EGU26-14544, updated on 11 Nov 2026
https://doi.org/10.5194/egusphere-egu26-14544
EGU General Assembly 2026
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Analysis of the 2023 Mw6.8 Al-Haouz, Morroco, Earthquake using a Bayesian Inversion and an extensive seismic catalog.

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Moderate earthquakes can be as destructive as large megathrust events, particularly when they occur close to metropolitan areas. On September 8, 2023, a moderate Mw 6.8 earthquake struck central Morocco, causing approximately 3,000 fatalities, mainly in the Marrakech region. The earthquake occurred in the High Atlas Mountains, an area characterized by relatively low seismic activity, where the largest previously reported events did not exceed Mb ≈ 5.5. Several questions remain open regarding the physics of this earthquake. The focal mechanism solutions indicate two possible fault geometries: one high-dip plane and one low-dip plane. Some studies suggesting a rupture on a low-dip plane, considering that the continental crust may not be able to host earthquakes at greater depths, while other studies propose that mantle upwelling could have trigger a rupture on a high-dip fault plane.

In this study, we investigate the possible physical processes underlying the 2023 Al Haouz earthquake using a high-resolution seismic catalog and a joint Bayesian kinematic inversion of the rupture history. The seismic catalog spans one year, from January to December 2023, , and was constructed using the PhaseNet framework together with a 1D velocity model. We perform a joint Bayesian kinematic inversion that incorporates previously published geodetic observations (InSAR) with the limited available near-field and regional seismic data, in order to constrain the rupture propagation.

Our earthquake catalog allows us to image seismicity aligned with the high-dip fault plane, providing additional constraints to distinguish between the two proposed fault geometries. In addition, we do not observe clear evidence of sustained seismic activity at greater depths either prior to or following the mainshock. This observation does not strongly support a hypothetical active upward migration of seismicity from depth, as might be expected in the presence of mantle upwelling. The joint inversion indicates a relatively simple rupture process, dominated by a single major slip patch that released most of the seismic energy before propagating away from the hypocenter. Our results suggest that tectonic loading mechanisms, alternative to mantle upwelling, could have acted as the primary source of stress accumulation in the region.