

CONSORTIUM TO STUDY TRENDS IN SEISMICITY

Quarterly report:
October 1–December 31, 2017

by

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February 7, 2018

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INTRODUCTION

The Kansas Geological Survey's Consortium to Study Trends in Seismicity (CSTS) is a public-private project aimed at studying trends in seismicity in Kansas. The CSTS is operated by the Kansas Geological Survey (KGS), a research and service division of the University of Kansas with a long history of studying the state's subsurface and seismic characteristics. Current members of the CSTS are from the state's UIC Class 1 disposal well community—wells that are used for disposal of municipal and industrial waste and regulated by the Kansas Department of Health and Environment. Membership in the CSTS is voluntary, with a common goal of understanding seismicity in proximity to member facilities.

About five years ago, seismicity increased significantly in Kansas and throughout the midcontinent. That led to the need to better define and understand seismicity, particularly as it relates to subsurface fluid disposal. The CSTS works to establish the baseline or background seismicity near those facilities and provide a scientific basis for criteria used in differentiating natural from induced seismicity. The CSTS oversees the operation of a seismic network that records and allows accurate location and magnitude estimates of seismicity in proximity to member injection wells for both felt earthquakes and especially for microseismic events that are hundreds of times smaller than routinely possible to detect with current regional seismic networks.

The following report describes three months of CSTS activities (from October 1 through December 31, 2017), including a discussion of member status; network station installation and operation; earthquakes recorded and identified, and earthquake alerts provided to members; web page development; and plans for the next three months and the coming year. In addition to a third quarterly report that will follow this report, an annual report will be provided to members and an annual meeting will be held on **July 18, 2018**, in Wichita.

STATUS OF MEMBERS

The CSTS was established with a two-tier membership system. For Tier 1 members, the CSTS provides equipment, installation, and monitoring of a seismograph station; maintaining a catalog of seismic events, updated weekly, with e-mail alerts within 24 hours or less of any earthquakes greater than magnitude 2 within 30 miles of a facility; quarterly reports of monitoring findings; and an annual meeting at which results are discussed and plans formulated for the coming year.

Tier 2 members have access to information related to the general information about the seismicity being studied by the CSTS and can attend the annual meeting, but do not have the right to vote at that meeting.

The CSTS currently has eleven Tier 1 members and one Tier 2 member.

STATUS OF NETWORK

The CSTS seismic network currently consists of 12 stations in Kearny, Ellsworth, Rice, McPherson, Reno, Kiowa, Sedgwick, Butler, and Johnson counties, Kansas (Figure 1). Waveforms for these stations are available for Tier 1 members on the seismic network page of the CSTS website. For each of those locations, ambient noise tests have been completed, aimed at identifying noise from nearby highways, trains, pump jacks, and other facilities that might interfere with earthquake analysis. Many of the existing sites are in cemeteries, on government property, or in other locations where noise levels are likely to be low. In all cases, written agreements with landowners have been obtained.

Each station consists of a seismic sensor that includes a shallowly buried seismometer embedded in a concrete platform atop a gravel layer, and a digitizer. Ground motion detected by the seismometer is transmitted back to KGS offices in Lawrence real-time via a cellular modem. That communication system is powered by a solar panel that charges two deep-cycle marine batteries. The footprint for each station is approximately 10 feet by 10 feet. The stations have operated with a better than 98% continuous data stream and within designated operational sensitivity and signal-to-noise ratio.

EARTHQUAKE ALERTS, EARTHQUAKE CATALOG

Earthquakes with magnitudes of 2 or larger are below felt levels but represent a threshold above which energy levels provide highly confident automatic analysis with a network as dense as the Consortium network in conjunction with the KGS regional and subregional network. It is therefore reasonable to provide accurate epicenter locations using automated picking routines with results available within minutes of the fault rupture responsible for the event. It will be the practice of the KGS to notify members of a M2 or larger earthquake within 30 miles of Tier 1 member wells. In the fourth quarter of the calendar year, there were 21 earthquakes that met these criteria (Table 1), less than half the number of alerts from the third quarter.

Microearthquake activity recorded by the CSTS network was similar to the previous quarter. A total of 81 earthquakes ranging from M 0.8 to 2.9 were recorded within 20 miles of member wells (Figure 2, Table 2). Most epicenters are located in previously identified clusters or along known trends. Subnetwork activity (Table 3) picked up more than double relative to the previous quarter, most notably within 12 mi of stations RC03 and RN02.

WEB PAGE CONTENT

The CSTS web page (<http://www.kgs.ku.edu/Geophysics/CSTS/index.html>) is operated by the KGS. It includes links to information about meetings, publications, network updates, and seismic updates (for Tier 1 members), and information about the seismic network for Tier 2 members. It includes semi-annual newsletters about earthquake activity, along with access to a comprehensive catalog of events, including time, location, magnitude, and the Seismic Action Score (based on evaluation criteria developed by the State's Induced Seismicity Task Force) for each event. The website also includes a series of pictures and accounts of the installation process and gives a feel

for the environment and footprint of each consortium station. Currently there is at least one station within 20 miles of every Tier 1 member's well (Figure 2). A short discussion and set of pictures are posted on the website documenting the installation process.

OTHER ACTIVITIES

Consortium staff have been engaged with a joint task force created by the KGS, KDHE, and Kansas Corporation Commission, studying issues related to fluid disposal in the Arbuckle Formation. Also, Consortium staff attended the annual meeting of the American Geophysical Union (AGU), which included a number of presentations and posters on the topic of induced seismicity in the midcontinent. In general, earthquake activity throughout the midcontinent is continuing to decline, and most studies project a continuation of that decrease, based on current rates of saltwater injection.

On the publication front, Shelby Peterie was the lead author of the article "Earthquakes in Kansas Induced by Extremely Far-Field Pressure Diffusion" in the refereed journal *Geophysical Research Letters*, published by the AGU. This peer-reviewed journal provides the necessary stamp of approval from the scientific community, allowing the article to be cited in the scientific literature. The article is available on-line (at <http://onlinelibrary.wiley.com/doi/10.1002/2017GL076334/full>). Also, Shelby Peterie was the lead author of the article, "Regional Pressurization and Induced Seismicity in Kansas," which will appear in an upcoming issue of the AGU publication *Eos* and will be made available to Consortium members upon its publication.

PLANS

Currently all 12 stations are installed and operating well within acceptable response levels. Over the next three months the KGS consortium team will focus almost exclusively on developing rapid techniques and procedures for accurately locating and characterizing extremely low energy earthquake epicenters.

Events of M2 or larger within 30 miles of any of Tier 1 member wells will continue to be automatically located and alerts provided to members in proximity within 24 hours (a goal we continue to strive to meet). There will also be a strong focus on sub-M1 earthquakes and establishing an experience-based understanding of the entire network's sensitivity and potential as well as areas of particular future interest. With that understanding, KGS consortium analysts will be able to search and confidently identify earthquake trends at extremely low energy levels resulting from very short fault ruptures, regardless of the triggering mechanism. The clustering and trends of earthquakes at those very small energy levels will help define areas to avoid or monitor for changes based on injection practices.

Also, improved response time for submitting alerts and a more automated process will be part of the scope of work for the next three months. Currently those alerts are only brought to the attention of members who have a well within 30 miles. It is our plan to include those alerts in our earthquake blog on the web page that will see an increased frequency of entries over the next three months.

Several extremely small earthquake clusters were identified within 15 miles of Class 1 injection wells during the past three months. We plan to spend time reviewing

those events to look for any characteristics that might be distinctive. As well, some effort will be made to look for correlations with near and local well activities of the past several months.

In addition, Consortium staff will begin planning and scheduling of presentations and discussion at the Consortium's annual meeting in Wichita, with an aim toward an efficient, informed conversation about the Consortium, member needs, and direction.

CONCLUSION

The KGS's CSTS had a successful second quarter. Agreements for the eleven Tier 1 members and the one Tier 2 member have remained in place. The installed stations have operated successfully, and alerts have been, for the most part, delivered to members as prescribed in the agreement. The CSTS continues to look at methods of providing additional information, and looks forward to the annual meeting for face-to-face conversation about seismicity, Class 1 wells, monitoring, and future activities of the Consortium. To enhance the quality and value of the product the CSTS is delivering to its members, feedback from members is essential and highly valued. Please spend time reviewing CSTS products and providing feedback about improvements to current or additional products.

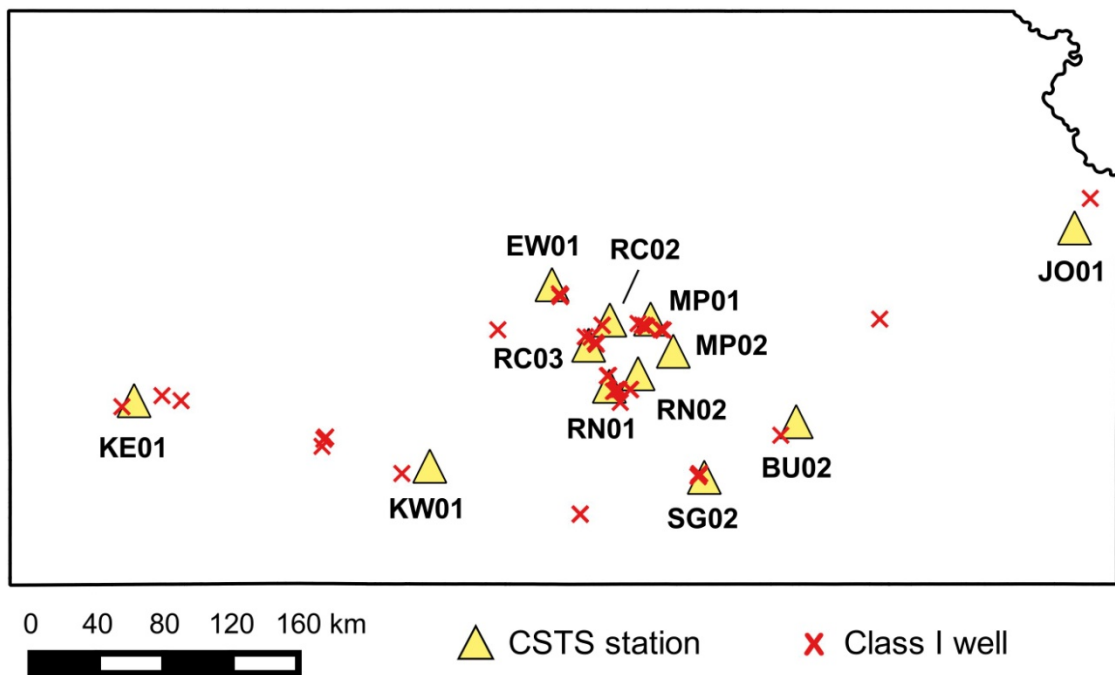


Figure 1. The 12 stations in the current CSTS seismic network.

Table 1. M 2 or larger earthquakes with epicenters located within 30 mi of Tier 1 member wells.

Origin Time (UTC)	Latitude	Longitude	Magnitude	County
2017-10-03 13:38:11	37.426	-97.397	2.8	Sumner
2017-10-07 20:41:24	37.425	-97.398	2.0	Sumner
2017-10-10 03:22:44	38.667	-97.495	2.2	Saline
2017-10-10 10:21:25	38.689	-97.495	2.1	Saline
2017-10-10 20:25:26	38.688	-97.483	2.9	Saline
2017-10-13 12:04:27	38.689	-97.487	2.7	Saline
2017-10-17 14:11:14	37.232	-97.476	2.0	Sumner
2017-10-17 19:01:49	38.643	-97.490	2.0	Saline
2017-10-17 21:50:53	38.652	-97.482	2.0	Saline
2017-10-19 09:19:55	37.413	-97.387	2.9	Sumner
2017-10-26 05:35:52	37.331	-97.777	2.0	Sumner
2017-11-08 03:17:51	37.363	-97.572	2.5	Sumner
2017-11-08 03:18:00	37.270	-97.610	2.8	Sumner
2017-11-13 15:52:07	38.641	-97.487	2.4	Saline
2017-11-24 17:46:55	37.607	-97.090	2.5	Butler
2017-11-28 02:11:22	37.739	-97.161	2.0	Sedgwick
2017-12-25 13:33:16	37.781	-97.952	2.0	Reno
2017-12-25 23:05:11	37.786	-97.954	2.3	Reno
2017-12-30 10:25:42	37.783	-97.952	2.4	Reno
2017-12-31 05:36:55	37.789	-97.942	2.1	Reno
2017-12-31 11:46:29	37.783	-97.947	2.2	Reno

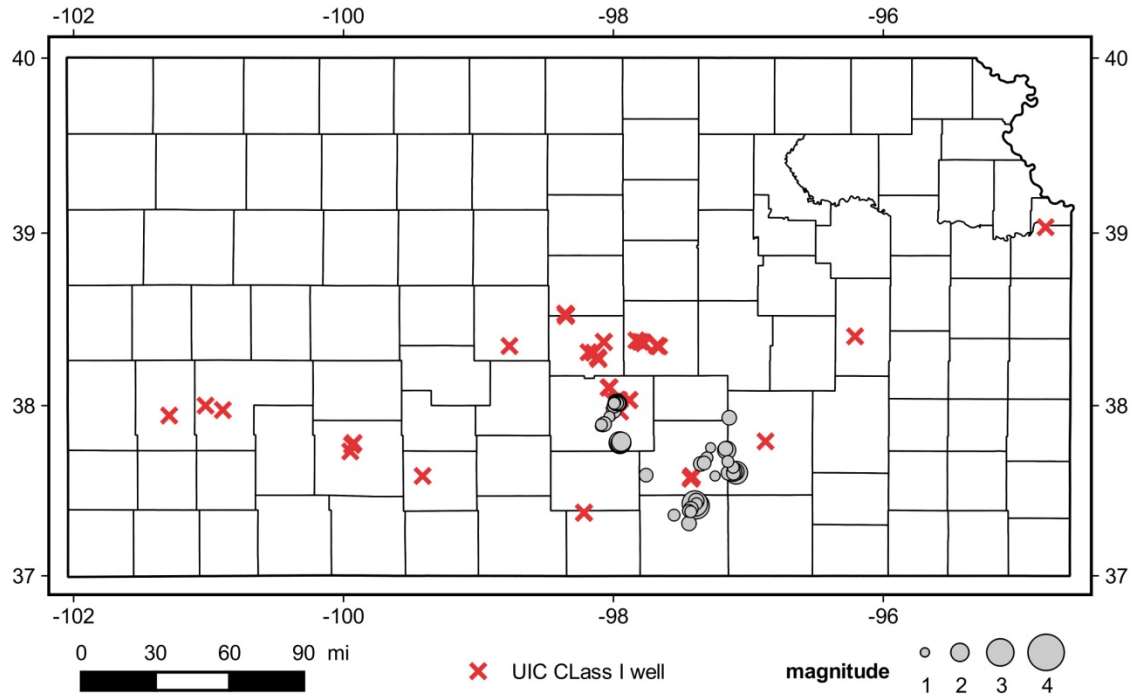


Figure 2. Earthquakes located within 20 miles of member wells.

Table 2. Earthquakes located within 20 miles of member wells.

Origin Time (UTC)	Latitude	Longitude	Magnitude	Origin Time (UTC)	Latitude	Longitude	Magnitude
2017-12-31 11:46:29	37.783	-97.947	2.2	2017-11-17 10:05:58	37.309	-97.440	1.6
2017-12-30 10:25:42	37.783	-97.952	2.4	2017-11-23 10:52:32	37.358	-97.551	1.3
2017-12-25 23:05:11	37.786	-97.954	2.3	2017-11-24 13:41:23	37.606	-97.148	1.6
2017-12-25 22:10:10	37.779	-97.942	1.5	2017-11-24 13:42:29	37.616	-97.113	1.4
2017-12-25 13:33:16	37.781	-97.952	2.0	2017-11-24 15:06:35	38.013	-97.965	1.1
2017-12-18 06:47:07	37.969	-97.998	1.6	2017-11-24 15:10:17	38.019	-97.984	1.5
2017-12-10 06:20:00	37.659	-97.353	1.6	2017-11-24 17:29:47	37.604	-97.111	1.5
2017-11-30 04:50:43	38.026	-97.969	1.4	2017-11-24 18:01:19	37.639	-97.113	1.3
2017-11-24 17:46:55	37.607	-97.090	2.5	2017-11-27 02:14:28	37.748	-97.154	1.4
2017-11-24 17:22:04	37.613	-97.096	1.9	2017-11-27 07:51:37	37.749	-97.176	1.1
2017-11-24 13:42:25	37.618	-97.104	1.6	2017-11-28 02:11:22	37.739	-97.161	2.0
2017-11-24 13:33:03	37.607	-97.112	1.9	2017-11-28 05:41:41	37.751	-97.169	1.2
2017-10-19 10:43:00	37.413	-97.394	1.9	2017-11-28 06:12:23	37.748	-97.169	1.6
2017-10-19 09:19:55	37.413	-97.387	2.9	2017-11-28 13:20:09	37.887	-98.079	1.5
2017-10-07 20:41:24	37.425	-97.398	2.0	2017-11-28 23:27:54	37.787	-97.942	1.5
2017-10-03 13:38:11	37.426	-97.397	2.8	2017-11-30 07:07:48	38.018	-97.979	1.8
2017-10-03 17:19:23	37.441	-97.386	1.7	2017-12-03 09:54:30	37.884	-98.081	1.2
2017-10-07 11:18:17	37.997	-97.996	1.5	2017-12-06 04:48:30	37.383	-97.441	1.4
2017-10-09 05:04:21	37.588	-97.247	1.1	2017-12-06 04:51:32	37.378	-97.427	1.3
2017-10-11 08:03:24	38.016	-97.974	1.5	2017-12-07 15:52:42	37.890	-98.084	1.4
2017-10-16 12:20:18	37.695	-97.307	1.3	2017-12-14 07:43:37	37.929	-97.142	1.6
2017-10-18 04:08:31	38.032	-97.996	1.1	2017-12-15 02:15:19	38.020	-97.985	1.5
2017-10-25 06:19:02	37.887	-98.084	1.3	2017-12-15 04:59:23	38.005	-97.990	0.8
2017-10-25 07:46:17	37.935	-98.030	1.2	2017-12-16 05:04:24	38.014	-97.979	1.5
2017-10-28 18:32:07	38.039	-97.963	1.1	2017-12-16 05:05:33	38.014	-97.994	1.4
2017-10-28 21:24:47	38.023	-97.969	1.6	2017-12-16 05:30:15	38.013	-97.965	1.6
2017-10-28 21:36:13	38.012	-97.980	1.5	2017-12-16 05:48:38	38.015	-97.976	1.5
2017-10-30 08:53:17	37.754	-97.280	1.1	2017-12-17 12:30:17	38.018	-97.990	1.3
2017-10-31 08:00:27	37.742	-97.168	1.1	2017-12-17 13:33:07	37.782	-97.939	1.7
2017-11-01 10:01:02	38.015	-97.964	1.7	2017-12-18 04:37:32	37.664	-97.328	1.5
2017-11-01 11:54:43	38.013	-97.959	1.7	2017-12-19 20:44:00	37.788	-97.938	1.8
2017-11-02 03:08:56	38.019	-97.989	1.3	2017-12-20 01:02:47	37.881	-98.097	1.1
2017-11-06 10:19:22	38.018	-97.985	1.4	2017-12-20 01:55:54	37.890	-98.074	1.2
2017-11-08 05:34:46	37.593	-97.758	1.5				

Table 3. Possible subnetwork earthquakes recorded within 12 miles of member wells (the largest published distance between an induced earthquake swarm and causal well). Epicentral distance is the estimated distance from the earthquake epicenter to the seismic station where it was recorded.

Station	Origin Time (UTC)	Distance	Magnitude	Station	Origin Time (UTC)	Distance	Magnitude
SG02	2017-10-01 16:05:15	9.1	0.6	RN01	2017-10-09 09:23:13	4.5	0.3
SG02	2017-10-13 05:32:44	10.6	1.0	RN01	2017-10-11 08:53:20	4.7	-0.2
SG02	2017-10-25 06:38:30	6.0	0.4	RN01	2017-10-20 23:26:20	4.6	0.6
SG02	2017-11-12 07:15:55	10.9	0.6	RN01	2017-10-22 20:15:26	4.7	0.6
SG02	2017-12-18 04:25:10	9.0	0.3	RN01	2017-10-24 00:13:03	4.7	0.4
SG02	2017-12-26 10:00:26	1.1	-0.6	RN01	2017-10-29 01:01:27	4.9	0.3
SG02	2017-12-30 06:48:07	0.6	-0.6	RN01	2017-10-29 01:02:12	4.8	0.4
RN02	2017-10-01 20:12:01	1.1	-0.9	RN01	2017-10-29 02:16:55	5.1	0.6
RN02	2017-10-08 01:03:24	1.8	-0.2	RN01	2017-10-29 08:54:35	4.9	0.4
RN02	2017-10-11 05:37:06	9.4	0.8	RN01	2017-10-29 09:41:21	4.9	0.3
RN02	2017-10-11 05:38:31	9.8	0.7	RN01	2017-10-29 23:02:01	4.9	0.6
RN02	2017-10-12 04:53:11	8.8	0.6	RN01	2017-10-30 00:58:42	4.8	0.2
RN02	2017-10-12 04:55:53	9.1	0.8	RN01	2017-10-30 05:28:52	4.9	0.2
RN02	2017-10-13 03:38:16	4.8	0.2	RN01	2017-11-03 09:19:40	4.8	0.7
RN02	2017-10-14 06:53:00	9.6	0.9	RN01	2017-11-04 14:38:22	4.6	0.8
RN02	2017-10-27 22:55:44	4.3	0.4	RN01	2017-11-07 08:31:24	4.8	0.8
RN02	2017-10-31 06:09:38	9.2	0.4	RN01	2017-11-07 09:55:13	4.9	0.5
RN02	2017-10-31 06:09:58	8.6	0.3	RN01	2017-11-07 23:30:22	4.7	0.9
RN02	2017-11-01 04:56:55	8.9	0.3	RN01	2017-11-09 10:05:18	5.0	0.2
RN02	2017-11-01 05:00:12	9.1	0.7	RN01	2017-11-11 03:01:47	4.9	0.8
RN02	2017-11-01 05:02:38	9.2	0.8	RN01	2017-11-11 03:36:05	4.7	0.4
RN02	2017-11-01 05:04:00	11.3	0.8	RN01	2017-11-12 05:29:36	5.0	0.4
RN02	2017-11-02 13:42:23	3.5	0.4	RN01	2017-11-13 07:10:16	4.7	0.5
RN02	2017-11-02 13:44:42	6.7	0.4	RN01	2017-11-14 20:40:57	3.5	0.1
RN02	2017-11-07 07:01:19	7.7	0.0	RN01	2017-11-18 18:27:44	4.4	0.6
RN02	2017-11-07 07:01:56	9.1	0.4	RN01	2017-11-20 21:30:41	2.4	-0.4
RN02	2017-11-07 07:03:59	6.8	1.0	RN01	2017-11-24 14:38:24	4.9	0.3
RN02	2017-11-07 07:04:32	8.8	0.3	RN01	2017-11-24 20:24:07	4.1	0.2
RN02	2017-11-07 07:05:21	9.9	0.1	RN01	2017-11-25 04:41:29	4.8	1.1
RN02	2017-11-07 07:05:46	8.9	0.4	RN01	2017-11-27 16:57:49	4.9	1.0
RN02	2017-11-07 07:06:31	9.9	0.2	RN01	2017-11-27 22:59:45	4.7	0.6
RN02	2017-11-08 05:58:40	10.6	0.0	RN01	2017-11-29 07:14:46	4.4	0.3
RN02	2017-11-08 05:59:21	9.9	0.3	RN01	2017-11-29 21:10:03	4.5	0.3
RN02	2017-11-08 06:00:08	9.9	0.2	RN01	2017-11-30 03:27:50	4.8	0.8
RN02	2017-11-08 06:00:57	9.9	0.4	RN01	2017-12-03 09:47:33	5.0	0.5
RN02	2017-11-10 05:57:11	9.5	0.4	RN01	2017-12-06 09:58:55	4.9	0.3
RN02	2017-11-10 05:57:55	9.2	0.4	RN01	2017-12-06 13:41:51	7.2	0.3
RN02	2017-11-10 05:58:43	9.5	0.4	RN01	2017-12-06 21:57:30	4.6	-0.4
RN02	2017-11-14 06:15:40	9.5	0.7	RN01	2017-12-08 12:05:14	7.8	0.3
RN02	2017-11-16 06:33:26	9.1	0.9	RN01	2017-12-12 01:25:37	4.9	0.0
RN02	2017-11-16 12:25:31	3.8	0.2	RN01	2017-12-12 01:54:55	4.8	0.6
RN02	2017-11-21 08:35:38	9.5	0.2	RN01	2017-12-14 05:28:03	4.5	0.2
RN02	2017-11-21 08:43:43	10.7	0.7	RN01	2017-12-14 23:07:31	4.7	-0.2
RN02	2017-11-21 08:44:57	9.5	1.3	RN01	2017-12-16 02:38:03	5.0	0.6
RN02	2017-11-23 03:32:09	10.3	0.4	RN01	2017-12-16 02:51:32	5.0	0.6
RN02	2017-11-29 10:42:32	2.5	0.6	RN01	2017-12-16 05:20:57	4.9	0.0
RN02	2017-12-01 05:36:19	9.7	0.1	RN01	2017-12-16 05:31:50	4.1	0.3
RN02	2017-12-04 10:06:17	4.8	0.0	RN01	2017-12-16 05:34:46	3.4	0.0
RN02	2017-12-28 06:02:02	8.7	0.0	RN01	2017-12-17 01:07:44	4.8	0.0
RN02	2017-12-28 06:03:04	9.8	0.6	RN01	2017-12-17 23:46:16	5.0	0.4
RN02	2017-12-28 06:07:17	9.4	0.4	RN01	2017-12-19 12:25:57	5.0	0.4
RN01	2017-10-02 14:31:37	4.8	0.2	RN01	2017-12-21 11:19:33	4.0	0.3
RN01	2017-10-05 04:55:49	4.8	0.3	RN01	2017-12-21 16:15:55	4.7	-0.4
RN01	2017-10-05 06:23:02	2.6	-0.2	RN01	2017-12-22 23:59:27	4.9	0.4
RN01	2017-10-07 08:36:00	4.7	0.3	RN01	2017-12-23 01:18:55	4.8	0.5
RN01	2017-10-07 13:23:09	4.5	0.6	RN01	2017-12-25 05:33:52	4.7	0.0
RN01	2017-10-08 13:22:32	4.8	0.5	RC03	2017-10-03 02:12:12	7.7	0.1

Table 3. (continued)

Station	Origin Time (UTC)	Distance	Magni- tude	Station	Origin Time (UTC)	Distance	Magni- tude
RC03	2017-10-03 02:12:37	8.8	0.6	RC03	2017-11-28 15:29:36	8.1	0.4
RC03	2017-10-03 02:13:06	8.2	0.5	RC03	2017-11-28 15:30:40	7.5	0.3
RC03	2017-10-04 02:23:02	8.4	1.0	RC03	2017-11-29 03:15:58	8.6	0.9
RC03	2017-10-11 02:14:00	9.6	0.6	RC03	2017-11-29 11:16:24	8.5	1.1
RC03	2017-10-12 02:23:48	8.5	0.7	RC03	2017-11-29 19:23:45	8.7	0.5
RC03	2017-10-12 02:25:04	7.0	0.5	RC03	2017-11-29 19:24:16	7.7	0.6
RC03	2017-10-12 02:25:28	7.0	0.6	RC03	2017-11-30 23:09:15	7.7	0.6
RC03	2017-10-13 02:21:34	8.8	0.9	RC03	2017-11-30 23:09:41	7.4	0.8
RC03	2017-10-16 04:13:47	6.6	0.3	RC03	2017-11-30 23:10:13	6.9	0.9
RC03	2017-10-18 02:36:38	9.0	0.5	RC03	2017-12-02 03:21:12	9.8	0.6
RC03	2017-10-18 02:37:58	8.3	0.4	RC03	2017-12-02 03:21:33	9.0	0.8
RC03	2017-10-19 02:34:32	7.9	0.9	RC03	2017-12-05 05:14:18	8.3	0.3
RC03	2017-10-19 02:36:24	8.1	1.1	RC03	2017-12-05 11:17:53	6.8	1.0
RC03	2017-10-24 02:19:06	8.8	1.0	RC03	2017-12-06 11:19:39	8.8	1.0
RC03	2017-10-25 02:13:06	8.7	0.9	RC03	2017-12-06 23:44:29	8.9	0.4
RC03	2017-10-25 02:14:04	8.3	1.0	RC03	2017-12-08 02:27:59	7.0	0.9
RC03	2017-10-25 02:15:32	7.4	1.0	RC03	2017-12-08 03:05:01	4.9	0.0
RC03	2017-10-26 02:17:12	6.9	1.0	RC03	2017-12-08 11:23:19	7.3	0.9
RC03	2017-10-31 02:27:06	8.1	0.6	RC03	2017-12-09 03:01:30	7.8	-0.4
RC03	2017-11-01 02:16:32	7.0	1.0	RC03	2017-12-09 03:01:34	7.8	0.8
RC03	2017-11-01 08:29:43	8.3	0.8	RC03	2017-12-09 03:01:56	7.8	0.6
RC03	2017-11-01 10:17:35	9.0	1.1	RC03	2017-12-12 03:14:53	8.6	0.4
RC03	2017-11-02 10:15:33	7.9	0.4	RC03	2017-12-12 03:16:05	9.3	0.4
RC03	2017-11-02 10:16:07	7.1	0.6	RC03	2017-12-12 11:13:12	6.8	0.6
RC03	2017-11-03 02:17:09	8.1	0.8	RC03	2017-12-13 03:15:11	6.7	1.0
RC03	2017-11-03 02:18:04	8.8	1.0	RC03	2017-12-13 11:16:32	7.0	0.1
RC03	2017-11-04 02:08:04	8.1	0.4	RC03	2017-12-13 11:17:00	7.9	0.6
RC03	2017-11-07 03:25:08	8.0	0.6	RC03	2017-12-13 23:33:13	8.1	0.5
RC03	2017-11-07 03:25:23	7.1	0.8	RC03	2017-12-13 23:34:52	7.3	0.6
RC03	2017-11-08 03:22:00	8.1	0.8	RC03	2017-12-14 11:10:19	7.3	0.4
RC03	2017-11-08 03:22:24	9.3	0.7	RC03	2017-12-14 11:10:37	7.1	0.5
RC03	2017-11-08 11:16:41	9.5	0.8	RC03	2017-12-14 11:11:19	7.0	0.2
RC03	2017-11-08 19:18:41	7.8	0.4	RC03	2017-12-15 03:21:23	6.9	0.8
RC03	2017-11-08 19:19:06	8.7	0.4	RC03	2017-12-15 11:17:09	8.7	0.7
RC03	2017-11-09 11:16:00	7.8	1.0	RC03	2017-12-16 03:11:50	7.5	0.6
RC03	2017-11-09 11:16:27	6.9	1.0	RC03	2017-12-16 03:12:37	8.5	0.6
RC03	2017-11-10 03:24:08	8.2	0.9	RC03	2017-12-19 03:11:20	7.3	0.6
RC03	2017-11-10 03:25:11	8.4	0.7	RC03	2017-12-20 01:55:22	8.5	0.5
RC03	2017-11-13 05:21:08	7.5	0.7	RC03	2017-12-20 02:52:40	7.9	1.0
RC03	2017-11-14 03:33:16	7.1	1.0	RC03	2017-12-20 19:15:07	8.0	0.6
RC03	2017-11-14 11:16:18	8.0	0.5	RC03	2017-12-21 11:12:22	7.2	0.4
RC03	2017-11-14 11:16:42	8.5	0.7	RC03	2017-12-21 11:12:41	7.3	0.6
RC03	2017-11-15 11:21:08	7.0	0.7	RC03	2017-12-22 19:13:31	7.0	0.3
RC03	2017-11-16 03:12:46	7.6	0.1	RC03	2017-12-22 19:14:10	6.9	0.6
RC03	2017-11-16 03:13:11	8.1	0.0	RC03	2017-12-23 03:06:11	7.8	0.5
RC03	2017-11-16 03:13:52	7.4	0.5	RC03	2017-12-23 03:08:10	7.2	0.6
RC03	2017-11-16 04:24:14	6.0	-0.2	RC03	2017-12-27 08:35:14	8.1	0.7
RC03	2017-11-17 03:12:11	8.5	1.1	RC03	2017-12-28 03:12:35	7.4	0.6
RC03	2017-11-17 11:16:13	8.5	0.5	RC03	2017-12-28 03:13:21	8.3	0.8
RC03	2017-11-18 03:07:12	8.9	0.4	RC03	2017-12-28 03:15:49	8.2	0.9
RC03	2017-11-20 19:14:31	7.1	0.4	RC03	2017-12-29 03:19:11	6.8	1.0
RC03	2017-11-20 19:15:31	7.3	0.4	RC03	2017-12-29 11:16:32	7.3	0.9
RC03	2017-11-21 11:12:05	7.1	0.7	RC02	2017-11-04 06:05:01	5.4	0.4
RC03	2017-11-22 03:20:33	8.6	0.4	RC02	2017-11-19 00:42:35	8.6	0.4
RC03	2017-11-22 03:21:13	8.2	0.4	RC02	2017-11-25 21:34:02	0.7	0.0
RC03	2017-11-23 03:12:52	8.1	0.6	RC02	2017-12-14 09:17:37	2.4	0.0
RC03	2017-11-23 03:14:06	8.0	0.4	RC02	2017-12-22 07:28:07	2.0	0.1
RC03	2017-11-23 03:15:32	7.1	0.8	RC02	2017-12-26 11:44:11	4.0	0.2
RC03	2017-11-25 18:34:02	0.2	-0.6	RC02	2017-12-27 10:20:03	3.3	0.7
RC03	2017-11-25 18:47:53	0.5	0.1	RC02	2017-12-27 12:39:04	4.5	0.2
RC03	2017-11-25 20:46:17	0.5	0.2	RC02	2017-12-27 12:51:52	4.2	0.3

Table 3. (concluded)

Station	Origin Time (UTC)	Distance	Magnitude
RC02	2017-12-27 13:16:15	4.9	0.1
RC02	2017-12-27 14:40:05	4.7	0.0
RC02	2017-12-27 23:14:51	7.7	0.1
RC02	2017-12-29 00:49:24	5.2	0.4
RC02	2017-12-29 01:38:47	4.7	0.3
RC02	2017-12-29 01:51:38	4.4	0.1
RC02	2017-12-29 03:41:31	8.6	0.6
RC02	2017-12-29 06:42:28	5.4	0.1
RC02	2017-12-29 07:37:35	5.3	0.1
MP02	2017-10-20 04:36:49	7.4	0.6
MP02	2017-11-03 10:05:43	9.1	0.4
MP02	2017-11-15 10:39:50	2.5	1.0
MP02	2017-11-23 05:05:06	2.4	-0.4
MP02	2017-12-18 11:52:57	4.2	-0.4
MP01	2017-10-04 12:10:56	5.4	1.2
MP01	2017-10-25 09:59:14	7.8	0.9
MP01	2017-11-03 11:50:14	2.2	-0.2
MP01	2017-11-08 09:26:07	5.1	0.4
MP01	2017-11-08 09:27:02	5.9	0.0
MP01	2017-11-19 11:16:01	6.0	0.3
MP01	2017-11-20 05:45:37	2.2	0.0
MP01	2017-12-13 04:02:14	0.3	0.0
KW01	2017-11-04 00:05:59	4.1	0.1
KW01	2017-11-20 16:09:44	1.0	-0.6
KW01	2017-12-04 15:02:06	2.7	0.2
KE01	2017-11-29 07:50:09	2.3	0.3
KE01	2017-11-29 07:52:27	3.1	0.1
KE01	2017-12-22 07:53:59	1.3	0.0
JO01	2017-10-17 15:24:31	5.1	0.7
EW01	2017-12-13 16:58:03	6.8	0.7
BU02	2017-10-21 23:46:35	3.5	0.4
BU02	2017-10-27 02:27:10	10.9	1.0
BU02	2017-10-27 02:27:53	10.6	0.4
BU02	2017-11-15 01:18:19	11.8	1.4
BU02	2017-11-15 04:08:06	11.7	1.1
BU02	2017-12-13 16:41:39	11.7	1.6
BU02	2017-12-26 10:56:32	0.9	-0.9
BU02	2017-12-27 10:49:15	2.0	-0.6