Submission code: WB8V6PQ0B5

See this and other abstracts on our website: https://home.sbgf.org.br/Pages/resumos.php

Seismic Velocity Monitoring From Single-Station Cross-Component Analysis of Ambient Noise for Tracking Groundwater Levels in Altamira, Brazil

Victor Guedes (Universidade de Brasília), Susanne Maciel (Universidade de Brasília)

Seismic Velocity Monitoring From Single-Station Cross-Component Analysis of Ambient Noise for Tracking Groundwater Levels in Altamira, Brazil

Copyright 2025, SBGf - Sociedade Brasileira de Geofísica/Society of Exploration Geophysicist.
This paper was prepared for presentation during the 19th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro, Brazil, 18-20 November 2025.Contents of this paper were reviewed by the Technical Committee of the 19th International Congress of the Brazilian Geophysical Society and do not necessarily represent any position of the SBGf, its officers or members. Electronic reproduction or storage of any part of this paper for commercial purposes without the written consent of the Brazilian Geophysical Society is prohibited.

Introduction

Seismic interferometry has emerged as a powerful method for subsurface investigation, with applications ranging from high-resolution imaging to time-lapse monitoring of temporal changes. By correlating recordings of passive seismic noise, it is possible to approximate the Green's function between two receivers as if one were an active source. In particular, the coda portions of the retrieved correlation functions are highly sensitive to small variations in elastic properties, making them effective for detecting subtle changes in seismic velocities. Monitoring seismic velocity changes (dv/v) from ambient noise correlations has proven useful in diverse fields such as landslides, volcanos, and tracking groundwater fluctuations. In this study, we apply this approach to evaluate the relationship between dv/v and seasonal variations in groundwater levels in the region of Altamira, Pará, Brazil. During the 2014–2016 period, this area experienced hydrological concerns due to the filling of the Belo Monte reservoir prompting a range of environmental studies. This context provides an opportunity to assess the sensitivity of seismic interferometry to hydrogeological processes.

Materials and Methods

We used continuous seismic data from station ATM1, located in Altamira, to compute dv/v time series from single-station, cross-component ambient noise correlations. Correlations were computed in the 2–10 Hz frequency band using the Phase Cross-Correlation (PCC) method, selected for its robustness against amplitude variations, improved sensitivity to weak signals in the coda, and as a less aggressive alternative to traditional waveform-based techniques. To improve the signal-to-noise ratio and capture mid-term temporal trends, we applied a 30-day moving window linear stack to the daily correlation functions. Relative velocity changes (dv/v) were estimated using the Moving Window Cross-Spectral (MWCS) method, which measures time delays between the stacked functions and a reference correlation computed as the average over the full time period. We also used data from a rain gauge station and groundwater level data from piezometric monitoring campaigns conducted in the region during the reservoir filling. Time series of seismic velocity changes, rainfall and piezometric levels were compared to assess potential correlations and seasonal patterns.

Results and Conclusions

The dv/v time series derived from station ATM1 showed a clear seasonal trend. We observed gradual decreases in seismic velocity during periods of rising groundwater levels, suggesting that increased pore pressure due to aquifer recharge caused reductions in seismic velocity. This inverse relationship between dv/v and piezometric levels is consistent with previous findings that associate pore pressure increases with reduced seismic wave velocity. Our findings demonstrate that ambient noise interferometry — even when applied to single-station data — can sensitively detect seasonal hydrological variations. The agreement between seismic and hydrological data highlights the potential of this technique for non-invasive monitoring of groundwater systems, particularly in regions with limited access to direct instrumentation. These results contribute to the growing field of passive geophysical monitoring and reinforce the role of seismic interferometry in understanding subsurface processes influenced by human activity and natural hydrological cycles.