocity gradient and continuous value across layers, is used to evaluate and improve a velocity model for processing micro earthquake data in Iceland.

The iterative Monte Carlo method is used to estimate velocity values, at boundaries between layers as described above, by searching for the velocity function that minimizes the residuals for observed arrival times for both P and S phases of micro earthquakes.

P and S velocities are determined simultaneously, i.e. the Poisson's ratio is not constrained in the inversion. The S wave data are given similar weights as P wave data.

The earthquakes are relocated in each iteration. The number of earthquakes used is typically in the range from a few hundred to a few thousand. The velocity functions are constrained with gradients that decrease with depth. This ensures that the travel-time curves are single valued and without any focusing of rays. The redundancy in the data set makes it possible to to generate a probability distribution of models.

Most processing of the digitally recorded earthquake data on the national seismic network in Iceland makes use of the standard SIL velocity model, with layers of constant velocity gradient. Our results show that the standard model fits well for earthquake locations in the central part of the South Iceland Lowland region but there are some discrepancies elsewhere, especially in volcanic zones.

The software is open source and can be accessed at https://github.com/4dseismic