2020 was an unprecedented year in many ways. University of Utah Seismograph Stations was thrown into the thick of things by not only dealing with the COVID-19 pandemic but also responding to the largest Utah earthquake to occur since 1992.

The pandemic impacted our operations by causing us to work-from-home among other things. There were also complications in working out how to safely conduct field work and research. Overall, UUSS was able to rise to the challenge and quickly adjust to all the changes. After our first full day of working-from-home, Utah experienced its largest earthquake since 1992.

The March 18, 2020 moderate M5.7 earthquake shook the Wasatch Front and brought a lot of attention to UUSS and our operations, especially as felt aftershocks continued to shake the public for months. We remained busy throughout the year because of the sequence. In a way, the Magna earthquake was a validation of the importance of the work we accomplish and a reminder that Utah is earthquake country.

The Magna, Utah, earthquake sequence provided substantial opportunities for research. Our staff and students worked on several different projects regarding the sequence. Research included documenting how we responded to the earthquake during a pandemic, evidence for a listric Wasatch Fault, and monitoring the sequence with nodal seismometers and machine learning.

Several of the Magna specific projects will be featured in a special issue of Seismological Research Letters that will focus on 2020 Intermountain West earthquakes. The special issue will be published in March 2021.

We’re grateful to call 2020 a successful year even through all the challenges it provided. Our staff and students worked hard and accomplished incredible things. We expect even greater accomplishments in 2021.

Best Wishes,
Keith D. Koper, UUSS Director
COVID-19 impact on UUSS

2020 brought a world-wide pandemic that impacted millions of lives. Constantly evolving information and directives caused a need for adaptability. University of Utah Seismograph Stations (UUSS) had the support and resources necessary to find success through the difficult year.

The beginning of the year brought whispers of COVID-19 and its potential to spread. In March, Utah received its first cases of the disease. By March 16, the state government announced a soft closure for public schools. The University of Utah announced a move to online learning and a transition to working from home for faculty and staff as part of the government’s directive.

March 17 was the first full work-from-home day for UUSS. A complicated situation was compounded when, on March 18, Utah experienced the largest instrumentally recorded earthquake in the Salt Lake Valley. UUSS showed amazing adaptability in responding to the earthquake while adhering to pandemic restrictions.

What was thought to be temporary work assignments soon became more permanent as restrictions increased through the rest of March and April. The work from home situation remained in place through the end of the year.

The M5.7 Magna, Utah earthquake on March 18 and the following sequence kept UUSS extremely busy. UUSS was forced to quickly find effective means of communication, deploy field equipment in a safe manner, and continue routine network operations in addition to the increased work from Magna. Methods that were put into place for earthquake response were able to improve and help operations throughout the rest of the year.

As the pandemic took the world by storm, UUSS produced quality work through good planning and diligence. UUSS published valuable research, attended conferences and meetings virtually, safely conducted equipment deployment, supported student research and education, and continued public service efforts.

FOOTNOTE: Becca Sumsion (left) and Mo Holt (right) participate in Preparedness Day on the Hill on Feb. 27, 2020.

OUTREACH

Outreach was severely limited due to COVID-19 and the work-from-home directive. Virtual capabilities increased the number of presentations and talks towards the end of the year. However, the beginning of the year’s restrictions greatly reduced outreach efforts.

Before March, some notable events were:
• Exhibit at Silver Mesa Elementary School – Jan. 14
• University of Utah College of Mines and Earth Sciences Open House – Jan. 30
• Utah: Life of Elevated Earthquake Risk panel – Feb. 4
• Preparedness Day on the Hill – Feb. 27

The most notable outreach in 2020 was the more than 45 media interviews that took place in relation to the Magna, Utah, earthquake sequence.
SEISMICITY IN THE UTAH REGION

Over the last year, 4,941 earthquakes have been located in the Utah region, well above the yearly average of 1,408. Much of this increase is due to the Magna sequence (see below). The magnitudes ranged from -1 to 5.7.

2020 by magnitude:
- M 5 = 1
- M 4 = 8
- M 3 = 80
- M 2 = 360
- M 1 = 2,066
- M < 1 = 2,466

The Magna sequence included 2,568 earthquakes beginning with the M 5.7 Mainshock on March 18, 2020. The earthquakes continue, but have slowed down to an average of less than 6 per week.

SEISMICITY IN THE YELLOWSTONE REGION

Over the last year, UUSS has located 1,722 earthquakes in the Yellowstone region, very close to the yearly average of 1,725. The magnitudes ranged from -0.1 to 3.1.

Earthquakes by magnitude:
- M 3 = 3
- M 2 = 91
- M 1 = 566
- M < 1 = 1,082

17 swarms, totalling 803 earthquakes, were located in 2020. The largest swarm totaled 148 earthquakes. It occurred between Dec. 1-14 and was located about 9 miles south southeast of Fishing Bridge, YNP, near the middle of Yellowstone Lake.
# SEISMO TEA

SeismoTea was interrupted early in the spring due to COVID-19 and the shift to working-from-home and online classes. Later in the summer, SeismoTea started again through virtual meetings. The fall semester was extremely successful and allowed a variety of speakers to present from throughout the country and internationally.

<table>
<thead>
<tr>
<th>Date</th>
<th>Name</th>
<th>Institution</th>
<th>Lecture Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 28</td>
<td>Sin-Mei Wu</td>
<td>PhD Candidate, Department of Geology and Geophysics, University of Utah</td>
<td>Spatiotemporal Seismic Structure Variations Associated with the 2018 Kīlauea Eruption based on Temporary Dense Geophone Arrays</td>
</tr>
<tr>
<td>Feb. 11</td>
<td>James Holt and Surya Pachhai</td>
<td>Postdocs, Department of Geology and Geophysics, University of Utah</td>
<td>Jamaica earthquake and free-oscillation of the Earth observed by global seismic stations</td>
</tr>
<tr>
<td>Feb. 25</td>
<td>Michael Thorne</td>
<td>Associate Professor, Department of Geology and Geophysics, University of Utah</td>
<td>Deep mantle oddities</td>
</tr>
<tr>
<td>Mar. 3</td>
<td>Kristine Pankow</td>
<td>Research Professor, Assos. Director of Seismograph Stations, University of Utah</td>
<td>Re-evaluating remote dynamic triggering by first establishing background seismicity rates</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul. 17</td>
<td>Wei Wang</td>
<td>Postdoc at the University of Southern California</td>
<td>Attenuation and scattering structure of southern California</td>
</tr>
<tr>
<td>Jul. 31</td>
<td>Elizabeth Cochran</td>
<td>Research Geophysicist, USGS Pasadena</td>
<td>Clustering Behavior of Induced Seismicity Reveals Triggering Processes</td>
</tr>
<tr>
<td>Aug. 7</td>
<td>Daniel Trugman</td>
<td>Assistant Professor, University of Texas at Austin</td>
<td>New Insights into Earthquake Rupture Processes from High-Resolution California Datasets</td>
</tr>
<tr>
<td>Aug. 14</td>
<td>Amanda Thomas</td>
<td>Associate Professor, University of Oregon</td>
<td>Overlapping regions of coseismic and transient slow slip on the Hawaiian décollement</td>
</tr>
<tr>
<td>Aug. 21</td>
<td>Marine Denolle</td>
<td>Assistant Professor, Harvard University</td>
<td>Monitoring the shallow Earth using the ambient seismic field: new theory, new tools, and applications</td>
</tr>
<tr>
<td>Aug. 28</td>
<td>Gesa Petersen</td>
<td>PhD student, GFZ Potsdam (Germany)</td>
<td>Lessons learned from regional CMT inversion of small earthquakes using the AlpArray Seismic Network</td>
</tr>
<tr>
<td>Sept. 4</td>
<td>Abdullah Mureen</td>
<td>Associate Professor, University of New Mexico</td>
<td>Automated Phase Classification for Next Generation Seismic Processing</td>
</tr>
<tr>
<td>Sept. 11</td>
<td>Ariel Lellouch</td>
<td>Postdoctoral Research Fellow, Stanford University</td>
<td>Seismic monitoring using downhole DAS — examples from the FORGE geothermal experiment</td>
</tr>
<tr>
<td>Sept. 18</td>
<td>Guannin Pang, James Holt, Katherine Whidden, Mo Holt; University of Utah Seismograph Stations</td>
<td></td>
<td>Updates on the 2020 Magna, UT earthquake sequence</td>
</tr>
<tr>
<td>Sept. 25</td>
<td>Daniel Blatter</td>
<td>Postdoctoral Scholar, Scripps Institution of Oceanography</td>
<td>Constraining melt fraction and volatile concentration at the lithosphere-asthenosphere boundary using Bayesian inversion of electromagnetic data</td>
</tr>
<tr>
<td>Oct. 2</td>
<td>Daniel Wells</td>
<td>PhD Student, University of Utah</td>
<td>Source Physics Experiment: Dry Alluvium Geology (DAG) Gradiometric Analysis</td>
</tr>
<tr>
<td>Oct. 9</td>
<td>Dino Bindi</td>
<td>Senior Scientist, GFZ</td>
<td>Decomposition of amplitude Fourier spectra into source, propagation and site amplification factors: insights on ground motion variability</td>
</tr>
<tr>
<td>Oct. 23</td>
<td>Kevin Kwong</td>
<td>Postdoctoral Scholar, University of Washington</td>
<td>Modernizing Local Tsunami Warning Operations with GNSS-derived Earthquake Source Products</td>
</tr>
<tr>
<td>Oct. 30</td>
<td>Zefeng Li</td>
<td>Professor, University of Science and Technology in China</td>
<td>Learning big earthquakes from big data: from source process to emergency response</td>
</tr>
<tr>
<td>Nov. 6</td>
<td>Matthew Haney</td>
<td>Research Geophysicist, USGS and Alaska Volcano Observatory</td>
<td>Detecting and characterizing explosive volcanic activity at Mt. Cleveland Volcano, Alaska</td>
</tr>
<tr>
<td>Nov. 13</td>
<td>Brandon Schmandt</td>
<td>Associate Professor, University of New Mexico</td>
<td>Wastewater injection-induced seismicity in the Raton Basin from 2016-2020</td>
</tr>
<tr>
<td>Nov. 20</td>
<td>Qicheng Zeng</td>
<td>PhD Student, University of Utah</td>
<td>Analysis of Local Seismic Events near a Large-N Array for Moho Reflections</td>
</tr>
</tbody>
</table>
On Wednesday, March 18, 2020, Utah was jolted by a magnitude 5.7 earthquake that occurred 3.1 miles north of Magna, Utah. The shaking from the earthquake was widely felt throughout the Wasatch Front area of north-central Utah.

Panic from the public was high. In addition to the current pandemic and the start of quarantine, this was the first moderate earthquake many Utah residents experienced.

The minute the earthquake occurred, the University of Utah Seismograph Stations (UUSS) jumped into action. The location was reviewed, the data posted to the internet, and a press release sent out.

With the recent work-at-home directive from the university, only a handful of staff were sent in to the office to handle network operations and media. Most of
the staff remained at home and effectively collaborated through the use of Google hangouts.

UUSS Director Keith Koper took the lead in talking with the media through several press conferences, videos, and phone calls. It soon became apparent the public needed correct and educational information not only about the M5.7 earthquake, but about earthquakes in general. This was especially made apparent as an unfounded rumor claimed there was a magnitude 9.0 earthquake about to happen.

UUSS staff and students were swamped with work. The website was closely monitored and updated, analysts worked endlessly in locating the numerous aftershocks that continued to shake Utah, moment tensor solutions and other findings were calculated to better understand what occurred, and technicians deployed temporary nodals and seismograph stations to increase the accuracy of the earthquake solutions.

The M5.7 was the largest earthquake to occur in Utah since a magnitude 5.9 earthquake in 1992 in southwestern Utah near St. George. The earthquake occurred in a seismically active part of the Salt Lake Valley. Before March 18, the area experienced six magnitude 3.0 or larger earthquakes since 1962, the largest being the magnitude 5.2 on September 5, 1962.

The M5.7 was designated the mainshock of the Magna Earthquake Sequence. There were no foreshocks. At the end of 2020, there were 2,568 earthquakes recorded as part of the Magna sequence. The sequence is ongoing but has slowed to an average of less than six earthquakes per week.

**RESEARCH**

In addition to the Magna M5.7 earthquake, there were other notable earthquakes in the Intermountain West in 2020. This led to research to be published in a special edition of Seismological Research Letters focusing on these events.

The Magna Earthquake Sequence was well-recorded due to the number of permanent and temporary seismometers located throughout the Salt Lake Valley. The well-recorded nature of the sequence led to several research opportunities both published and ongoing that have impacted and will continue to impact our understanding about faults, earthquakes, and seismic hazard in Utah and the Intermountain West.

Prior to the Magna earthquake, the exact location at depth of the Wasatch fault was unknown, but many scientists thought it dipped at a steep angle deep beneath the Salt Lake Valley. Based on data from the Magna sequence, several research papers now suggest the sequence actually occurred on the Salt Lake City segment of the Wasatch fault. Evidence also suggests that the fault curves to a shallower angle and is not as deep beneath the surface as previously thought.

Researchers concluded that because of the likely shallower dip of the fault, which would put it closer to the surface, ground shaking estimates may be higher than previously thought for future earthquakes on the Salt Lake City segment of the Wasatch fault. Based upon these findings, ground-motion scenarios for future Wasatch fault earthquakes should be reevaluated to account for increased shaking.

Additional research published to date included increasing the number of detected earthquakes through machine learning, testing novel methods for magnitude determination, and documenting the challenges of responding to an earthquake during a pandemic.

**COMMUNICATION**

The Magna sequence impacted the way UUSS communicated internally and externally. The work-from-home situation necessitated the use of an instant messaging system to make quick contact with each other. UUSS heavily relied on Google hangouts. As 2020 progressed, many smaller groups were formed on hangouts to streamline conversations and make efficient decisions.

The need to quickly communicate with the public regarding current events also became apparent. In addition to responding to requests from the news media, UUSS established our own methods of communicating through social media to get information out quickly. The number of social media followers increased drastically because of the M5.7 earthquake. The @UUSSQuake Twitter account gained over 10,000 followers.

For the first few months after the M5.7 mainshock, whenever there were felt aftershocks or perceived
shaking, social media users turned to our social media platforms to find more information. We learned the importance of responding quickly and as accurately as possible to help placate people's fears. Even media outlets turned to our social media for information and many of our tweets were quoted in their articles.

The increased followers on our social media platforms also led to an opportunity to explore new ways to educate and inform the public about seismicity in Utah and Yellowstone. This led to our bi-weekly updates and other scheduled social media posts.

2020 and the Magna sequence were robust reminders that Utah is earthquake country. It confirmed, yet again, that seismic monitoring is important work.

PRESENTATIONS

<table>
<thead>
<tr>
<th>Date</th>
<th>Personnel</th>
<th>Location</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>Kris Pankow</td>
<td>Benz/NEIC Coffee Hour</td>
<td>The 18 March 2020 Mw 5.5 Magna, Utah, Earthquake Sequence</td>
</tr>
<tr>
<td>May 7</td>
<td>Keith Koper</td>
<td>Utah Seismic Safety Commission</td>
<td>Responding to the 18 March 2020 Mw 5.7 Magna, Utah, Earthquake Sequence</td>
</tr>
<tr>
<td>June 17</td>
<td>Keith Koper</td>
<td>Idaho National Labs</td>
<td>Initial Results for the 18 March 2020 M 5.7 Magna, Utah, Earthquake Sequence</td>
</tr>
<tr>
<td>July 23</td>
<td>Keith Koper</td>
<td>EERI virtual seminar</td>
<td>Seismic Analysis of the 18 March 2020 M 5.7 Magna, Utah, Earthquake Sequence</td>
</tr>
<tr>
<td>Aug.</td>
<td>Kris Pankow</td>
<td>Intermountain Center for Disaster Preparedness Lunch &amp; Learn</td>
<td>Earthquakes Don't Stop for Pandemics</td>
</tr>
<tr>
<td>Aug. 10</td>
<td>Jamie Farrell</td>
<td>Yellowstone Volcano Observatory seminar series</td>
<td>Using Seismology to Image the Steamboat/ Cistern Hydrothermal Plumbing System in the Norris Geyser Basin</td>
</tr>
<tr>
<td>Fall</td>
<td>Maria Mesimeri</td>
<td>Seismology I, 2020 Fall Semester, Department of Geology and Geophysics, University of Utah</td>
<td>Backprojection Imaging of the 2020 M 5.5 Magna, Utah Earthquake using a Local Dense Strong Motion Network</td>
</tr>
<tr>
<td>Sept.</td>
<td>Kris Pankow</td>
<td>Beaver County Commissioners and Milford Public Outreach</td>
<td>Seismic Monitoring at FORGE</td>
</tr>
<tr>
<td>Oct.</td>
<td>Kris Pankow</td>
<td>Utah Seismic Safety Commission</td>
<td>Seismic Monitoring at FORGE</td>
</tr>
<tr>
<td>Oct. 23</td>
<td>Keith Koper</td>
<td>University of Oregon virtual geophysics seminar</td>
<td>Analysis of the March 2020 Magna, Utah, Earthquake Sequence: Evidence for a Listric Wasatch Fault</td>
</tr>
<tr>
<td>Nov. 4</td>
<td>Maria Mesimeri</td>
<td>UU/GFZ Seminar</td>
<td>Detecting the Undetectable: Microearthquake Hunting in South-central Utah</td>
</tr>
<tr>
<td>Nov. 13</td>
<td>Mo Holt</td>
<td>University of Oregon</td>
<td>Distinguishing between Earthquakes and Explosions Recorded at Local Distances</td>
</tr>
<tr>
<td>Dec. 3</td>
<td>Mo Holt</td>
<td>University of Washington</td>
<td>Low-yield, Local-distance Seismic Discrimination</td>
</tr>
<tr>
<td>Dec. 3</td>
<td>James Holt &amp; Katherine Whidden</td>
<td>UU/GFZ Seminar</td>
<td>Towards Robust and Routine Determination of M 3 for Small Earthquakes: Application to the 2020 M 5.7 Magna, Utah, Seismic Sequence</td>
</tr>
</tbody>
</table>

COMMITTEE SERVICE

Dr. Keith K. Koper
- Editor-in-Chief, The Seismic Record, 2020 – present
- Guest Editor, Seismological Research Letters special focus section on 2020 Intermountain West earthquakes
- Chair of SSA Richter Award Subcommittee, 2018 – present
- Vice-Chair & Chair of Utah Seismic Safety Commission, 2010–present
- Member of AGU Aki Award Subcommittee, 2019 – present
- Member of U.S. Air Force Seismic Review Panel, 2011 – present
- Member of EOS editorial advisory board, 2010 – present

Dr. Kristine L. Pankow
- Guest Editor, Seismological Research Letters: Focus Section on Monitoring During a Crisis, 2020 – present
- Guest Editor, Journal of Seismology Special Issue: Induced seismicity: observations, modeling, monitoring, discrimination, and risk management strategies, 2019 – 2020
- Powell Cntr. Working Group, Future Opportunities in Regional & Global Seismic Monitoring, 2018 – present
- Utah Mine Safety Technical Advisory Council, July 1, 2011 – present
- Advanced National Seismic System (ANSS):
  - NIC representative to ANSS Steering Committee (non-voting), 2019 – present
  - Regional Coordinator, Intermountain West (IMW) region, 2010 – present
  - Member, ANSS National Implementation Committee (NIC), 2010 – present
  - ANSS NIC Working Groups: Member, Revisiting Performance Standards Working Group, 2020

Dr. James C. Pechmann
- Member, Western States Seismic Policy Council Program Committee, 2019 – present
- Participant, Utah Geological Survey, Basin and Range Province Earthquake Working Group, 2018 – present
- Member, Utah Quaternary Fault Parameters Working Group, Utah Geological Survey, 2003 – present
- Member, Working Group on Utah Earthquake Probabilities, Utah Geological Survey, 2003 – present
- Reviewer, Seismological Research Letters, 2019, 2020
- Reviewer, National Science Foundation, 2020
- College Council, 2018 – present
- Diversity and Climate Committee, 2020 – present
- Graduate Affairs Committee 2019 – present

Dr. Jamie M. Farrell
- Chief Seismologist, Yellowstone Volcano Observatory, 2017 – present
- Duty Seismologist, Seismograph Stations
- Member, Graduate Students Committee, Dept. of Geology and Geophysics and University of Texas at El Paso
- Member, University of Utah Dept. of Geology and Geophysics Merit Review committee, 2020
- Member, University of Utah Dept. of Geology and Geophysics Awards committee, 2020
- Member UNAVCO Geodetic Data Services Advisory Committee, 2020 – present
- Co-teacher, GEO 6920-030, MSSST, University of Utah, Spring 2020
FUNDING

<table>
<thead>
<tr>
<th>Budget Category</th>
<th>Percent of Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATE OF UTAH</td>
<td>32%</td>
</tr>
<tr>
<td>NETWORK: USGS</td>
<td>32%</td>
</tr>
<tr>
<td>EARTHQUAKE HAZARDS</td>
<td></td>
</tr>
<tr>
<td>DOE - FORGE</td>
<td>11%</td>
</tr>
<tr>
<td>YELLOWSTONE: USGS</td>
<td>11%</td>
</tr>
<tr>
<td>VOLCANO HAZARDS</td>
<td></td>
</tr>
<tr>
<td>OTHER</td>
<td>14%</td>
</tr>
</tbody>
</table>

U.S. Geological Survey - Earthquake Hazards Program 32.16%
- Regional and urban seismic monitoring: Wasatch Front and neighboring Intermountain West region

State of Utah 31.65%
- Earthquake monitoring, research, education and outreach in the Utah region

U.S. Geological Survey - Volcano Hazards Program 11%
- Operational and maintenance of the Yellowstone regional seismic network and earthquake information system

U.S. Department of Energy - FORGE 11%
- Enhanced geothermal system concept testing and development at the Milford City, Utah FORGE site

Other 14%

U.S. Geological Survey DOI 1.09%
- Temporal characteristics of aftershock sequences in the Intermountain West

U.S. Department of Energy .36%
- Structurally controlled geothermal systems in the Eastern Great Basin Extensional Regime, Utah

Sandia National Laboratory – Department of Energy 4.05%
- Geophysical monitoring and characterization of the Utah Region

Air Force Research Laboratory 2.74%
- Evaluation of ML-MC as a possible depth discriminant at local distances 1.57%
- Modeling and Observing the Effect of Source Depth on Seismic Waveforms Recorded at Local Distances for Purposes of Source Class 1.16%

National Science Foundation 5.42%
- Capitalizing on earthscope transportable array data to better characterize induced seismic sequences .09%
- Mapping fine scale structure in earth’s inner core with a global array of seismic arrays 1.97%
- The origin and propagation of shallow water microseisms: a multidisciplinary study at Yellowstone Lake 2.22%
- Controlled source seismic investigation of the top of the Yellowstone magmatic system 1.14%

SPONSORS

University of Utah:
- College of Mines and Earth Sciences
- Department of Geology and Geophysics
- Department of Mining Engineering
- Energy and Geoscience Institute
- Advanced National Seismic System
- Air Force Research Laboratory
- Arizona Geological Survey
- Brigham Young University, Idaho
- Idaho National Laboratory
- International Seismological Centre
- Lawrence Livermore National Laboratory
- Montana Bureau of Mines and Geology
- National Science Foundation
- National Strong Motion Project
- Northern Arizona University
- Plate Boundary Observatory
- RioTinto
- Sandia National Laboratory
- State of Utah
- University of Nevada, Reno
- U.S. Bureau of Reclamation
- U.S. Department of Energy
- U.S. Geological Survey
- Utah Department of Public Safety
- Utah FORGE
- Utah Geological Survey
- Yellowstone National Park

Student Alysha Armstrong shows support for the University of Utah in the Rio Tinto Earthquake Information Center.
Monique Holt  
Ph.D. Candidate Geophysics  
Monique worked on calculating first-motion focal mechanisms for the Magna earthquake sequence. She also worked on her dissertation research, which deals with using local magnitude and coda magnitude to tell shallow events from deep events. Since the magnitude scales are difficult to develop, she has been working on just using measurements of waveform amplitude and duration as a proxy.

Guanning Pang  
Ph.D. Candidate Geophysics  
Guanning’s research focused on the Magna M5.7 earthquake. He was first author on the paper detailing the discovery of the M5.7 earthquake occurring on the Salt Lake Segment of the Wasatch fault and that the fault is listric, or curved, with a steep dip near the surface that curves to a shallower 30–35° at depth. The paper also suggests that ground shaking in the Salt Lake City region in future Wasatch fault earthquakes may be higher than previously estimated.

Daniel Wells  
Ph.D. Candidate Geophysics  
Daniel primarily worked on the Utah FORGE project performing ambient noise tomography using four different nodal geophone arrays combined with permanent seismometers. He used a combination of eikonal tomography and ellipticity measurements to generate a 3D velocity model for part of Southern Utah.

Alysha Armstrong**  
Senior - Geoscience-Geophysics | MS Geophysics  
Alysha worked on detecting mining induced seismicity at Suflco mine using template matching. In a project with Los Alamos National Laboratory, she worked on discriminating quarry blasts from earthquakes using spectral variance — a proposed measure of the modulations introduced into the spectra of delay-fired mining blasts. She graduated with her BS in geoscience in May and is now working on her MS in geophysics. Her thesis research is focused on detecting previously uncatalogued earthquakes in the Yellowstone region using machine learning and template matching techniques.

Nicholas Forbes**  
Senior - Geoscience-Geophysics | MS Geophysics  
Nicholas worked on spatial-temporal analysis of the 2008–2009 Yellowstone Lake earthquake swarm. He utilized double difference and hierarchical clustering algorithms to perform relocations of the initial swarm. He applied template matching detection methods to the initial catalog and then used the hierarchical clustering relocation method to relocate the improved earthquake catalog in order to study geodynamical processes associated with the earthquake swarms. He also helped with research in Yellowstone and on the Magna earthquake sequence. Nicholas graduated with his BS in geoscience in May and is now working on his MS in geophysics.

Amy Record*  
MS Geophysics  
Amy’s research focused on defining and characterizing earthquake sequences in south-central Utah using several clustering techniques. The goal was to assess the influence of fluids in the upper crust on earthquake generation in that area. Amy defended her thesis: “Characterizing Seismic Clusters in South-Central Utah” and graduated in December 2020.

Avery Conner*  
Senior - Geoscience-Geophysics  
Avery researched an earthquake sequence in the San Rafael Swell Region of Utah. She refined event locations in order to establish a potential fault structure, and detected more earthquakes associated with the sequence. Through this research, Avery plans to learn more about tectonic structures present in the San Rafael Swell, as well as determine if the 2019 sequence is linked to a 1988 M 5.2 earthquake.

Barrett Johnson*  
Senior - Geoscience-Geophysics  
Barrett researched the Bluffdale, Utah, earthquake sequence. Using waveform cross-correlation methods to calculate differential travel times, Barrett worked to relocate the initial earthquake locations with a cluster-based relative relocation algorithm, GrowClust. The results allowed him to determine if the sequence occurred on the Wasatch fault, illuminate the complex nature of the tectonic setting surrounding the Bluffdale region, and make more precise earthquake hazard assessments moving forward.

Jonathan Voyles*  
Senior - Geoscience-Geophysics and Geological Engineering  
Jonathan worked on the ML–MC depth-based discrimination at local distances project for three years. During that time, he tested M L–MC on a new catalog of explosions in Utah, simulated what mechanisms are driving the M C depth-dependence using high-performance computing, and tested M L–MC using machine learning methods.

Zachary Claerhout | Boe Ericksen | Miles Haynes  
Student Analysts  
Utilized various seismic stations located in Utah, Wyoming, and surrounding states to locate earthquakes. Also monitored mining operation blasts in the state of Utah, teleseism events, or background noise.
ABSTRACTS, PUBLICATIONS, & REPORTS

ABSTRACTS

Air Force Research Laboratory Technical Interchange Meeting, Melbourne, FL, January 28–30, 2020


Seismological Society of America Annual Meeting, Albuquerque, New Mexico April 27–30, 2020


Pang, K. (2020). The October 2019 earthquake swarm in the Mineral Mountains, Utah and its relation to the geothermal system, EGU 2020, poster, abstract SM6.1

American Geophysical Union Fall Meeting, Online, December 1–17, 2020


PROCEEDINGS


Pang, K. (2020). The October 2019 earthquake swarm in the Mineral Mountains, Utah and its relation to the geothermal system, EGU 2020, poster, abstract SM6.1


PROCEEDINGS


PUBLICATIONS


Holt, J. (2020). A vision for a diverse and equitable environment through the lens of Inclusive Earth, Environment through the lens of Inclusive Earth, Environment through the lens of Inclusive Earth, Environment through the lens of Inclusive Earth, Environment through the lens of Inclusive Earth, Environment through the lens of Inclusive Earth.


Pang, K. (2020). The October 2019 earthquake swarm in the Mineral Mountains, Utah and its relation to the geothermal system, EGU 2020, poster, abstract SM6.1


REPORTS


