



SBGf Conference

18-20 NOV | Rio'25

Sustainable Geophysics at the Service of Society

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Submission code: WKB7NVDAJN

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Discrimination of Natural and Anthropogenic Seismic Events in the Carajás Region Using Random Forest

LUIZ GUSTAVO SILVA SANTOS (Universidade de Brasília), **Itallo Clementino Ramalho Rodrigues** (Universidade de Brasília), **Isabel Cristina Garcia Lopez**, **Susanne Maciel** (Universidade de Brasília)

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Introduction

The Carajás mining region presents intense seismic activity resulting from both natural processes and anthropogenic activities related to mining operations. Accurate discrimination between these event types is fundamental for effective seismic monitoring and geological risk assessment in the region. Traditional methods based on spatiotemporal criteria and waveform characteristics frequently produce inconsistent results due to local geological complexity. This study implements Random Forest (RF), a robust machine learning technique, to develop a classifier capable of distinguishing natural and anthropogenic seismic events in the Carajás region.

Method and Theory

Our methodology combines spatiotemporal analysis with the Random Forest technique for event classification. We utilize data from the Brazilian Seismological Network from 2013 to 2025, focusing on events with magnitudes between 0 and 4.5. Initial data processing is performed with SeisComP3 and ObsPy, followed by the extraction of discriminative features from seismic records. The RF algorithm follows Breiman's methodology, building multiple decision trees that classify each event by voting. We extract spectral characteristics (corner frequency, energy ratios between frequency bands), source parameters, and temporal patterns from the waveforms. This approach is complemented with spatiotemporal criteria, considering proximity to mining operations and occurrence during working hours (Monday to Friday, 6:00-19:00 UTC-3) as potential indicators of anthropogenic events. The model is validated using standard machine learning metrics, including precision and recall.

Results and Conclusions

The Random Forest classifier will achieve overall accuracy exceeding 95% in discriminating between natural and anthropogenic seismic events in the Carajás region. Analysis of feature importance will reveal that spectral parameters, particularly corner frequencies and energy ratios between different frequency bands, will be the most effective discriminators. Anthropogenic events will consistently show lower corner frequencies and steeper spectral falloff at high frequencies compared to natural earthquakes of similar magnitude. The model will maintain high performance across different magnitude ranges and signal-to-noise ratio conditions. Application of this methodology will result in a refined seismic catalog for the Carajás region, revealing spatial patterns where natural events are primarily associated with known geological structures. In contrast, anthropogenic events are concentrated around active mining operations. This approach will contribute to Brazilian seismology by providing a systematic and reproducible method for discriminating events in mining regions.