Toward Comprehensive Catalogs of Volcanic Seismicity: Insights from Template-Matching, Machine Learning and Network Coherence at Mount Saint Helens Volcano

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***Abstract*:**

Resolving the structure and dynamics of magmatic systems in the lower crust remains particularly challenging due to limited observational constraints. Here, we compare advanced seismic detection methods using continuous data from the Mount St. Helens network during the 2008–2024 non-eruptive period. Starting from the Pacific Northwest Seismic Network VT catalog (4,088 events), a template-matching (TM) approach by Hirao et al. (2025) produced a high-resolution catalog containing 31,215 VT events and ~10,000 regional tectonic earthquakes. We evaluate this catalog against a machine-learning (ML) workflow using the VolPick model (Zhang et al., 2024), which yields over 100,000 robust detections after filtering, including VT, regional tectonic, and deep long-period (DLP) earthquakes. TM performs best during intense VT swarms by improving event tracking, whereas ML substantially enhances long-term catalog completeness by detecting earthquakes absent from the template database, particularly during quiescent periods. The ML approach identifies and locates 43 DLP events, nearly doubling the number in the original catalog. We are also testing CovSeisNet (CSN), a coherence-based method for automated DLP detection. CSN successfully recovers known DLP events, and ongoing work integrates TM, ML, and CSN to better characterize LP/DLP source processes and their implications for subsurface fluid and magma transport.

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