

Supplementary material:

Map-view and cross-section videos:

IB_2010.gif shows map-view of the September 2010 3 mainshock-aftershock sequences as they were migrating from N towards S in time.

IB_2010_cs.gif shows a cross section in the same direction as the main cross sections in the paper. We can observe a time migration from deep to shallow.

NonLinLoc and HypoDD parameters:

Recalculation of initial locations obtained by Antelope was performed using NonLinLoc software using a 1D velocity model obtained by averaging neighboring 1D velocity models of the 3D model by Guidarelli et al. 2017 for the domain of Western Slovenia.

We computed the grid size using 0.5 km node size and performed relocation Oct-Tree Sampling Algorithm.

After we obtained new locations we performed a relative relocation of clusters of events using latest version of HypoDD software which enables usage of 3d velocity models. We relocated each swarm and mainshock aftershock sequence using the 3d velocity model of Guidarelli et al. 2017. Input for the HypoDD were P and S arrival times of detected events using EQCorrscan software, which already give corrected times by using cross-correlation of master and slave event. Because of this, there is no need in using differential time input for the events.

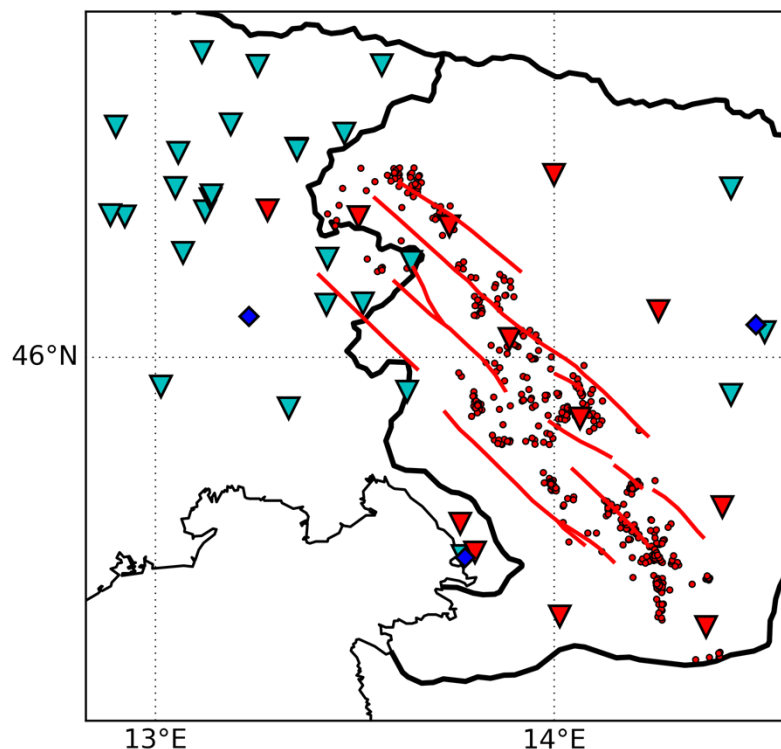


Figure S 1: In the map of the region of interest, station used for matched-filter detection of earthquakes are represented in red, while the station used only in STA/LTA and manual inspection of waveforms are shown in cyan. Red lines represent the active faults of western Slovenia and red dots the locations of the templates used for matched-filter detection of earthquakes.

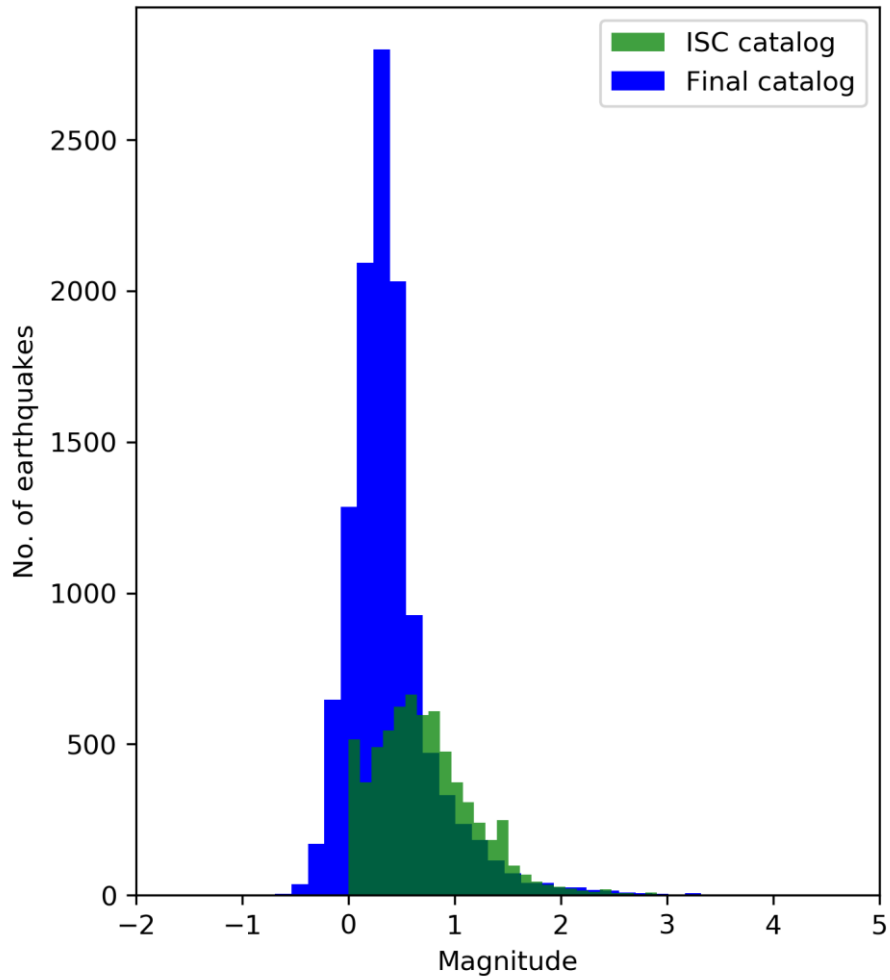


Figure S 2: Magnitude of completeness of the two catalogues. The magnitude of completeness of ISC catalogue is 0.9. The magnitude of completeness for final catalogue was lowered to -0.1 mainly due to the addition of low magnitude swarm events and missed earthquake activity along Ravne fault.

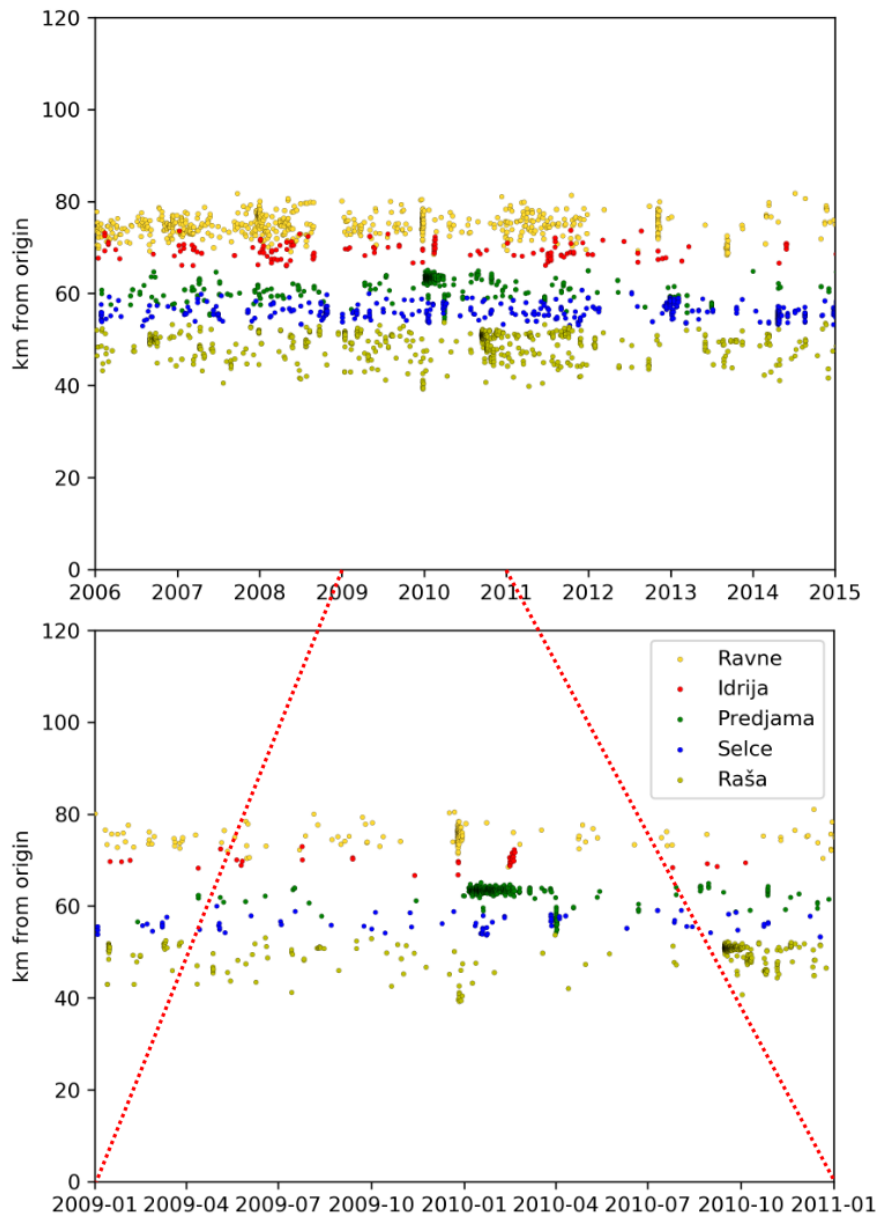


Figure S 3: Top figure shows earthquake activity through time perpendicular to the system of active faults in western Slovenia, coloured according to the active fault. The histogram represent total number of earthquakes per month of selected fault. Bottom figure is the same as top, but only for the time from 2009 to 2011 when the investigated migration of swarms and mainshocks happened.

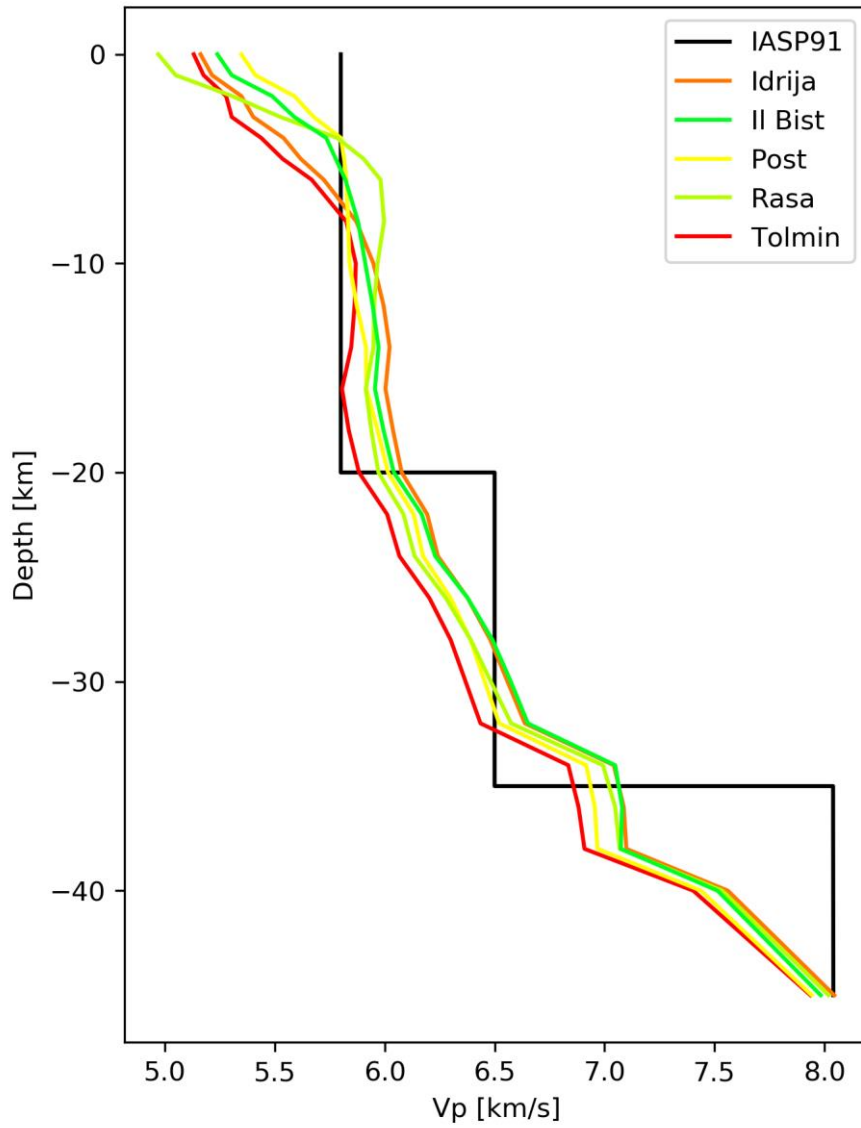


Figure S 4: Comparison between 1D IASP91 velocity model (black) used for initial locations and 3D model used for relocation of earthquakes. 3D model is slightly faster in the shallow part, resulting in slightly deeper locations of relocated earthquakes. Different colours of the 3D velocity model represent different sub-areas of the original regional model.

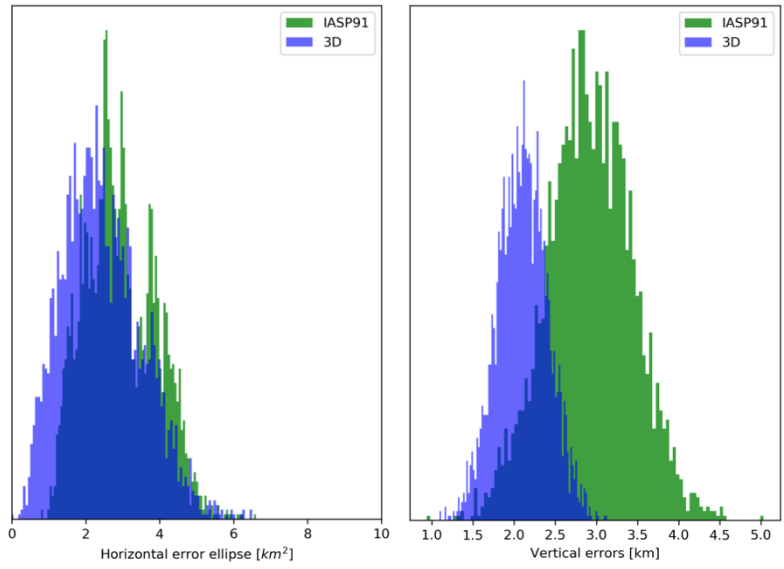


Figure S 5: Left figure represents horizontal errors of earthquakes located using IASP91 (green) model and 3D velocity model (blue). As observed in the figure, the horizontal errors do not change drastically. Right figure shows vertical errors using IASP91 model (green) and 3D model (blue). We observe lowering of the errors after relocation.

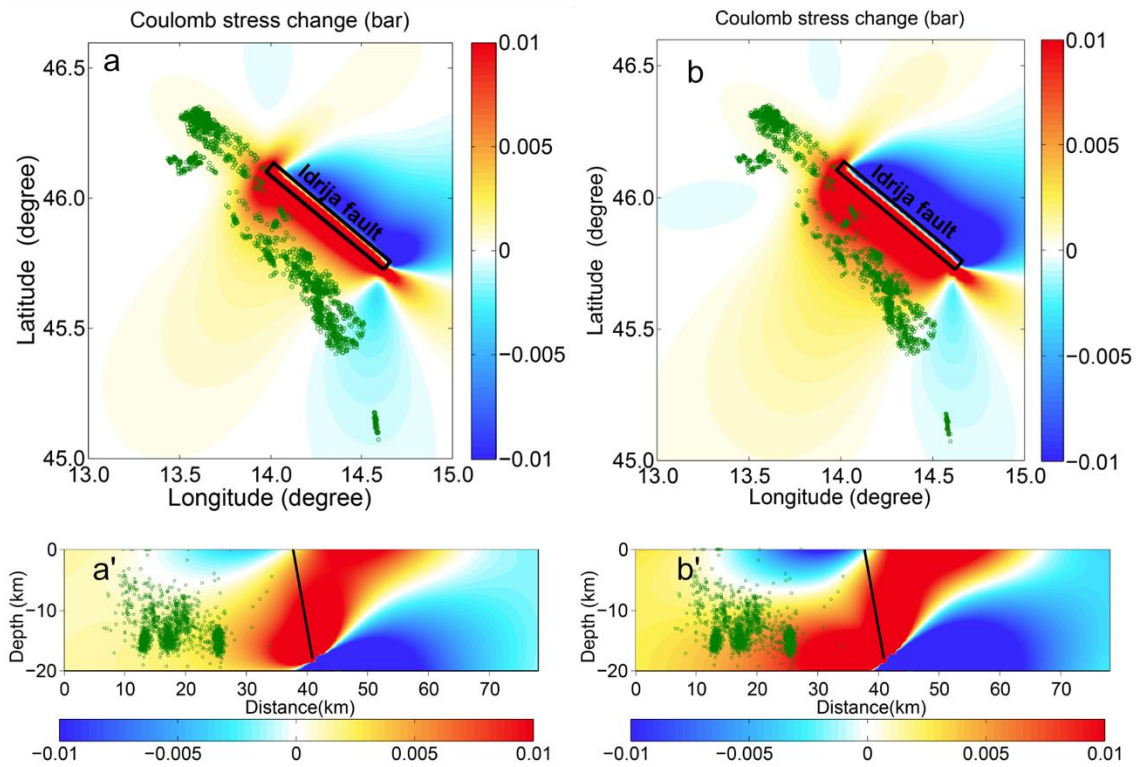


Figure S 6: ΔCFS as computed using the same parameters as for normal and shear stresses. We used $\mu = 0.4$ for the left figure and $\mu = 0.8$ for right figure. We can observe that change in normal stresses and unclamping of the faults better explains earthquake activity along the active fault of western Slovenia.

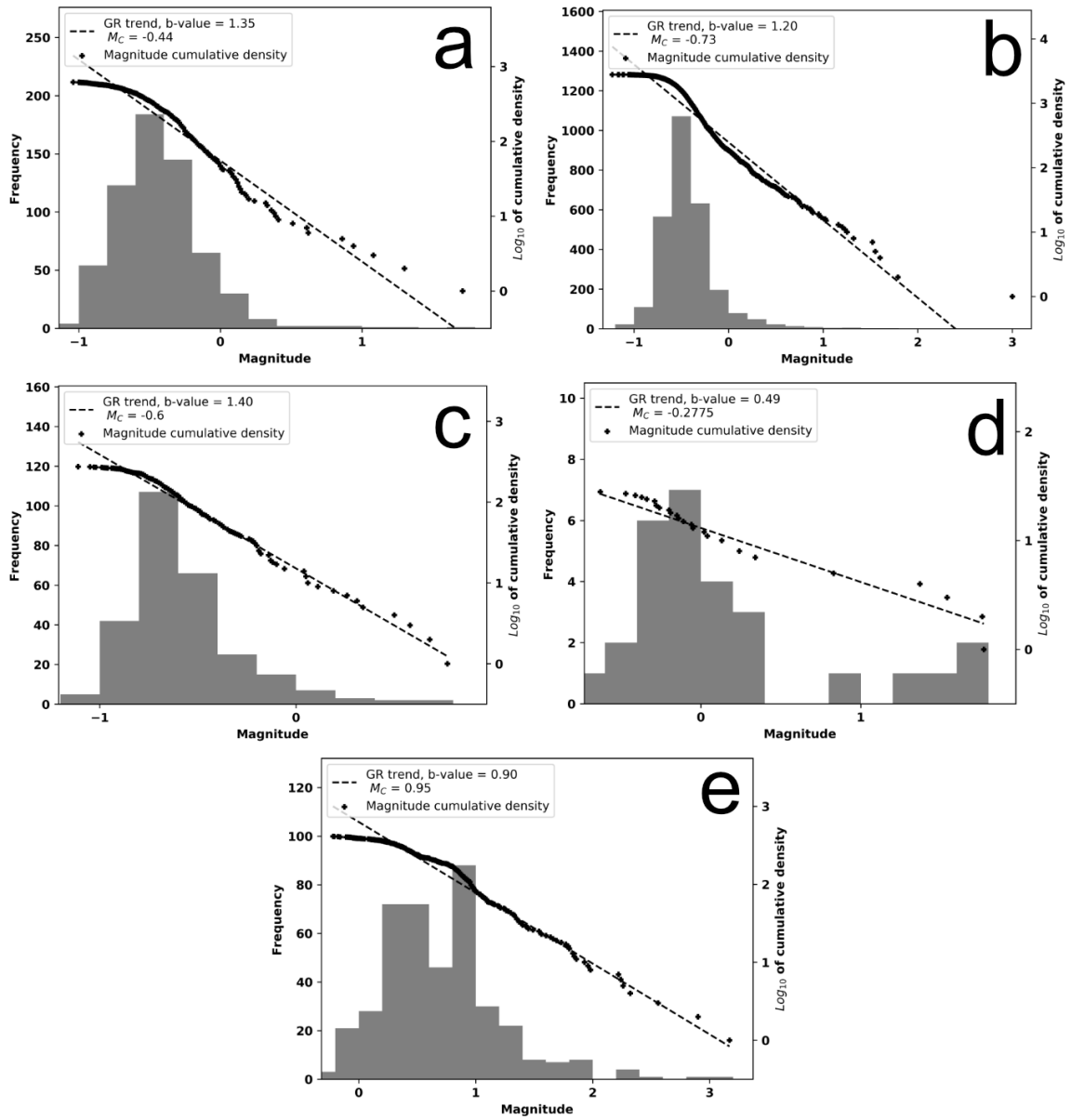


Figure S 7: Magnitude of completeness for the individual swarms observed along the active faults of western Slovenia. a) Vipava swarm 2006, b) Postojna swarm 2010, c) Selce swarm 2017, d) Ilirska Bistrica swarm 2017 and e) Rijeka swarm 2017.

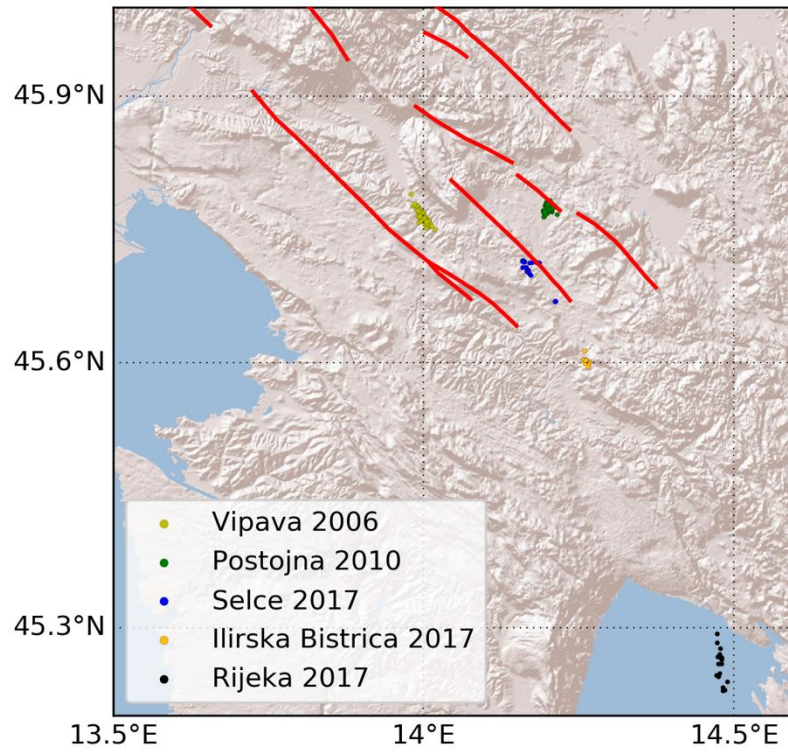


Figure S 8: Location and timings of the swarms discussed in the Swarms section of the paper. As mentioned in the paper, swarms are present only in the central and southern part of the fault system along all the faults.

Latitude	Longitude	Origin time
45.7366	14.1343	2006-01-27T21:25:43.317000Z
45.7369	14.1389	2006-01-27T21:33:01.485000Z
45.726	14.1351	2006-01-27T22:01:34.949000Z
45.7322	14.1501	2006-01-27T22:01:46.581000Z
45.7341	14.1341	2006-01-27T22:06:48.182000Z
45.7336	14.1375	2006-01-28T00:02:45.170000Z
45.7235	14.1307	2006-01-30T14:06:26.171000Z
45.7365	14.1422	2006-01-30T16:44:34.726000Z
46.1269	13.8524	2006-02-12T14:31:10.252000Z
46.122	13.8501	2006-02-12T14:34:29.725000Z
46.0972	13.8119	2006-02-12T14:35:10.714000Z
46.1057	13.8218	2006-02-12T14:36:08.954000Z
46.1344	13.8742	2006-02-12T14:40:02.513000Z
46.0739	13.8014	2006-02-12T14:41:25.467000Z
46.0902	13.8012	2006-02-12T14:43:56.311000Z
46.1391	13.873	2006-02-12T14:59:18.296000Z
45.8534	13.928	2006-07-30T19:57:15.999986Z
45.8766	14.0995	2006-08-03T19:29:11.999993Z
45.944	13.9365	2006-08-06T02:14:44.999986Z
45.7674	13.9938	2006-09-01T08:06:12.212000Z
45.7671	14.0042	2006-09-01T16:56:07.471000Z
45.7718	14.0037	2006-09-01T21:25:56.476000Z
45.7727	13.9985	2006-09-01T21:45:42.915000Z
45.7825	13.9928	2006-09-14T01:46:40.374000Z
45.8711	14.0881	2006-09-18T07:11:48.000002Z
45.771	14.005	2006-09-18T12:05:04.984000Z
45.7807	13.9924	2006-09-21T14:00:32.443000Z
45.77	14.0013	2006-09-21T14:05:22.046000Z
45.7787	13.9917	2006-09-22T03:03:05.654000Z
45.7691	14.0045	2006-09-22T03:44:10.232000Z
45.7764	13.9979	2006-09-23T03:56:57.538000Z
45.7774	13.9939	2006-09-23T07:32:23.901000Z
45.7753	13.9947	2006-09-24T10:13:26.546000Z
45.7754	13.9933	2006-09-24T10:15:02.950000Z
45.7798	13.9876	2006-09-24T11:18:16.480000Z
45.7745	13.9935	2006-09-24T12:39:34.812000Z
45.7699	13.9914	2006-09-24T13:21:55.987000Z
45.7709	14.0006	2006-09-26T01:42:23.683000Z
45.7827	13.988	2006-09-26T18:28:58.365000Z
45.7752	13.9994	2006-09-28T01:49:32.642000Z
45.7722	13.9975	2006-09-29T22:01:26.339000Z
45.772	13.9939	2006-10-02T05:05:06.743000Z
45.967	13.767	2007-02-22T00:16:08.999994Z
45.899	13.984	2007-03-07T00:53:24.999999Z
45.976	13.855	2007-03-31T19:00:51.999993Z
45.94	13.798	2007-04-12T22:38:39.000003Z
45.927	13.977	2007-05-11T00:01:40.000001Z
45.986	14.074	2007-07-16T06:20:31.000009Z
45.931	13.848	2007-07-31T02:13:22.999997Z
46.013	13.862	2007-11-12T16:52:37.999982Z
45.856	13.951	2007-12-10T19:46:41.999996Z
45.936	13.918	2007-12-31T02:54:11.999985Z
46.3298	13.6481	2008-01-01T22:07:44.054000Z
45.929	13.943	2008-02-03T15:22:09.999991Z
45.913	13.945	2008-03-21T05:42:23.999995Z
45.893	14.01	2008-06-19T22:51:25.000011Z
45.937	14.091	2008-07-02T07:10:42.999992Z
45.937	14.091	2008-07-02T07:10:42.999992Z
45.967	13.922	2008-07-10T10:38:21.999985Z
45.965	13.931	2008-07-10T10:39:58.999988Z
45.923	14.092	2008-07-12T06:12:55.000012Z
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45.99	13.85	2008-07-16T07:51:26.000007Z
45.933	13.799	2008-07-29T02:33:07.000007Z
45.937	14.011	2008-08-22T02:38:22.000004Z
45.7154	14.2437	2008-09-20T09:23:53.331000Z
45.7164	14.242	2008-09-20T10:23:53.872000Z
45.6498	14.1954	2008-09-23T19:56:44.598000Z
45.6724	14.1721	2008-09-24T22:49:47.990000Z
45.702	14.1662	2008-10-03T15:13:07.636000Z
45.7154	14.169	2008-10-20T12:52:36.986000Z

45.7112	14.1777	2008-10-21T08:12:39.474000Z
45.7165	14.1674	2008-10-21T08:17:08.373000Z
45.6913	14.2054	2008-10-21T08:54:52.974000Z
45.6903	14.2124	2008-10-21T14:19:13.139000Z
45.7118	14.1767	2008-10-22T18:21:21.423000Z
45.7122	14.1704	2008-10-22T19:33:25.053000Z
45.7078	14.1814	2008-10-28T03:18:31.738000Z
46.203	13.6159	2009-01-10T20:09:43.573000Z
45.9056	13.8103	2009-01-14T09:38:16.00009Z
45.9118	13.8015	2009-01-14T10:05:37.999988Z
45.9324	13.796	2009-01-14T10:28:51.000017Z
45.915	13.7983	2009-01-14T11:06:50.999994Z
45.9211	13.8089	2009-01-14T11:19:37.00006Z
45.9225	13.7999	2009-01-14T12:02:02.999989Z
45.9082	13.8184	2009-01-14T12:15:28.000005Z
45.8975	13.7927	2009-01-14T12:31:21.000016Z
45.9182	13.8161	2009-01-14T12:39:41.000016Z
45.9092	13.812	2009-01-14T13:35:45.000009Z
45.9239	13.8039	2009-01-14T15:27:19.999993Z
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45.9032	13.8072	2009-01-14T17:49:16.000013Z
45.9192	13.8078	2009-01-14T21:11:35.999987Z
45.9158	13.8096	2009-01-15T03:01:36.000001Z
45.914	13.8063	2009-01-15T03:08:24.999999Z
45.9133	13.8035	2009-01-15T04:03:52.000007Z
45.9116	13.8026	2009-01-15T04:14:32.000010Z
45.916	13.8074	2009-01-15T12:09:39.000003Z
46.3108	13.6002	2009-01-31T00:26:47.235000Z
46.3207	13.6427	2009-02-02T21:33:24.699000Z
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45.7485	14.1291	2009-02-21T11:01:05.023000Z
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46.2798	13.6461	2009-10-29T17:45:05.183000Z
45.9988	13.946	2009-10-30T15:46:00.000004Z
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45.9503	14.0631	2009-10-31T13:50:36.000012Z
45.9537	14.0602	2009-10-31T13:56:50.000003Z
45.9537	14.0602	2009-10-31T13:56:50.000003Z
45.9467	14.0602	2009-10-31T13:59:06.000010Z

45.9467	14.0602	2009-10-31T13:59:06.000010Z
45.9626	14.058	2009-10-31T14:02:00.999992Z
45.9626	14.058	2009-10-31T14:02:00.999992Z
45.9532	14.0525	2009-10-31T14:04:13.000010Z
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45.6974	14.2414	2009-11-08T06:19:50.878000Z
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46.2944	13.4688	2009-11-15T12:46:20.207000Z
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45.9488	14.0549	2009-11-30T14:22:34.000014Z
45.9488	14.0549	2009-11-30T14:22:34.000014Z
46.1714	13.531	2009-12-18T10:46:42.267000Z
46.2428	13.695	2009-12-25T01:35:13.161000Z
46.2405	13.702	2009-12-25T01:53:02.159000Z
46.3017	13.6513	2009-12-25T07:13:31.011000Z
46.2522	13.7119	2009-12-25T07:45:51.143000Z
46.2564	13.7133	2009-12-25T09:04:40.403000Z
46.3108	13.6558	2009-12-25T10:24:46.761000Z
46.2876	13.6566	2009-12-25T10:31:21.266000Z
46.238	13.7266	2009-12-25T11:27:40.408000Z
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46.2438	13.7087	2009-12-25T13:12:37.556000Z
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46.3178	13.6383	2009-12-25T19:56:20.377000Z
46.3133	13.6388	2009-12-25T20:46:23.949000Z
46.3291	13.5146	2009-12-25T21:13:23.236000Z
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46.3164	13.6615	2009-12-26T05:02:49.398000Z
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46.3244	13.6012	2009-12-26T08:12:25.640000Z
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45.7645	14.1823	2010-01-08T19:35:03.147000Z
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45.7722	14.1951	2010-01-12T22:12:50.667000Z
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45.7771	14.2037	2010-01-12T23:23:54.556000Z
45.7774	14.2008	2010-01-12T23:28:54.555000Z
45.7808	14.2055	2010-01-12T23:42:44.800000Z
45.7712	14.2008	2010-01-13T00:27:45.227000Z
45.7803	14.2111	2010-01-13T00:33:39.897000Z
45.7817	14.2055	2010-01-13T01:49:40.745000Z
45.7779	14.2101	2010-01-13T02:05:12.505000Z
45.7763	14.2115	2010-01-13T02:17:56.762000Z
45.7714	14.1937	2010-01-13T03:03:11.724000Z
45.7818	14.2091	2010-01-13T16:21:36.268000Z
45.7785	14.2104	2010-01-13T19:34:47.492000Z
45.7709	14.1972	2010-01-14T02:13:25.599000Z
45.7693	14.1971	2010-01-15T14:20:54.024000Z
45.7726	14.1922	2010-01-15T14:31:10.106000Z
45.7731	14.1957	2010-01-15T14:37:54.104000Z
45.7703	14.1889	2010-01-15T14:39:10.385000Z
45.7717	14.1922	2010-01-15T15:40:45.357000Z
45.7796	14.2053	2010-01-15T15:48:55.175000Z

45.7716	14.1955	2010-01-15T17:28:08.766000Z
45.7762	14.2094	2010-01-15T20:05:26.926000Z
45.7749	14.2075	2010-01-15T20:33:30.602000Z
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45.7711	14.1976	2010-01-16T02:42:37.941000Z
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45.7615	14.1941	2010-01-17T02:00:21.621000Z
45.7744	14.205	2010-01-17T10:11:42.370000Z
45.7707	14.1959	2010-01-20T10:59:53.251000Z
45.7745	14.2079	2010-01-20T11:43:01.046000Z
45.8889	14.0992	2010-01-21T11:07:22.999988Z
45.7771	14.1958	2010-01-22T11:09:08.326000Z
46.3149	13.6595	2010-01-22T21:03:46.768000Z
45.7819	14.2022	2010-01-23T11:26:59.658000Z
45.8485	13.9511	2010-01-23T14:22:46.999990Z
45.7716	14.1972	2010-01-23T23:06:34.049000Z
45.7756	14.205	2010-01-24T20:15:21.214000Z
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45.7433	14.143	2010-01-28T11:09:51.107000Z
46.0421	13.9191	2010-01-28T23:51:28.999990Z
45.7728	14.1891	2010-01-29T05:15:01.074000Z
45.7686	14.1937	2010-01-29T11:27:53.879000Z
45.7741	14.1928	2010-01-29T11:43:10.164000Z
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45.6507	14.3065	2014-04-22T23:45:49.281000Z
45.6487	14.2483	2014-04-23T06:02:24.301000Z
45.6541	14.2589	2014-04-23T12:06:05.168000Z
45.646	14.2545	2014-04-23T21:03:56.757000Z
45.6514	14.2508	2014-04-24T03:55:43.683000Z
45.6498	14.2578	2014-04-24T04:11:13.672000Z
45.6451	14.2477	2014-04-28T11:10:20.150000Z
45.645	14.2666	2014-04-28T11:26:18.041000Z
45.6549	14.2513	2014-04-28T11:41:21.073000Z
45.6507	14.3065	2014-05-02T02:09:38.342000Z
46.093	13.8557	2014-05-29T07:41:47.695000Z
46.0833	13.8635	2014-05-29T08:36:39.534000Z
46.1084	13.8783	2014-05-29T11:04:31.374000Z
46.1083	13.8757	2014-05-29T11:05:18.909000Z
46.122	13.8905	2014-05-29T11:10:47.612000Z
46.1025	13.8586	2014-05-29T11:25:12.831000Z
45.418	14.4708	2014-06-04T01:28:56.871000Z
45.6508	14.2532	2014-06-04T04:33:31.985000Z
45.6702	14.2437	2014-07-06T23:16:36.966000Z
45.669	14.2391	2014-07-06T23:17:00.020000Z
45.6423	14.268	2014-11-03T14:35:24.458000Z
45.6414	14.2711	2014-11-06T04:43:02.483000Z
45.7377	14.1574	2014-12-24T06:12:16.357000Z
45.7373	14.1352	2014-12-24T13:19:37.192000Z
45.7081	14.4733	2014-12-30T06:56:59.227000Z
45.6634	14.2522	2014-12-30T09:28:16.651000Z

45.7402	14.0221	2015-01-06T08:13:35.349000Z
45.7074	14.2005	2015-01-06T10:53:57.138000Z
45.9204	14.0714	2015-01-08T04:59:05.000003Z
45.9204	14.0714	2015-01-08T04:59:05.000003Z
45.7512	14.0474	2015-03-22T15:46:49.671000Z
45.7561	14.0484	2015-03-22T15:50:22.547000Z
45.7534	14.0334	2015-03-22T20:59:34.079000Z
46.318	13.6108	2015-08-29T18:47:03.809000Z
46.3201	13.6021	2015-08-29T18:59:26.992000Z
46.3237	13.6075	2015-08-29T19:29:01.494000Z
46.3158	13.6079	2015-08-29T20:49:55.566000Z
46.3192	13.5982	2015-08-30T00:02:50.321000Z
46.3235	13.6037	2015-08-30T07:12:58.881000Z
46.3211	13.609	2015-08-30T08:55:17.619000Z
46.2904	13.5285	2016-11-17T01:52:21.514000Z
46.307	13.5901	2016-11-25T14:38:29.177000Z
45.767	14.2238	2017-02-03T15:13:31.352000Z
45.8475	14.2335	2017-07-02T09:26:31.889000Z
45.7008	14.1809	2017-07-09T04:36:05.172000Z
45.7008	14.1844	2017-07-09T04:57:07.050000Z
45.6995	14.1813	2017-07-09T05:04:56.770000Z
45.7007	14.1818	2017-07-09T05:32:33.219000Z
45.7026	14.1833	2017-07-09T08:18:19.498000Z
45.7006	14.1803	2017-07-09T17:06:55.161000Z
45.118	14.7687	2017-08-08T04:12:03.424000Z
45.133	14.7977	2017-08-08T04:32:26.304000Z
45.1795	14.5624	2017-08-08T09:35:06.219000Z
45.1932	14.5621	2017-08-08T09:43:06.945000Z
45.1738	14.5671	2017-08-08T09:51:27.986000Z
45.1445	14.5801	2017-08-08T12:47:52.938000Z
45.1599	14.5565	2017-08-08T18:00:56.825000Z
45.1803	14.5608	2017-08-08T20:42:36.520000Z
45.1838	14.5668	2017-08-08T23:42:25.672000Z
45.1775	14.5642	2017-08-09T00:37:31.685000Z
45.1676	14.5739	2017-08-09T00:45:51.543000Z
45.1881	14.5942	2017-08-09T11:37:05.053000Z
45.2005	14.5628	2017-08-09T13:29:57.338000Z
45.1729	14.5694	2017-08-09T14:09:06.071000Z
45.1846	14.564	2017-08-09T14:28:12.808000Z
45.1831	14.5649	2017-08-09T18:50:31.056000Z
45.1291	14.5738	2017-08-09T19:05:15.883000Z
45.1931	14.5619	2017-08-09T19:46:59.587000Z
45.1547	14.5695	2017-08-09T22:00:22.365000Z
45.1669	14.5676	2017-08-09T22:14:25.835000Z
45.1825	14.563	2017-08-09T22:19:23.176000Z
45.1654	14.5725	2017-08-09T23:13:33.096000Z
45.1886	14.5601	2017-08-10T08:36:46.590000Z
45.1813	14.5668	2017-08-10T16:19:02.255000Z
45.2031	14.5616	2017-08-10T17:41:48.234000Z
45.2107	14.5498	2017-08-10T18:23:00.584000Z
45.4745	14.3889	2017-08-17T09:57:17.676000Z
45.4818	14.4126	2017-08-21T10:22:48.758000Z
45.4749	14.4131	2017-08-21T16:35:31.620000Z
45.4759	14.4149	2017-08-24T03:30:12.348000Z
45.1821	14.5615	2017-08-24T14:15:49.363000Z
45.1852	14.5638	2017-08-24T20:23:46.484000Z
45.4834	14.4155	2017-08-30T23:55:10.738000Z
45.2816	14.4722	2017-09-27T00:12:23.994000Z
45.2784	14.4791	2017-09-29T02:44:47.855000Z
45.2764	14.4773	2017-09-29T04:00:07.294000Z
45.2786	14.4766	2017-09-29T04:57:09.328000Z
45.2769	14.4747	2017-09-29T13:13:08.709000Z
45.2841	14.4727	2017-09-29T13:17:21.480000Z
45.2804	14.472	2017-09-29T14:01:04.788000Z
45.2748	14.4749	2017-09-29T14:01:37.624000Z
45.2666	14.4815	2017-10-01T18:18:32.814000Z
45.2678	14.4767	2017-10-01T19:50:22.975000Z
45.263	14.4797	2017-10-01T19:55:56.569000Z
45.2742	14.4724	2017-10-01T20:08:11.292000Z
45.2677	14.4798	2017-10-01T23:31:09.329000Z
45.2571	14.4833	2017-10-02T00:20:33.656000Z
45.275	14.4746	2017-10-02T00:29:38.403000Z

45.2447	14.4758	2017-10-02T00:31:49.964000Z
45.6142	14.3854	2017-10-08T02:20:12.610000Z
45.6178	14.3836	2017-10-08T06:33:17.972000Z
45.612	14.385	2017-10-08T06:40:09.962000Z
45.6139	14.3895	2017-10-08T06:48:17.789000Z
45.6128	14.3849	2017-10-08T07:19:36.538000Z
45.6133	14.3843	2017-10-08T07:55:06.753000Z
45.6122	14.3798	2017-10-08T11:18:56.213000Z
45.6133	14.386	2017-10-08T11:23:28.858000Z
45.6137	14.3859	2017-10-08T11:49:14.562000Z
45.6133	14.3866	2017-10-08T12:09:47.824000Z
45.6129	14.3882	2017-10-08T12:38:28.914000Z
45.6116	14.3857	2017-10-08T12:40:26.767000Z
45.6144	14.3865	2017-10-08T13:36:47.412000Z
45.6123	14.3865	2017-10-08T14:34:51.278000Z
45.6128	14.388	2017-10-08T14:37:07.687000Z
45.6107	14.3876	2017-10-08T14:44:19.145000Z
45.6114	14.3849	2017-10-08T15:45:15.101000Z
45.6127	14.3843	2017-10-08T17:05:18.186000Z
45.6146	14.3867	2017-10-08T17:17:29.308000Z
45.6134	14.2707	2017-10-12T21:34:31.079000Z
45.4704	14.3544	2017-10-22T17:47:46.190000Z

Table S 1: Locations and origin times of templates used for matched-filter detection of earthquakes.