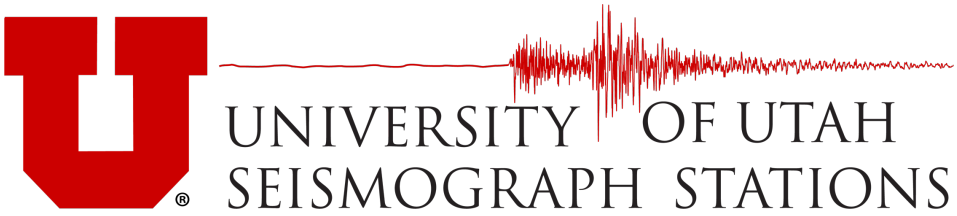
University of Utah Seismograph Stations Briefing Book

13 January 2021



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1. Introduction

The University of Utah Seismograph Stations (UUSS) capitalizes on a state-federal partnership to conduct research, education, and outreach related to earthquakes, seismic monitoring, and seismic safety in the Utah region. As a founding member of the Advanced National Seismic System (ANSS), UUSS shares the mission of providing prompt and accurate information related to seismic events, including their effect on the built environment. Notable UUSS partner agencies at the state level include the Utah Seismic Safety Commission, the Utah Geological Survey, and the Utah Division of Emergency Management. The primary partner agency at the federal level is the United States Geological Survey (USGS).

1a. History and structure of UUSS

On April 11, 1966, the University of Utah Board of Regents recognized Seismograph Stations as an organizational entity. The term "University of Utah Seismograph Stations" originally referred to a small group of seismographic installations with onsite photographic recording. In 1971, the founding UUSS director, Dr. Kenneth Cook, worked with the Governor's office to establish state funding for UUSS, and in 1972 a line-item appropriation for UUSS was established by the state legislature. Dr. Cook served as UUSS director until 1976, and was followed by Dr. Stanley Ward (1976–1980), Dr. Robert Smith (1980–1985), Dr. Walter Arabasz (1985–2010), and Dr. Keith Koper (2010–present).

UUSS is an organizational unit within the Dept. of Geology and Geophysics (GG), which in turn is a unit within the College of Mines and Earth Science (CMES). Faculty who work within UUSS report to the Chair of GG for academic duties, and report to the UUSS director for operational duties. The UUSS director reports to the Chair of GG for academic duties and to the Dean of CMES for operational duties. UUSS does not award academic degrees. All graduate and undergraduate students working within UUSS have a separate home academic department, most commonly GG but sometimes others such as the Department of Mining Engineering.

1b. Mission statements

The current UUSS mission statement was adopted in 2016 and reads:

"*Reducing the risk from earthquakes in Utah through research, education, and public service.*"

UUSS also adheres to the current ANSS mission statement:

"To provide accurate and timely data and information products for seismic events, including their effects on buildings and structures, employing modern monitoring methods and technologies."

1c. Personnel

Full-time UUSS personnel currently include one tenure-line faculty member, three research faculty, one research scientist, three post-doctoral research associates, a seismic network manager, a seismic software administrator, two seismic engineers, two seismic technicians, two seismic analysts, an administrative officer, and a communications specialist. Part-time UUSS personnel currently include one post-doctoral research associate, one research scientist, three field assistants, and two undergraduate researchers. The UUSS organizational chart is presented in section 5.

1d. Graduate Student Affiliates

UUSS currently has five graduate student affiliates based in the Dept. of Geology and Geophysics:

1. Nicholas Forbes, M.S. expected 2021, mentored by Prof. Koper
2. Guanning Pang, Ph.D. expected 2021, mentored by Prof. Koper
3. Monique Holt, Ph.D. expected 2022, mentored by Prof. Koper
4. Daniel Wells, Ph.D. expected 2022, mentored by Prof. Pankow
5. Alysha Armstrong, M.S. expected 2022, mentored by Prof. Koper

1e. Undergraduate Research Assistants

UUSS currently employs two undergraduate research assistants, both from the Dept. of Geology and Geophysics:

1. Boe Ericksen, B.S. expected 2021
2. Zachary Claerhout, B.S. expected 2022

2. Core Activities

2a. Operation and maintenance of Utah regional seismic network

UUSS operates and maintains a combined urban-regional network of 208 seismic stations (network code UU), which generate 680 distinct channels of data, to monitor Utah seismicity. The continuous digital data are archived locally at the UUSS Earthquake Information Center (EIC), as well as at the IRIS Data Management Center (DMC) in Seattle, WA, from which they are publicly available. The Utah network is designed to be robust with respect to power and telemetry failures. Redundancy is provided by six overlapping data collection nodes and 13 mountain-top relay sites. A hot-backup site for the UUSS EIC exists in Richfield, Utah, approximately 250 km south of Salt Lake City. Additional backup is provided by the USGS National Earthquake Information Center (NEIC) in Golden, CO, via the Denver Federal Center.

Since 2012, UUSS has used the ANSS Quake Monitoring System (AQMS) to detect and locate seismicity in the Utah region. In a typical year, UUSS locates over 1,500 earthquakes in the Utah region: 1 in the M4 range, 12 in the M3 range, and 130 in the M2 range, with 20 earthquakes reported as felt. For earthquakes larger than about M3.5, full moment tensors are estimated by inverting broadband, regional distance waveforms. UUSS also routinely computes ShakeMaps for events larger than M3. All earthquake information products are submitted to the ANSS Comprehensive Catalog (ComCat) and presented on the UUSS and/or USGS webpages.

2b. Operation and maintenance of Yellowstone regional seismic network

With additional support from the USGS Volcano Hazards Program, UUSS maintains a second seismic network in and around Yellowstone National Park (network code WY). Operations for the two networks are integrated, with both using the same instance of AQMS. The Yellowstone network is smaller than the Utah network (UUSS operates and maintains 30 stations corresponding to 106 channels in Yellowstone), however the seismicity rate is comparable to that in Utah. In a typical year, UUSS locates about 2,500 earthquakes in the Yellowstone region.

2c. Public service, outreach, and education

UUSS participates in public outreach in a variety of ways. Typical activities include:

- Providing tours of the UUSS facilities
- Deploying a traveling earthquake exhibit designed for schools, public institutions, and groups interested in earthquake preparedness.
- Radio, television, and print interviews with local, national, and international media
- Presentations to local community groups

Complete descriptions of outreach activities are compiled each year in the UUSS annual report. UUSS personnel also provide expert advice to various academic and governmental entities. The following list documents some of the current professional service activities of UUSS personnel:

- Chair of Utah Seismic Safety Commission (Prof. Koper)
- Member of Seismic Review Panel for U.S. Air Force (Prof. Koper)
- Editor-in-chief, *The Seismic Record* (Prof. Koper)
- Member of the Utah Mine Safety Technical Advisory Council (Prof. Pankow)
- Regional (IMW) coordinator of ANSS (Prof. Pankow)

2d. Scientific Research

UUSS scientists have a broad range of research interests revolving primarily around studies of seismic sources and Earth structure. UUSS scientists are involved in both applied and basic research and have a wide network of collaborators. Specific topics include:

- New methods of earthquake detection and location
- New methods of measuring earthquake magnitude
- New methods of array processing of seismic and infrasound data
- Analysis of the rupture properties of large earthquakes
- Discrimination of earthquakes from other seismic sources
- Characterization of induced earthquakes
- Dynamic earthquake triggering
- Statistical seismology, as it relates to earthquake sequences and in developing advanced traffic light systems
- Seismic hazard analysis
- Earthquake ground motion analysis
- Crustal structure of the Intermountain West Region
- Seismotectonics of the Intermountain West Region
- Volcano seismology, especially the Yellowstone region
- Analysis of ambient seismic noise
- Characterization of acoustic (infrasonic) signals generated by earthquakes, quarry blasts, and rocket motor detonations
- Deep earth structure, especially the core

Recent external awards and recent peer-reviewed journal publications that include UUSS personnel are documented in section 4.

3. Funding Model

UUSS has three sources of core funding that together make up 80–90% of the UUSS budget.

1. State of Utah appropriation
    a. Follows state fiscal year (FY), July 1 through June 30
    b. FY21 – $760,155; FY20 – $777,300; FY19 – $760,500
    c. About 85% personnel, 15% non-personnel
    d. Projected to fund 5.17 FTE in FY21
2. Cooperative agreement with the USGS Earthquake Hazards Program
    a. Follows project year (PY), Feb. 1 through Jan. 31
    b. PY22 – $844,459; PY21 – $811,200; PY20 – $811,200
    c. About 25% indirect costs, 67% personnel, 8% non-personnel
    d. Awarded semi-competitively in 5 year agreements, currently year 1 of 5
    e. Projected to fund 4.90 FTE in PY22
3. Cooperative agreement with the USGS Volcano Hazards Program
    a. Follows project year (PY), Feb. 1 through Jan. 31
    b. PY22 – $408,568; PY21 – $327,671; PY20 – $317,495
    c. About 25% indirect costs, 63% personnel, 12% non-personnel
    d. Awarded semi-competitively in 5 year agreements, currently year 5 of 5
    e. Projected to fund 2.07 FTE in PY22

UUSS supplements its core funding with awards from the Air Force Research Laboratory, the U.S. Department of Energy, Los Alamos National Laboratory, Sandia National Laboratory, the National Science Foundation, the National Institute of Occupational Safety and Hazard, the United States Geological Survey, and the Utah Division of Emergency Management. A list of recent external awards is presented in section 4. The total UUSS budget is approximately $2.5M per year.

4. Performance and Reporting

4a. Annual reports

UUSS produces formal annual reports on a calendar year cycle. The report for a given calendar year is usually available by the spring of the following year. Hard copies are distributed to a list of approximately 200 colleagues, university leaders, state governmental officials, USGS personnel, and alumni. The reports are also available electronically as PDF files. Reports for the years 2012–2017 are available from the UUSS website (*quake.utah.edu*).

4b. Quarterly seismicity reports

UUSS produces formal reports on seismic activity in Utah and Yellowstone on a quarterly basis. The reports include the detailed status of the two seismic networks. The reports for a given quarter are generally available before the end of the following quarter. The reports are distributed electronically and are available from the UUSS website (*quake.utah.edu*).

4c. State of Utah metrics

UUSS has three performance indicators that are tied to the UUSS mission statement:

1. Timeliness of response to earthquakes in the Utah region (public service)
2. Publications and presentations related to earthquakes (research & education)
3. External funds raised to support the UUSS mission (research, education, & public service)

The three corresponding performance targets are:

1. For 100% of earthquakes with magnitude (M) 3.5 or greater that occur in the Utah region UUSS will transmit an alarm to the Utah Department of Emergency Management within 5 minutes and post event information to the web within 10 minutes.
2. Each year UUSS researchers will publish at least five papers in peer-reviewed journals, make at least 10 presentations at professional meetings, and make at least 10 oral presentations to local stakeholders.
3. Each year UUSS will generate external funds that equal or exceed the amount provided by the State of Utah.

4d. Publications

The following list contains 39 publications in peer-reviewed academic journals with at least one UUSS scientist as author or co-author. The list is in reverse chronological order for 2018–present. UUSS personnel and student affiliates are indicated with bold font. UUSS personnel also routinely contribute to project reports, conference proceedings, and other professional

publications, many of which are peer-reviewed. All UUSS publications, including meeting abstracts, are documented in the annual reports.

—2021 Peer-Reviewed Journal Publications (7)—

39. **Holt, J., K. M. Whidden, K. D. Koper, K. L. Pankow**, K. Mayeda, **J. C. Pechmann**, **B. Edwards**, R. Gök, and W.R. Walter (2021). Towards robust and routine determination of Mw for small earthquakes: Application to the 2020 Mw 5.7 Magna, Utah, seismic sequence, *Seism. Res. Lett.*, in press.
38. **Baker, B., M. M. Holt, K. L. Pankow, K. D. Koper,** and **J. Farrell** (2021). Monitoring the 2020 Magna, Utah earthquake sequence with nodal seismometers and machine learning, *Seism. Res. Lett.*, in press.
37. Tibi, R., P. Hammond, R. Brogan, C. J. Young, and **K. D. Koper** (2021). Deep learning denoising applied to regional distance seismic data in Utah, *Bull. Seism. Soc. Am.*, in press.
36. **Koper, K. D., M. M. Holt, J. R. Voyles, R. Burlacu**, M. L. Pyle, R. Wang, and B. Schmandt (2021). Discrimination of small earthquakes and buried single-fired chemical explosions at local distances (<150 km) in the Western U. S. from comparison of local magnitude (M_L) and coda duration magnitude (M_C), *Bull. Seismol. Soc. Am.*, doi:10.1785/0120200188.
35. **Mesimeri, M., H. Zhang, and K. L. Pankow** (2021). Backprojection imaging of the 2020 Mw 5.5 Magna, Utah, earthquake using a local dense strong-motion network, *Seism. Res. Lett.*, doi:10.1785/0220200326.
34. **Pankow, K. L.,** E. A. Vanacore, and S. Barrientos (2021). Preface to the focus section on seismic monitoring during crises, *Seism. Res. Lett., 92*, 3–5, doi:10.1785/0220200405.
33. **Pankow, K. L.**, **J. Rusho, J. C. Pechmann, J. M. Hale, K. Whidden, R. Sumsion, J. Holt, M. Mesimeri, D. Wells, and K. D. Koper** (2021). Responding to the 2020 Salt Lake Valley, Utah, earthquake sequence during the COVID-19 pandemic shutdown, *Seism. Res. Lett.*, *92*, 6–16, doi:10.1785/0220200265.

—2020 Peer-Reviewed Journal Publications (12)—

32. Stabile, T. A., A. P. Rinaldi, and **K. Pankow** (2020). Preface to the special issue "Induced seismicity: observations, monitoring, and risk management strategies", *J. Seismol., 24*, 917–919, doi:10.1007/s10950-020-09956-x.
31. Alfaro-Diaz, R., A. A. Velasco, **K. L. Pankow**, D. Kilb (2020). Optimally oriented remote triggering in the Coso geothermal region, *J. Geophys. Res., 125*, e2019JB019131, doi:10.1029/2019JB019131.
30. **Pankow, K.**, and D. Kilb (2020). Going beyond rate changes as the sole indicator for dynamic triggering of earthquakes, *Sci. Rep., 10*, 4120, doi:10.1038/s41598-020-60988-2.
29. Russo, E., A. Tibaldi, G. P. Waite, F. L. Bonali, F. Massin, and **J. Farrell** (2020). Unraveling the complex deformation pattern at Yellowstone plateau through seismicity and fracture analysis, *Tectonics, 778*, doi:10.106/j.tecto.2020.228352.
28. **Pang, G., K. D. Koper, M. Mesimeri, K. L. Pankow, B. Baker, J. Farrell, J. Holt, P. Roberson, R. Burlacu, J. C. Pechmann, K. Whidden, M. M. Holt**, A. Allam, and C. DuRoss (2020). Seismic analysis of the 2020 Magna, Utah, earthquake sequence: Evidence for a listric Wasatch fault, *Geophys. Res. Lett., 47*, e2020GL089798, doi:10.1029/2020GL089798.
27. Johnson, S. A., D. J. A. Chambers, M. S. Boltz, and **K. D. Koper** (2020). Application of a convolutional neural network for seismic phase picking of mining-induced seismicity, *Geophys. J. Inter.*, *224*, 230–240, doi:10.1093/gji/ggaa449.
26. Anthony, R. E., A. T. Ringler, D. C. Wilson, M. Bahavar, and **K. D. Koper** (2020). How processing methodologies can distort and bias power spectral density estimates of seismic background noise, *Seism. Res. Lett., 91*, 1694–1706, doi:10.1785/0220190212.
25. **Pankow, K. L.**, M. Stickney, J. Y. Ben-Horin, M. Litherland, S. Payne, **K. D. Koper**, S. L. Bilek, and K. Bogolub (2020). Regional seismic network monitoring in the eastern Intermountain West, *Seism. Res. Lett.*, *91*, 631–646, doi:10.1785/0220190209.
24. **Voyles, J., M. M. Holt**, **J. M. Hale**, **K. D. Koper**, **R. Burlacu**, and D. J. A. Chambers (2020). A new catalog of explosion source parameters in the Utah region with application to M_L-M_C based depth discrimination at local distances, *Seism. Res. Lett.*, *91*, 222–236, doi:10.1785/0220190185.
23. **Wu, S.-M.**, F.-C. Lin, **J. Farrell**, B. Shiro, L. Karlstrom, P. Okubo, and **K. D. Koper** (2020). Spatiotemporal seismic structure variations associated with the 2018 Kilauea eruption based on temporary dense geophone arrays, *Geophys. Res. Lett.*, *47*, e2019GL086668, doi:10.1029/2019GL086668.

22. Xu, Y., **K. D. Koper**, **R. Burlacu**, R. B. Herrmann, and D.-N. Li (2020). A new uniform moment tensor catalog for Yunnan, China, from January 2000 through December 2014, *Seism. Res. Lett.*, *91*, 891–900, doi:10.1785/0220190242.
21. **Pankow, K. L.**, M. Stickney, J. Y. Ben-Horin, M. Litherland, S. Payne, **K. D. Koper**, S. L. Bilek, and K. Bogolub, (2019). Regional seismic monitoring in the Eastern Intermountain West, *Seism. Res. Lett.*, 91, 631–646, doi:1785/0220190209.2.

—2019 Peer-Reviewed Journal Publications (8)—

20. **Holt, M. M.**, **K. D. Koper**, W. Yeck, S. D'Amico, Z. Li, **J. M. Hale**, and **R. Burlacu** (2019). On the portability of M_L-M_C as a depth discriminant for small seismic events recorded at local distances, *Bull. Seismol. Soc. Am.*, *109*, 1661–1673.
19. **Koper, K. D.** (2019). The importance of regional seismic networks in monitoring nuclear test-ban treaties, *Seism. Res. Lett.*, doi:10.1785/0220190160.
18. Linville, L., **K. L. Pankow**, T. Draelos, C. J. Young, and S. Alvarez (2019). Leveraging long-term seismic catalogs for automated real-time event classification, *Geophys. Res. Lett., 46*, 3643–3651, doi:10.1029/2018GL081119.3.
17. **Pang, G.**, **K. D. Koper**, **J. M. Hale**, **R. Burlacu**, **J. Farrell**, and R.B. Smith (2019). The 2017–2018 Maple Creek earthquake sequence in Yellowstone National Park, USA, *Geophys. Res. Lett., 46*, 4653–4663, doi:10.1029/2019GL082376.
16. Schmandt, B., C. Jiang, and **J. Farrell** (2019). Seismic perspectives from the western U.S. on magma reservoirs underlying large silicic calderas, *J. Volcanol. Geotherm. Res., 384*, 158–178, doi:10.1016/j.volgeores.2019.07.015.
15. Wu, S.M., F.C. Lin, **J. Farrell**, and A. Allam (2019). Imaging the deep subsurface plumbing of Old Faithful geyser from low-frequency hydrothermal tremor migration, *Geophys. Res. Lett., 46*, 7315–7322, doi:10.1029/2018GL081771.
14. Ye, L., T. Lay, H. Kanamori, and **K. D. Koper** (2019). Reply to: Comment by Rodrigo Cienfuegos on "Rapidly Estimated Seismic Source Parameters for the 16 September 2015 Illapel, Chile, M_w 8.3 Earthquakes" by Lingling Ye, Thorne Lay, Hiroo Kanamori, and Keith D. Koper, *Pure Appl. Geophys.,* 176, 2753, doi:10.1007/s00024-019-02214-3.
13. **Zhang, H.**, **K. L. Pankow**, and W. Stephenson (2019). A Bayesian Monte-Carlo inversion of spatial auto-correlation (SPAC) for near surface Vs structure applied to both broadband and geophone data, *Geophy. J. Int., 217*, 2056–2070, https://doi.org/10.1093/gji/ggz136.

—2018 Peer-Reviewed Journal Publications (12)—

12. Arrowsmith, S., C. Young, and **K. Pankow** (2018). Implementation of the waveform correlation event detection system (WCEDS) method for regional seismic event detection in Utah, *Bull. Seism. Soc. Am., 108*, 3348–3561, doi:10.1785/0120180097.5.
11. Attanayake, J., C. Thomas, V. F. Cormier, M. S. Miller, and **K. Koper** (2018). Irregular transition layer beneath the Earth's inner core boundary from observations of antipodal PKIKP and PKIIKP waves, *Geochem. Geophys. Geosyst., 19,* 3607–3622*,* doi:10.1029/2018GC007562.
10. **Farrell, J.**, S. M. Wu, K. M. Ward, and F. C. Lin (2018). Persistent noise signal in the FairfieldNodal three-component 5-Hz geophones, *Seism. Res. Lett., 89*(5), 1609–1617, doi:10.1785/0220180073.
9. Jiang, C., B. Schmandt, **J. Farrell**, F. C. Lin, and K. M. Ward (2018). Seismically anisotropic magma reservoirs underlying silicic calderas, *Geology, 46(*8), 727–730, doi:10.1130/G45104.1.
8. Jiang, C., B. Schmandt, S. M. Hansen, S. Dougherty, R. W. Clayton, **J. Farrell**, and F.-C. Lin (2018). Rayleigh and S wave tomography constraints on subduction termination and lithospheric foundering in central California, *Earth Planet. Sci. Lett., 488*, 14–26, doi:10.1016/j.epsl.2018.02.009.
7. Kilb, D. L., A. Yang, N. Garrett, **K. Pankow**, J. Rubinstein, and **L. M. Linville** (2018). Tilt Trivia: A free multiplayer app to learn geoscience concepts and definitions, *Seism. Res. Lett., 89*, 1908–1915, doi:10.1785/0220180049.
6. **Koper, K. D.**, **K. L. Pankow**, **J. C. Pechmann**, **J. M. Hale**, **R. Burlacu**, W. L. Yeck, H. M. Benz, R. B. Herrmann, D. T. Trugman, P. M. Shearer (2018). Afterslip enhanced aftershock activity during the 2017 earthquake sequence near Sulphur Peak, Idaho, *Geophys. Res. Lett., 45*, 5352–5361, doi:10.1029/2018GL078196.6.
5. **Linville, L.**, **K. L. Pankow**, and D. Kilb (2018). Contour-based earthquake detection using Transportable Array data, *Seism. Res. Lett., 89*, 1514–1523, doi:10.1785/0220170242.7.

4. **Pang, G.**, **K. D. Koper**, M. C. Stickney, **J. C. Pechmann**, **R. Burlacu**, **K. L. Pankow**, S. Payne, and H. M. Benz (2018). Seismicity in the Challis, Idaho region, January 2014 – May 2017: Late aftershocks of the 1983 MS7.3 Borah Peak earthquake, *Seism. Res. Lett., 89*, 1366–1378, doi:10.1785/0220180058.
3. Tibi, R., **K. D. Koper**, **K. L. Pankow**, and C. Y. Young (2018). Discrimination of anthropogenic events and tectonic earthquakes in Utah using a quadratic function approach with local-distance amplitude ratios, *Bull. Seism. Soc. Am., 108*, 2788–2800, doi:10.1785/0120180024.11.
2. Tibi, R., **K. D. Koper**, **K. L. Pankow**, and C. Y. Young (2018). Depth discrimination using Rg-to-Lg amplitude ratios for seismic events in Utah recorded at local distances, *Bull. Seism. Soc. Am., 108*, 1355–1368, doi:10.1785/0120170257.
1. **Trow, A. J., H. Zhang, A. S. Record, K. A. Mendoza, K. L. Pankow**, P. E. Wannamaker (2018). Microseismic event detection using multiple geophone arrays in southwestern Utah, *Seism. Res. Lett., 89*, 1660–1670, doi:10.1785/0220180065.8.

4e. External Funding

The following list documents external awards in which a UUSS scientist was either PI, co-PI, or co-I for external awards with start dates between 2018 and 2021. UUSS personnel are indicated with bold font. Agency acronyms are listed in section 6. The USGS cooperative agreements pay the reduced UU indirect rate for public service (36.5%), while all other awards pay the full UU indirect rate (52.5%). Total external research expenditures for UUSS during 2018–2020 were $4.27M.

—2021 Start Dates—

Deferred Maintenance: Regional and Urban Seismic Monitoring: Wasatch Front, Utah, and Neighboring Intermountain West Region, DOI USGS, G20AC00036, Jul. 1, 2020–Jun. 30, 2021, $102,000, (**Koper**, PI; **Pankow,** co-PI)

Geophysical Monitoring and Characterization of the Utah Region, DOE Sandia National Laboratory, 2200945, Oct. 1, 2020–Sept. 30, 2021, $122,113, (**Koper,** PI; **Pankow,** co-PI**)**

Modeling and Observing the Effect of Source Depth on Seismic Waveforms Recorded at Local Distances for Purposes of Source Class, AFRL, FA9453-20-2-0034, Jul. 1, 2020–Jun. 30, 2012, $369,971, (**Koper,** PI)

—2020 Start Dates—

Regional and Urban Seismic Monitoring: Wasatch Front, Utah, and Neighboring Intermountain West Region, DOI USGS, G20AC00036, Feb. 1, 2020–Jan. 31, 2021, $811,200, (**Koper**, PI; **Pankow** co-PI)

Operation and Maintenance of the Yellowstone Regional Seismic Network and Earthquake Information System, DOI USGS, G16AC00029, Feb. 1, 2020–Jan. 31, 2021, $327,671, (**Koper**, PI; **Farrell**, co-PI)

Temporal Characteristics of Aftershock Sequences in the Intermountain West, DOI USGS, G20AP00028, Jan. 1, 2020–June 30, 2021, $48,009, (**Pankow**, PI)

Collaborative Research: Controlled Source Seismic Investigation of the Top of the Yellowstone Magmatic System, NSF, 1950331, Mar. 15, 2020–Feb. 28, 2022, $196,458, (**Farrell**, PI)

—2019 Start Dates—

Regional and Urban Seismic Monitoring: Wasatch Front, Utah, and Neighboring Intermountain West Region, DOI USGS, G15AC00028, Feb. 1, 2019–Jan. 31, 2020, $811,200, (**Koper**, PI; **Pankow,** co-PI)

Operation and Maintenance of the Yellowstone Regional Seismic Network and Earthquake Information System, DOI USGS, G16AC00029, Feb. 1, 2019–Jan. 31, 2020, $317,495, (**Koper**, PI; **Farrell**, co-PI)

Regional and Urban Seismic Monitoring: Wasatch Front, Utah, and Neighboring Intermountain West Region, DOI USGS, G15AC00028, Sept. 1, 2019–April 20, 2020, $157,000, (**Koper**, PI; **Pankow,** co-PI)

Enhanced Geothermal System Testing and Development at the Milford, Utah FORGE (Phase 3), DOE, National Energy Technology Laboratory, DE-FOA-DEEE0007080, 2019–2023, $142M (Total Project) (**Pankow**, Co-I)

—2018 Start Dates—

Geophysical Monitoring and Characterization of the Utah Region, DOE Sandia National Laboratory, 1885590, Jan. 31, 2018–Sept. 30, 2020, $173,000 (**Koper**, PI; **Pankow,** co-PI)

Regional and Urban Seismic Monitoring: Wasatch Front, Utah, and Neighboring Intermountain West Region, DOI USGS, G15AC00028, Feb. 1, 2018–Jan. 31, 2019, $780,000, (**Koper**, PI; **Pankow,** co-PI)

Operation and Maintenance of the Yellowstone Regional Seismic Network and Earthquake Information System, DOI USGS, G16AC00029, Feb. 1, 2018–Jan. 31, 2019, $316,536, (**Koper**, PI; **Farrell**, co-PI)

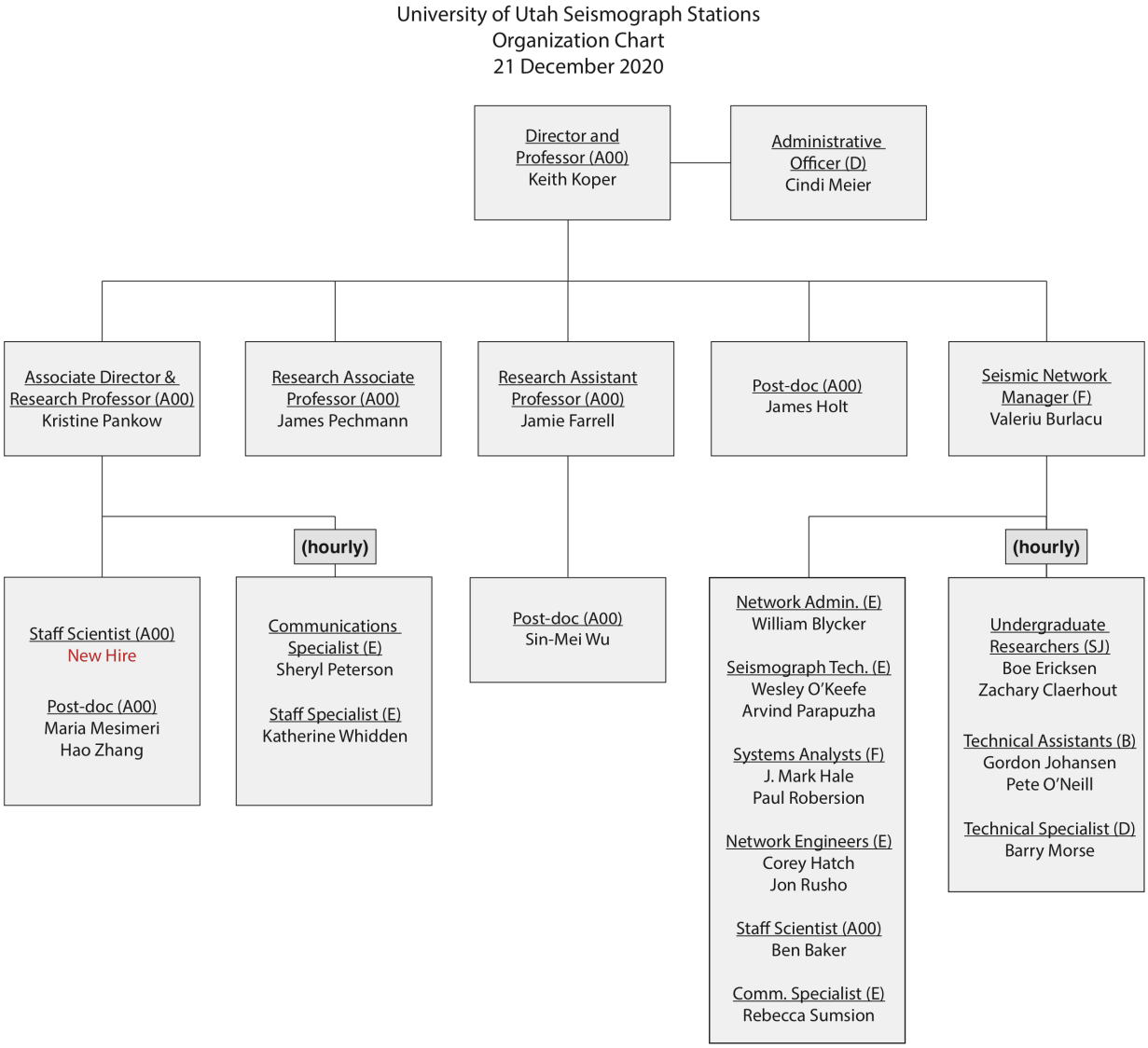
The Origin and Propagation of Shallow Water Microseisms: A Multidisciplinary Study at Yellowstone Lake, NSF, 1760094, May 21, 2018–May 31, 2021, $93,258 (**Farrell**, PI; **Koper,** co-PI)

Regional and Urban Seismic Monitoring: Wasatch Front, Utah, and Neighboring Intermountain West Region, DOI USGS, G15AC00028, Oct. 1, 2018–Sept. 30, 2019, $170,000, (**Koper**, PI; **Pankow,** co-PI)

Enhanced Geothermal Testing and Development Milford, Utah FORGE Site (Phase 2b), DOE, National Energy Technology Laboratory, DE-FOA-0000890, 2018–2020, $368,750 (UUSS part) (**Pankow**, co-I)

Structurally Controlled Geothermal Systems in the Eastern Great Basin Extensional Regime, Utah (Phase 3), DOE, National Energy Technology Laboratory, DE-FOA-DEEE0006732, 2018–2019, $52,505 (UUSS Part) (**Pankow**, Co-I)

5. Organizational Chart



Graduate student affiliates are not listed in this chart.

The University of Utah effective FTE count for UUSS is 21.85 as of 12 January 2021.

6. Acronyms and Abbreviations

AFRL – Air Force Research Laboratory
ANSS – Advanced National Seismic System
CMES – College of Mines and Earth Sciences
co-I – co-Investigator
co-PI – co-Principal Investigator
DOE – U.S. Department of Energy
EHP – Earthquake Hazards Program in the USGS
EIC – Earthquake Information Center at UU
FY – Fiscal Year
FTE – Full Time Equivalent (employee)
GG – Department of Geology and Geophysics
IRIS – Incorporated Research Institutions for Seismology
IRIS DMC – IRIS Data Management Center
LANL – Los Alamos National Laboratory
NIOSH – National Institute of Occupational Safety and Health
NSF – National Science Foundation
PI – Principal Investigator
PY – Project Year
UGS – Utah Geological Survey
USGS – United States Geological Survey
UU – University of Utah
UUSS – University of Utah Seismograph Stations
VHP – Volcano Hazards Program in the USGS