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Implementation of a computational routine for 1D velocity structure inversion using seismic event data

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Introduction

The characterization of the subsurface velocity structure is essential both for more accurate hypocentral determinations, especially for local seismicity studies, and for estimating the properties of the medium.

Although there are software and applications that assist in such characterization, it is understood that it is necessary to develop a computational routine to allow customization and control of the entire process.

In view of the above, this work focused on implementing a routine to invert and estimate the 1D seismic velocity structure of the local shallow crust using P and S body-wave arrival times recorded by seismographic stations from local events.

For validation, after developing and evaluating the models with synthetic data, we applied the routine to real seismic data from the Frutal region, Minas Gerais, Brazil, to study the local seismicity.

Method and/or Theory

The methodology employed minimizes discrepancies in seismic-wave arrival times by adopting a flat, homogeneous layer model that incorporates parameters such as velocity, slowness, radius, and layer thickness. To validate the approach, a synthetic model was constructed. Both linear and non-linear inversion techniques were implemented within the routine to achieve tighter control over recovering P- and S-wave arrival times.

After analyzing and validating the inversion process, implemented in the MATLAB environment, we applied it to seismic events recorded in the Frutal region, MG (Brazil) between 2012 and 2025. Data sources included stations from the Brazilian Seismographic Network and local stations installed and/or operated by the Seismological Observatory at the University of Brasília.”

Results and Conclusions

With the implementation of the inversion routine, it was possible to estimate a 1D seismic velocity structure model for the Frutal region and, consequently, improve the estimates of the hypocenters of the recorded seismic events and contribute to a greater understanding of the structure of the local shallow crust.