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An enhanced earthquake catalog of the 2010 Mw 8.8 Maule aftershock sequence using modern tools

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Understanding rupture mechanisms, seismicity propagation, distribution, and migration after a major earthquake relies on the quality of earthquake catalogs, particularly their detection capabilities, location accuracy, and magnitude completeness. On February 27, 2010, a Mw 8.8 earthquake struck the Maule region in south-central Chile, causing widespread damage and substantial loss of life. As the largest well-instrumentally recorded earthquake in Chile, this event offers a unique opportunity to revisit an old dataset, refine the aftershock sequence analysis, and gain deeper insights into subduction zone dynamics.

Here we analyze ~10 months of continuous seismic data from the International Maule Aftershock Deployment (IMAD), a temporary network with about 156 stations deployed throughout the rupture zone. Using the recent Back-Projection and Matched Filtering (BPMF) workflow, which integrates PhaseNet, a deep-learning-based phase picker, we detected more than 100,000 earthquakes with at least 10 P and S-wave arrival phases. We relocated these events using NonLinLoc-SSST-Coherence, a probabilistic algorithm. A subset of them served as templates for template matching, producing a final catalog of about 375,000 events. This represents nearly a ninefold increase in detected events compared to prior catalogs and achieves a magnitude of completeness of Mw ~1.7, lowering it by over one order of magnitude.

Our catalog significantly enhances the spatio-temporal resolution, revealing intricate seismic structures (e.g., fault geometries) and dynamic post-seismic activity. Our improved relocations draw these key features, including the shallower seismic zone in the Pichilemu-Vichuquén region (33.5°S–35°S) and deeper seismic clusters near Concepción (37°S–38°S) in unprecedented detail. Temporal b-value variations (0.8–1.1) reveal zones of high-stress accumulation and the activation of multiple fault systems, highlighting the heterogeneous nature of post-seismic deformation. This high-resolution dataset underscores the potential of modern methodologies and algorithms, unveiling features from older data with improved clarity and detail.

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