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Use of the Source Scanning Algorithm (SSA) in Seismology

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Introduction

Determining hypocentral location is a fundamental aspect of seismology, although it constitutes an ill-posed problem according to Hadamard's criterion. It involves estimating a seismic event's spatial coordinates (including depth) and origin time. Traditionally, this problem is addressed using the Geiger method (Geiger, 1912), which iteratively adjusts the coordinates to minimise the residuals between observed arrival times and model predictions (Lee & Lahr, 1975; Klein, 1978, 1989; Barry et al., 1986). In northeastern Brazil, several seismographic networks continuously record data for several months or years; the visual picking of P and S waves for this period can be impractical. Alternative methods have been explored, such as waveform stacking, eliminating the need to manually identify seismic phases (Cesca & Grigoli, 2015; Grigoli et al., 2016). These methods, based on variations of the Source Scanning Algorithm (SSA) developed by Kao & Shan (2004), systematically adjust the hypocenter position (x, y, z) in a discretised space, maximising a "brightness" function that indicates the precision of the location.

Method and/or Theory

Although effective, SSA is computationally intensive, which has motivated recent efforts toward parallelisation, enabling its continuous application to acquire data (Leandro et al., 2020). However, to optimise its performance, it is crucial to understand under which specific conditions, such as the number of available stations, signal-to-noise ratio, and the geometry of the seismic network, SSA outperforms conventional methods. Therefore, this research plan proposes using synthetic and real data to investigate these conditions and promote the routine use of SSA in seismology. The objectives include understanding the operation of the SSA algorithm, locating synthetic events, adding noise to seismograms and testing SSA's performance under different noise levels and acquisition geometries, validating the methodology with real data from a seismic network in northeastern Brazil, for which a catalogue of events using the Geiger method is already available; and finally, comparing the results obtained by both methods.

Results and Conclusions

The serial and parallelised versions of SSA are available for use in the project. We will test SSA for automatic event locations, especially in noisy environments or networks with unfavourable geometry. The comparison with the Geiger method will allow for an assessment of the accuracy, robustness, and feasibility of using SSA as an operational tool for routine seismic monitoring in Brazil.