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The 2018 Dynamic Networks Data Processing and Analysis Experiment (DNE18)

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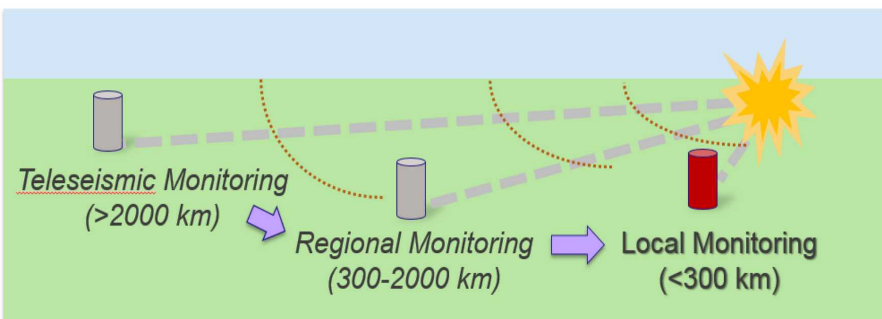
1. The Challenge: Local Distance Monitoring



To monitor for smaller explosions in support of the Comprehensive Test Ban Treaty (CTBT) (The Treaty, 2016), it is necessary to transition from regional distance monitoring to local distance monitoring due to the attenuation of signals as they propagate through the solid Earth or atmosphere.

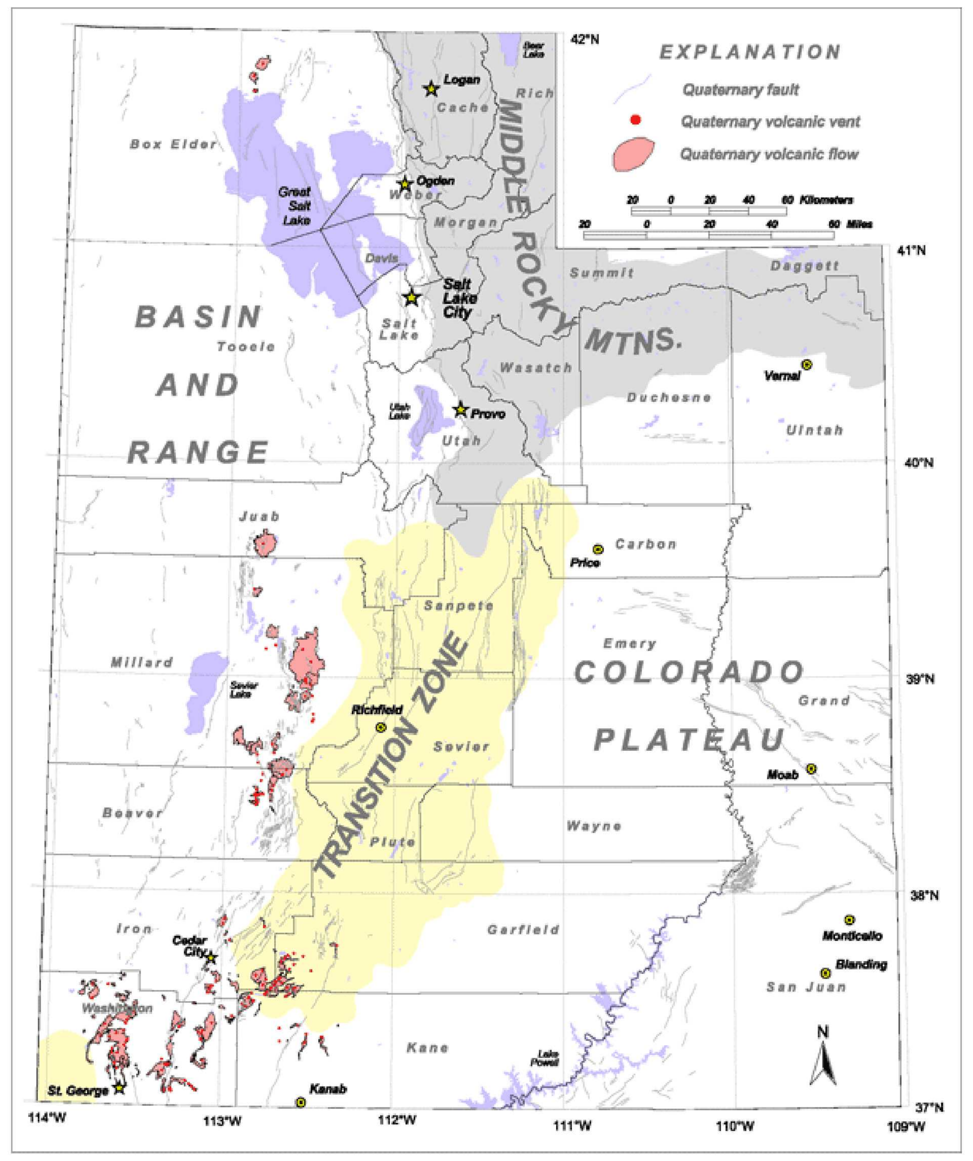
Historically, nuclear explosion monitoring has been done using dedicated sensor networks at significant standoff distances, such as the International Monitoring System (IMS, see Monitoring Regime, 2016). To monitor at local distances implies augmenting those traditional networks with openly available data from other sensor networks, hence we have introduced the idea of "dynamic networks" that change by region and by time according to the available data.

The nuclear explosion treaty monitoring R&D groups at Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories are improving existing monitoring methods and exploring new ones with goal of finding the best ways to process dynamic networks data to lower event detection and characterization thresholds.

3. Why Utah?

For multiple reasons, Utah was selected as the monitoring region between December 1, 2010 - February 28, 2011.

✔ Tectonically Complex



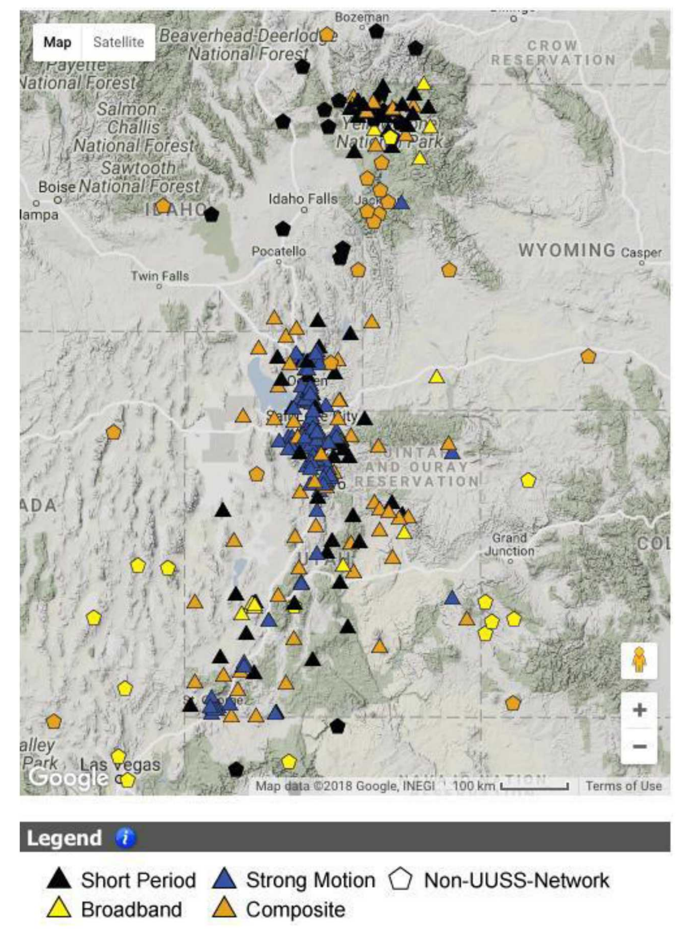
Physiographic provinces, Quaternary faults, Quaternary volcanic rocks, and Quaternary volcanic vents in Utah (after Stokes, 1977; Hecker, 1993, and Black and others, 2000).

Figure from the Utah Geologic Survey website.

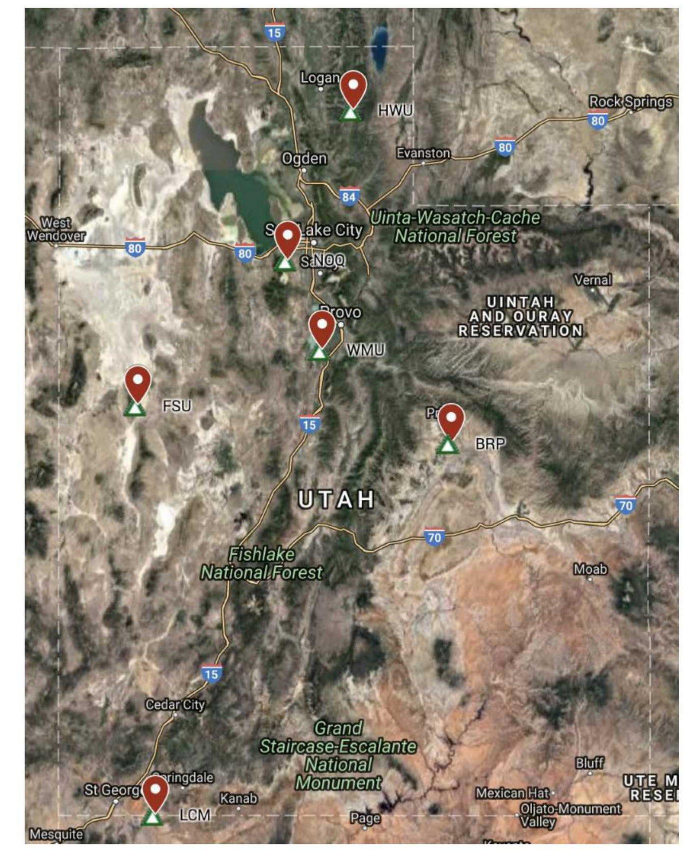
Utah is tectonically complex, consisting of parts of three distinct physiographic provinces: the Basin and Range, the Middle Rocky Mountains, and the Colorado Plateau. The important implication for monitoring is that signal propagation characteristics will be complex, potentially requiring the use of sophisticated models.

✔ Good Seismic and Infrasound Sensor Coverage

Seismic Sensors

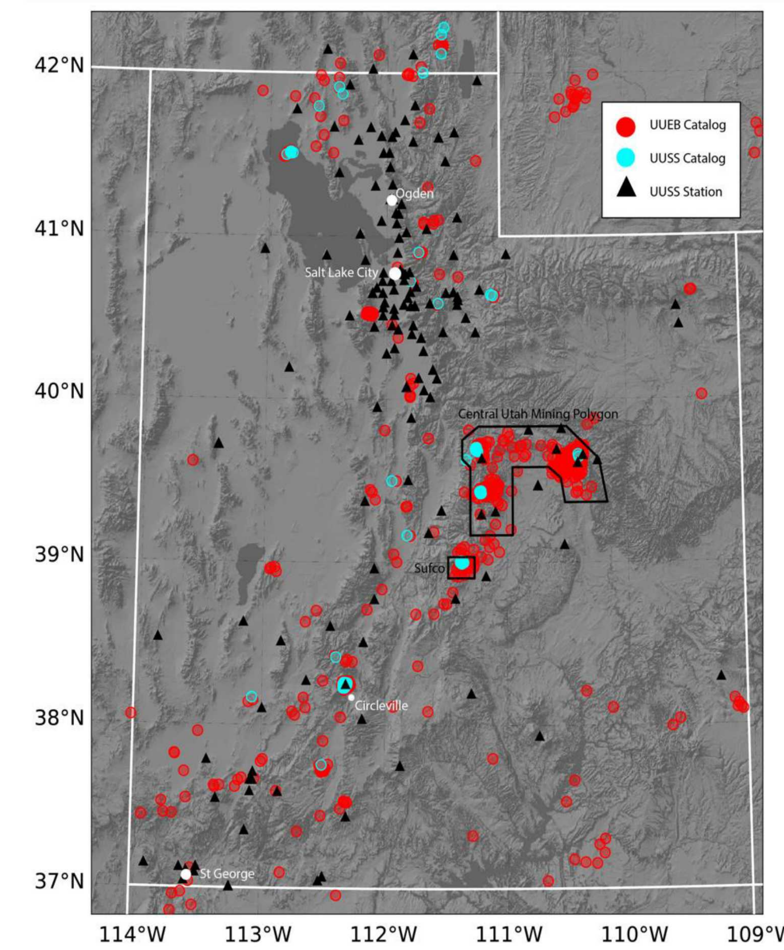


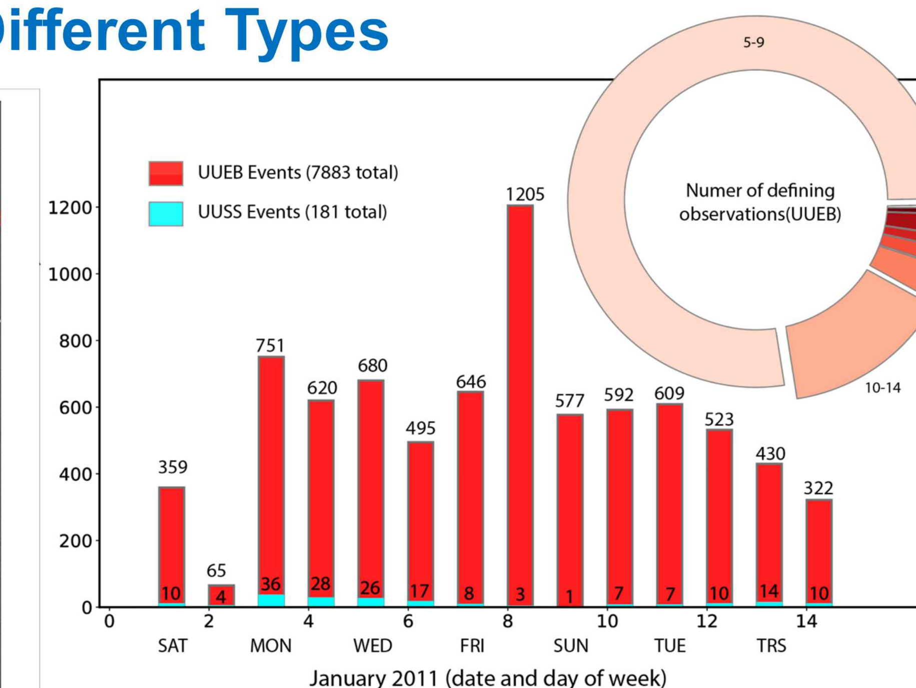
Infrasound Sensors



The University of Utah operates a dense seismic network (the University of Utah Seismograph Stations network with 182 stations) that includes short-period, broadband, and strong motion sensors spanning the state. During the DNE18 time interval there were 6 infrasound arrays deployed, an unusually high number for such a small region. The large numbers of both types of sensors provide opportunities to investigate optimal and minimal numbers and locations of sensors needed to achieve monitoring goals.

✔ Numerous Events of Different Types



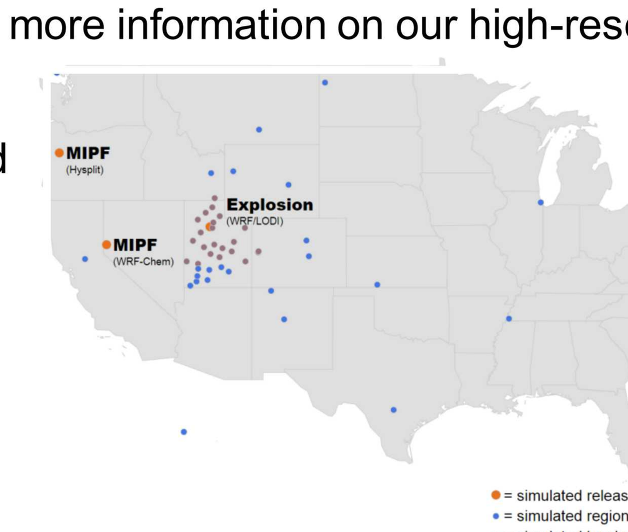


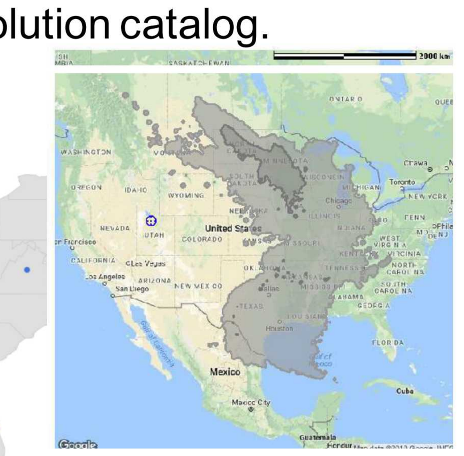
Utah has many seismic events, both natural (earthquakes) and anthropogenic (primarily mining related). The earthquakes primarily follow the N-S trending Intermountain Seismicity Belt; mining events include both shallow blasts and mining induced "earthquakes" related to coal mining in the central part of the state.

Though the University of Utah processes the UUSS data to produce an event catalog for monitoring earthquake hazard, they do not attempt to build all the very small events that are of potential interest to us, so an expert analyst manually scanned continuous waveform data for Jan 1-14, 2011 and built all events seen at more than 3 stations, regardless of magnitude. This time period included an aftershock sequence near the southern Utah town of Circleville due to a M_w 4.7 event that occurred on January 3, 2011. See Linville et al. 2019 for more information on our high-resolution catalog.

✘ Radionuclide and Electromagnetic Data

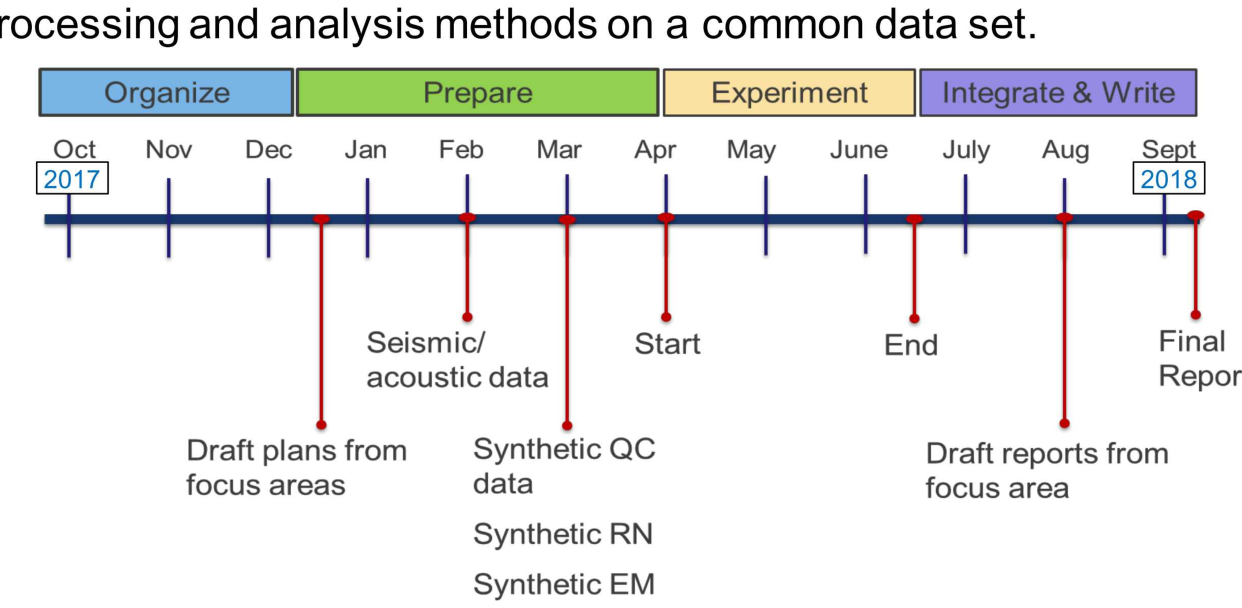
Our monitoring research focuses on combining multiple sensing modalities, including radionuclide (RN) and electromagnetic (EM). There were no real RN or EM data sets available for Utah during this time period, so it was necessary to simulate both types of data. An explosion event that was coincident with a large shallow mining blast event that occurred at the Bingham Canyon Mine south of Salt Lake City on January 11, 2011, was used as the source term for each data simulation. Tying the radionuclide simulations to that location and time required complex atmospheric transport modeling and detailed information about the atmospheric conditions at that time, as well as a detailed model of the terrain. The simulation included nuisance signals from medical isotope production facilities.





2. The DNE18 Experiment

To assess current local monitoring capabilities, identify gaps, and target and prioritize future work, the labs jointly organized the 2018 Dynamic Networks Experiment, during which 46 researchers from all 4 labs focused their data processing and analysis methods on a common data set.



4. Focus Areas

To group related R&D projects and facilitate comparison, 4 data processing and analysis focus areas for DNE18 were identified:

Data QC | Signal Detection | Event Building | Event Identification

For each of these focus areas, a leader was designated and charged with: 1) determining which lab R&D projects should be included, 2) developing a common set of metrics, 3) providing guidance on desired standardization (e.g. format of data processing products), 4) setting up and leading regular coordination meeting, 5) integrating the individual results after the experiment was over, and 6) providing a written summary report to the overall DNE18 leaders for integration into the DNE18 Final Report, which spans all the focus areas.

5. Summary

DNE18 was a quad-lab data processing and analysis experiment to evaluate current monitoring capabilities for smaller explosions using dynamically changing, hybrid networks of whatever sensors are openly available. The ultimate purpose of DNE18 was to help target and prioritize future treaty monitoring work at the labs. In total, the experiment involved 46 researchers and took almost a year from initial planning to the production of the DNE18 Final Report. Several of the individual DNE18 capability evaluations are described in other posters in this session.

Beyond the scientific results, the most successful aspects of the experiment were the extensive planning and coordination, the careful selection and preparation of a common data set (which both minimized researcher time spent wrangling with data and facilitated comparison of results), and the grouping of related research into focus areas, which not only facilitated comparison of results but also helped establish a greater cohesion across the lab treaty monitoring R&D groups.

References

1. The Treaty (2018). Retrieved from https://www.ctbto.org/the-treaty/
2. Station Profiles (2018). Retrieved from https://www.ctbto.org/verification-regime/station-profiles/
3. Linville, L., R. Brogan, C. Young, and K. Aur (2019). *Global to local scale high-resolution event catalogs for algorithm testing and source studies*, submitted to Seismological Research Letters.

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