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Implementation of algorithm for bidimensional analysis of direct seismic waves travel times

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Introduction

Direct seismic waves are the first-arriving body waves that propagate along the shortest path through the near-surface medium, traveling directly from the source to the receiver without interacting with subsurface interfaces. Their travel time analysis permits the inference of the velocity of the medium they are traveling through, which is a fundamental parameter for characterization of near-surface geological materials.

This work implements a computational algorithm which permits the inference of the velocity in a medium by the least squares method with tikhonov regularization, utilizing the direct wave travel times as data.

Method and/or Theory

The algorithm was developed in Python, a high-level, interpreted, and general-purpose scripting language. It uses the relationship between the direct wave travel time measured in a sensor with the velocity of the medium the wave is traveling, when the wave’s trajectory is supposed to be a straight line, to obtain a model which can be inverted for the slowness of the medium, which is used to obtain the velocity.

A synthetic shallow velocity distribution was generated for the usage as a direct model, whose result was then used in the inversion algorithm to recover the same velocity distribution. A range of different geometries of source-receiver distributions and noise levels was studied to analyse the best conditions of medium properties recovery.

Results and Conclusions

It was possible to recover the synthetic model by the application of the developed inversion routine for different noise-to-signal ratios and for different geometries of velocity anomaly. When the noise-to-signal ratio is too big, it’s necessary to apply inversion restrictions to be able to identify the anomaly, and when the geometry of the source-receiver distribution is not well distributed in the azimuthal and radial directions, the inversion won’t have the expected results.