Finite-source attributes of 39 M 3.9 to 5.5 Ridgecrest, California earthquakes

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Introduction

- Understanding rupture processes of small and moderate magnitude earthquakes can shed light on earthquake physics, fault zone material properties, and fault stress states because of their frequent occurrence and their relative-uniform spatial distributions.
- We use data recorded by the Southern California Seismic Network and 19 temporary broad-band strong motion seismic stations (networks ZY and GS) to study 39 M ≥ 3.5 Ridgecrest earthquakes.
- We use the second seismic moments method to resolve finite-source attributes of the earthquakes, including rupture length, width, duration, velocity, directivity, and stress drop.

Second Moments of a Mw 4.5 EQ

- Identifying adjacent 1.5 < M < 3.0 earthquakes as empirical Green's functions (eGF).
- Performing eGF deconvolution to obtain Apparent Source Time Functions (ASTFs).
- Measuring the duration of each ASTF to obtain the second-order apparent temporal moment.
- Inverting the second moments of the earthquake with the measurements.

Finite-fault attributes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Optimal estimates</th>
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</thead>
<tbody>
<tr>
<td>Lc (km)</td>
<td>0.68</td>
</tr>
<tr>
<td>Wc (km)</td>
<td>0.38</td>
</tr>
<tr>
<td>τc (s)</td>
<td>0.13</td>
</tr>
<tr>
<td>Δt (s)</td>
<td>3.34</td>
</tr>
<tr>
<td>ωAst (rad/s)</td>
<td>1.00</td>
</tr>
<tr>
<td>Stress Drop (MPa)</td>
<td>24.0</td>
</tr>
</tbody>
</table>

Figure 2. The apparent source time functions (ASTFs) of the example Mw 4.5 earthquake (event ID 38458079) in Figure 1). The lines are P-wave ASTFs and the red lines are S-wave ASTFs.

Stress drop estimates with different model assumptions

Stress drop estimates (Eshelby, 1957):

\[ \Delta \sigma = C(L_c, W_c, \nu) \frac{M_0}{W \cdot S} \]

where M0 is the earthquake moment, C is a function of the near-source Poisson ratio and the aspect ratio the rupture ellipse, and S is the rupture area.

Figure 6. Stress-drop estimates of 29 Ridgecrest earthquakes that have been analyzed using both the spectral-fitting method and the second moments method (this study). The stress-drop estimates of the spectral-fitting method are obtained from Trugman (2020).

- The stress-drops are estimated assuming an elliptical crack model. The estimates range from 1.3 to 454.9 MPa with a median of 35.2 MPa.
- If we assume the earthquakes ruptured as circular cracks with the rupture length estimate as the radius, our stress-drop estimates are comparable to 29 events that are also resolved using the spectral method in Trugman (2020).
- The lower bounds of the stress drops (solutions with the maximum rupture area within a given misfit range) is about one-order of magnitude less than the estimates in Trugman (2020) of the 29 earthquakes.
- These results show that model assumptions can lead up to two orders of magnitude differences in the stress-drop estimates for the same earthquakes with the same set of measurements.

References