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Analysis of empirical B–Δ relationships in Southern and Southwestern Zagros and evaluation of their applicability in earthquake early warning systems

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Extended Abstract

Summary

This study evaluates the performance of the single- station B–Δ method in earthquake early warning systems (EEWS) for Southern and Southwestern Zagros regions. The method aims to provide rapid estimates of earthquake magnitude and epicentral distance using only the first few seconds of the P wave in a single accelerogram. A total of 72 accelerograms from 16 earthquakes with Mw ≥ 4 were analyzed. By fitting an exponential function to the initial P wave segment, parameters A (attenuation) and B (initial slope) were derived using least squares regression. The obtained results show a clear linear inverse relationship between log B and log Δ, enabling epicentral distance estimation, while magnitude can be estimated from the peak P-wave amplitude. The obtained empirical relations for the study regions are : $log\,\Delta = -0.1142\,log\,B + 1.55 \pm 0.46$, $M_{est} = 0.337\,log\,P_{max} - 0.804\,log\,B + 5.659 \pm 0.34$. A comparison of the results with the observed data demonstrates satisfactory accuracy. These relations can serve as fast and reliable tools for the early estimation of earthquake source parameters in EEWS applications across the Zagros regions.

Introduction

Earthquake early warning systems (EEWS) are designed to provide a few seconds of lead time before strong ground shaking reaches populated or critical areas. Rapid estimation of earthquake parameters, especially magnitude and epicentral distance, is essential for effective alerts. The B–Δ (single-station) method offers a simple and fast approach, relying on the first few seconds of the P-wave to estimate these parameters.

Although P-wave amplitudes are small, they carry important information about the earthquake potential impact. The B–Δ method has successfully been used in Japan and adapted in various regions of Iran, including Tehran, East Azerbaijan, and Kerman provinces. In this study, we apply this method to seismic data from the Southern and Southwestern Zagros regions (including Lorestan, Khuzestan, and Bushehr provinces) to develop regional empirical relationships suitable for local EEWS applications.

Methodology and Approaches

This study employed the B–Δ method in MATLAB software environment to analyze 72 vertical accelerograms selected from a total of 137 records in the Southern and Southwestern Zagros regions. For each record, the first 3 seconds of the P-wave were used to fit an exponential envelope function and extract parameters B and A via least-squares regression.

Epicentral distances were calculated from event and station coordinates. Empirical relationships were then derived between log B and log Δ, and between log B and log P_{max}, allowing estimation of both distance and magnitude. The obtained models were validated for different magnitude and distance ranges to improve reliability.

Results and Conclusions

The analysis confirmed a clear inverse linear relationship between log B and log Δ, consistent with previous studies. The best performance in estimating epicentral distance was achieved using records from stations located within 50–60 km of the epicenter, especially for events with Mw ≥ 5. Similarly, a reliable correlation was found between log B and

log P_{max} for magnitude estimation. The smallest differences between the observed and estimated magnitudes occurred at stations near 60 km. The proposed regional models are effective for use in EEWS and demonstrate satisfactory accuracy using only single-station data.