Systematic Search for Spontaneous Non-Volcanic Tremor in the Vicinity of the San Jacinto Fault, Southern California

Gregor Hillers and Jean-Paul Ampuero
California Institute of Technology, Seismological Laboratory, Pasadena, USA
gregor@gps.caltech.edu

Identification of Potential Tremor Signals

We identify potential tremor signals suitable for visual inspection by an analyst ...

... if the transient duration of the correlated envelopes is coherent for a number of stations and if the number of correlated station-to-station pairs is above a fraction of possible pairs and if (most) maximum to mean ratios are below a threshold (eliminate earthquake signals).

We benchmark the algorithm using data that include known spontaneous tremor signals originating in the SAF Parkfield/Cholame region. We analyze one month of data from the HRSN stations and colocated surface stations. The pattern below compares 6 hours from 2 days, using four different cc window lengths.

Color coding of detection pattern below

<table>
<thead>
<tr>
<th>Number of 'correlated' cc window pairs scaled by the number of possible pairs</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction of transients per cc window with duration larger than threshold</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(Alternatively: number of stations where transient duration larger than threshold)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large amplitude detection: at least one fourth (or any other fraction) of the cc windows contain large amplitudes (not to scale)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatically identified potential tremor signal (no 0 yes 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-sec tremor template identified by D. Shelly (not to scale)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12 HRSN borehole stations

3 surface broadband stations

We apply the transient detection algorithm [1] to the target area in the vicinity of the San Jacinto fault using data only from the PBO borehole stations, after learning that amplitudes associated with potential tremor signals in this area are weaker compared to signals from the SAF central section. To confirm the tectonic origin of the analyst-reviewed automatically selected signals, we use waveforms from these highlighted time periods as initial templates in a low frequency earthquake (LFE) matched-filter approach:


0 Use data from limited time periods identified by [1] using exclusively PBO stations as initial templates to facilitate computational pressure

1 Construct stacked master templates for repeated, robust LFE verification, using larger thresholds

5 Use highest-similarity templates to adjust for P and S arrival on vertical and horizontal components; Perform grid search to determine most likely source location using these measurements

[3] Clustering of Similar Waveforms to Construct Stacked Templates

The similarity of 48 matching waveforms is exploited to construct stacked master templates of the type shown in the top traces of the figure. Groups of robust detections, now with higher resolution detections of closely spaced LFE's with similar source processes

This study was partly funded by the Gordon and Betty Moore Foundation