www.crewes.org

The application of deconvolution to continuously recorded passive seismic data: results from a passive microseismic data set near Fox Creek, Alberta

R. M. Weir , R. Salvage, D. C. Lawton , and L. R Lines

This report is a follow up from a report submitted for the last MIC conference in 2018. Continuously recorded data has the following issues:

i. Along with the desired signal, passive seismic data often contains noise generated from traffic, pipelines, human activity, as well as the sensor itself.

ii. the raw data may also contain high frequencies, which are beyond the bandwidth of recorded seismic events

iii. Crossfeed between horizontal and vertical channels (coupling of signal or noise from horizontal to vertical)

Here we tested the effectiveness of seismic processing the raw as applied to seismic event detection on continuously recorded data. We applied:

i. Deconvolution, filtering and scaling applied to the vertical channels

ii. Filtering and scaling applied to the horizontal channels

Preliminary results suggest a significant increase in the number of detected events, when compared with input data that had only undergone pre-filtering.

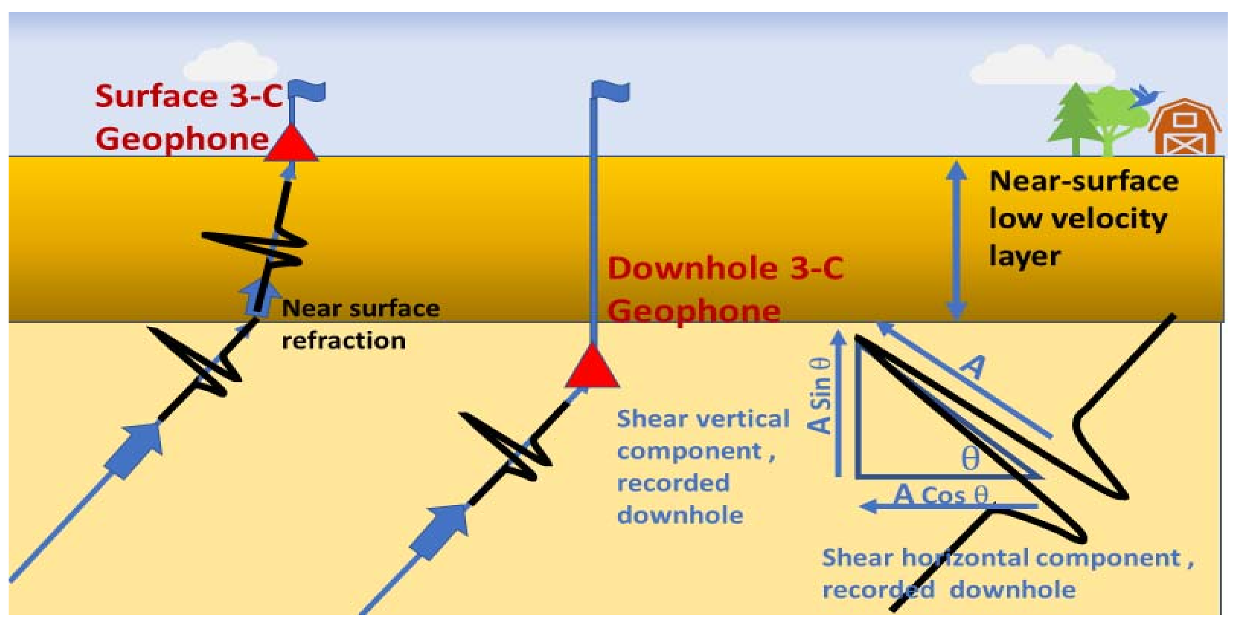


Figure 1. An illustration of how the near surface layer effects the Geophone recording at surface, as compared to buried geophones. Buried geophones record all components of the incoming wavefield

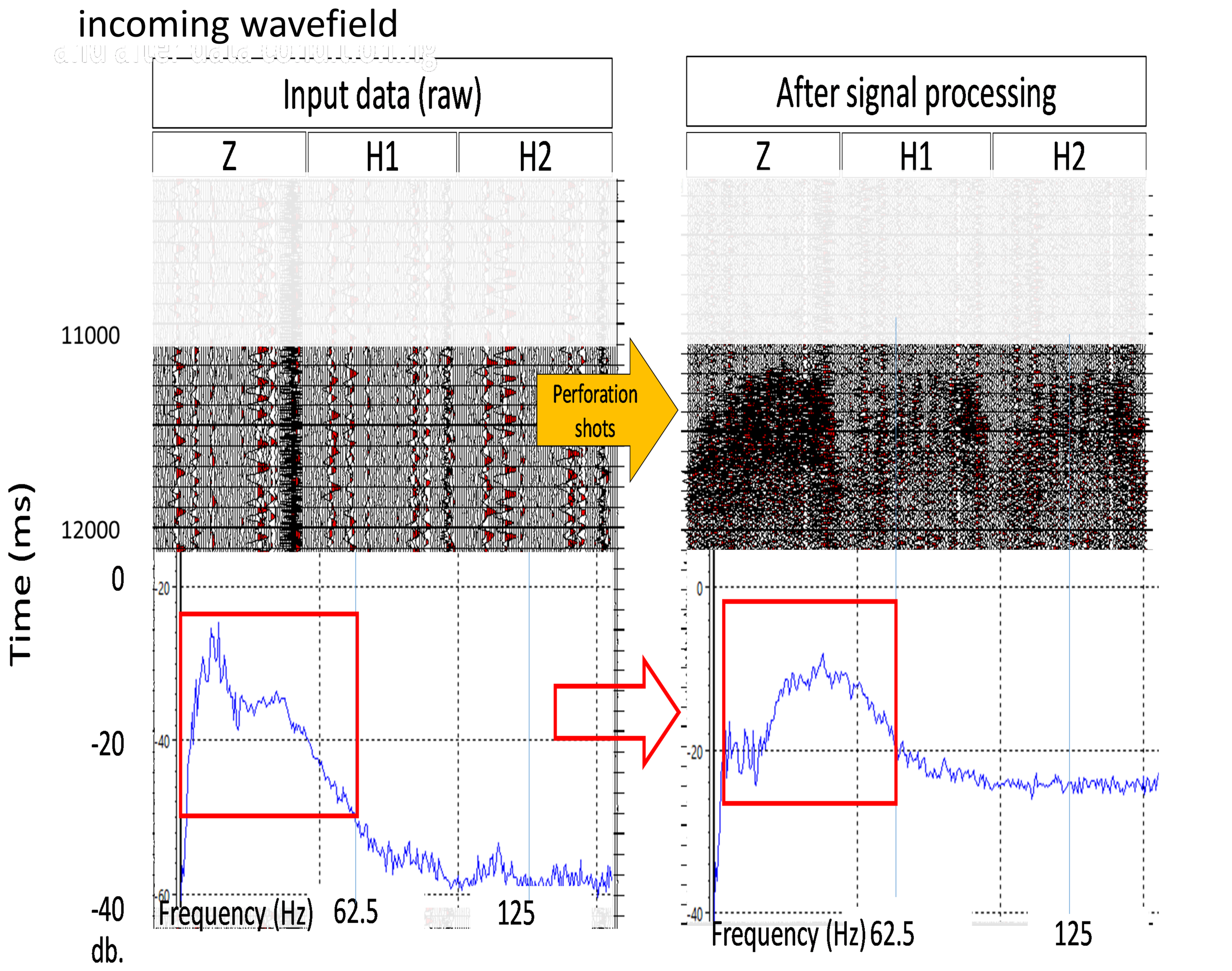


Figure 2. Deconvolution test. This record shows the effect of a spiking deconvolution of a raw record acquired during a perforation shot. The peroration shot is viable on the wiggle trace display after deconvolution. The spectrum of the record has been flattened, with frequencies up to 65 hz. Recovered.

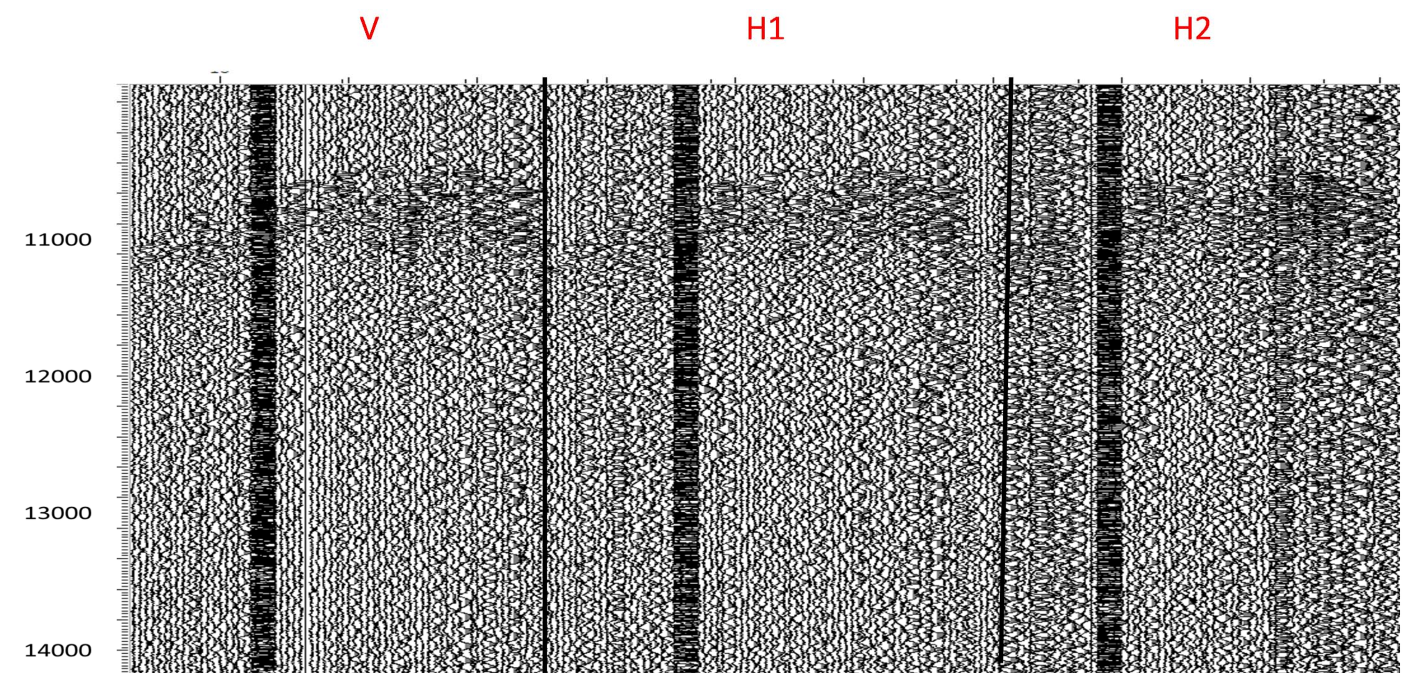


Figure 3. Raw input data from a 60 second seismic record} This record shows P and S waves arriving on both the horizontal (H1, H2) and vertical channels (V) (cross-feed). The geophones were buried at 27m, beneath the surface and therefore were below the low velocity layer present the subsurface. The buried geophones will record all components of the signal, surface phones have the surface effect to separate the P and S signals.

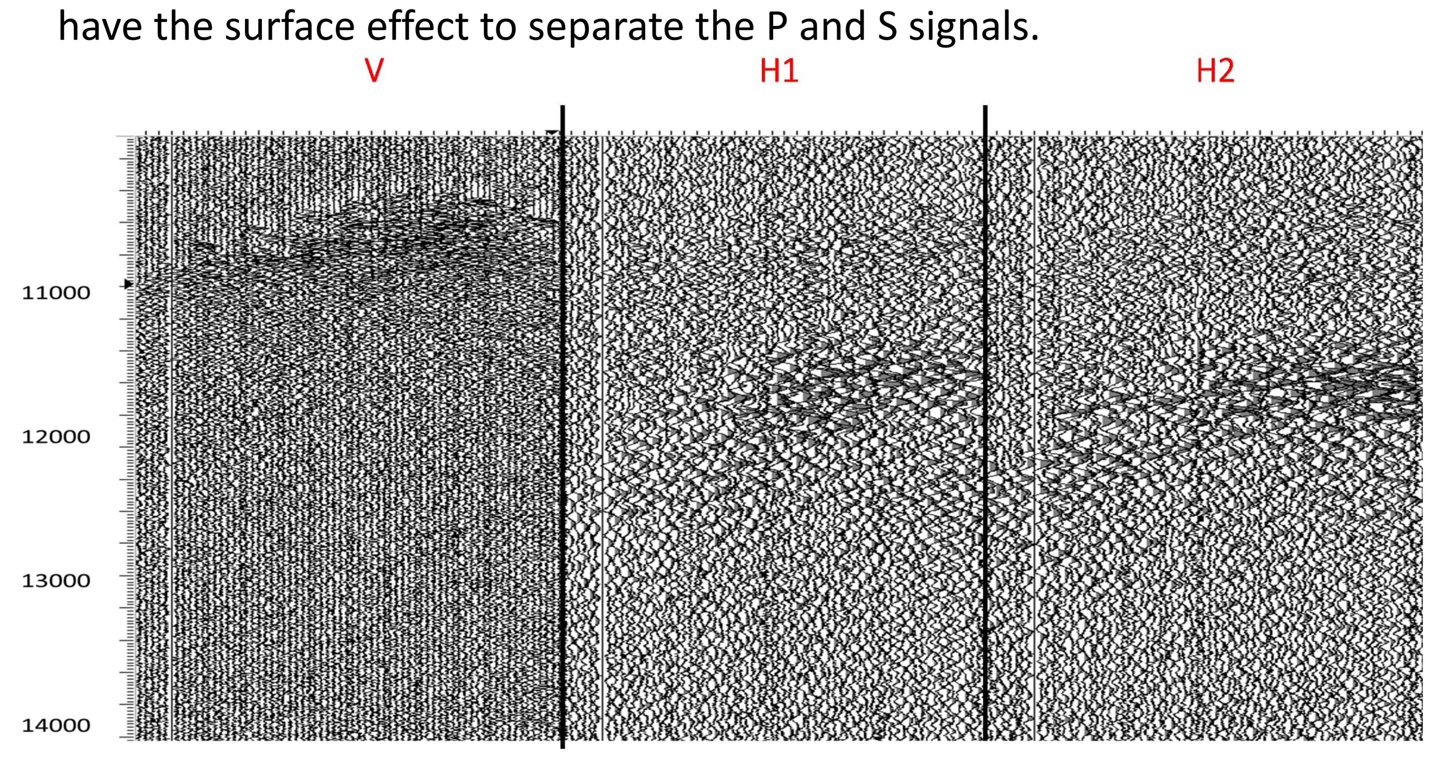


Figure 4. Record 24006 processed using deconvolution , filtering and scaling on the vertical channel (V). A 0-15 Hz. filter along with a trace equalization scalar was applied to the H1 and H2 channels. This is what was used for the entire data set, and passed on to REDPy.

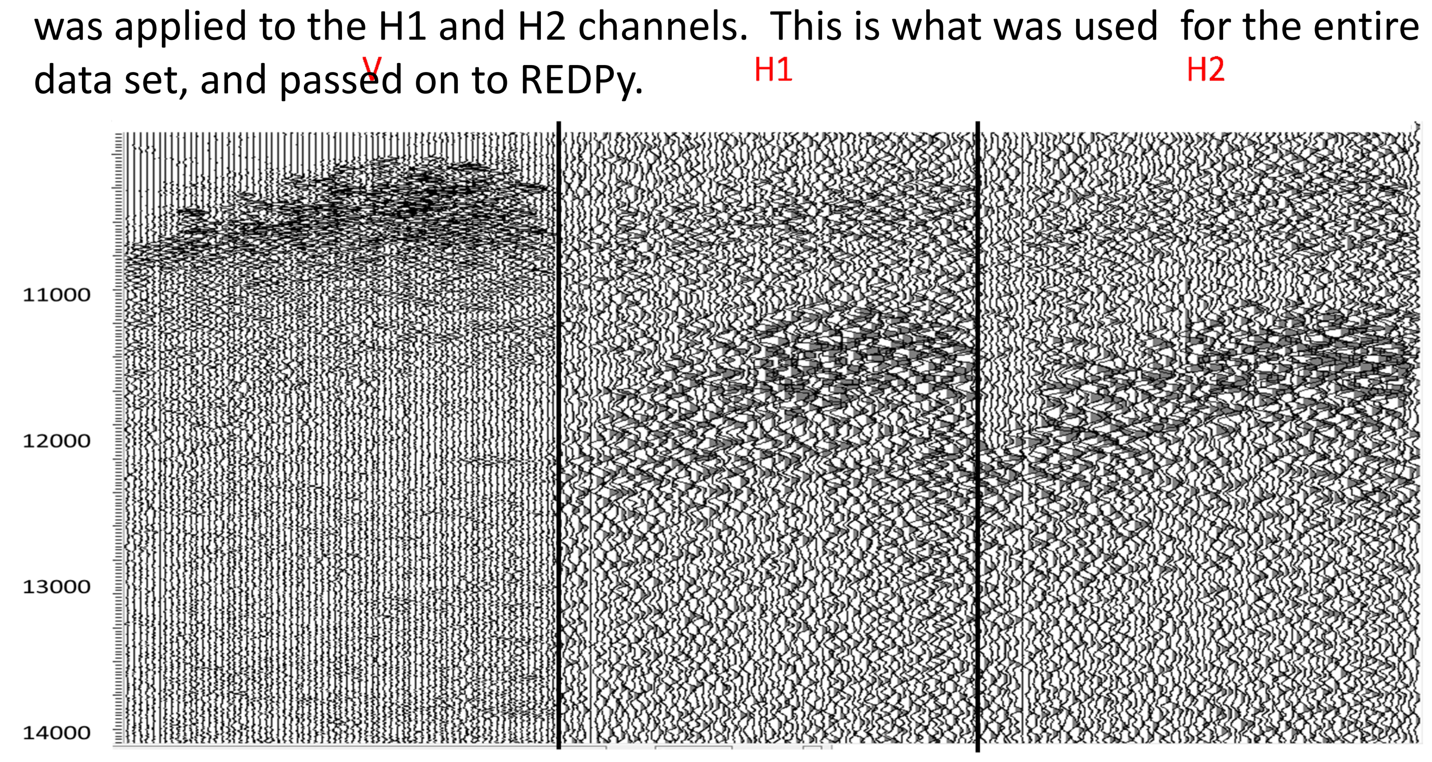


Figure 5. Record number 24006 processed using decon, filtering and scaling (V), and filter and scale on the H1 and H2 channels. In addition, random noise attenuation was applied, using the Shearlet transform as described by Hauser and Steidl, 2014.

Vertical channel processing

i. Deconvolution, Weiner spiking, 80 ms operator, 1 percent prewhitining

ii. Scaling, mean amplitude trace balancing

iii. Filtering, 8-12-65-75 bandpass

Horizontal channel processing:

i. Scaling, mean amplitude trace balancing

ii. Filtering, 15 Hz high cut, no low cut applied

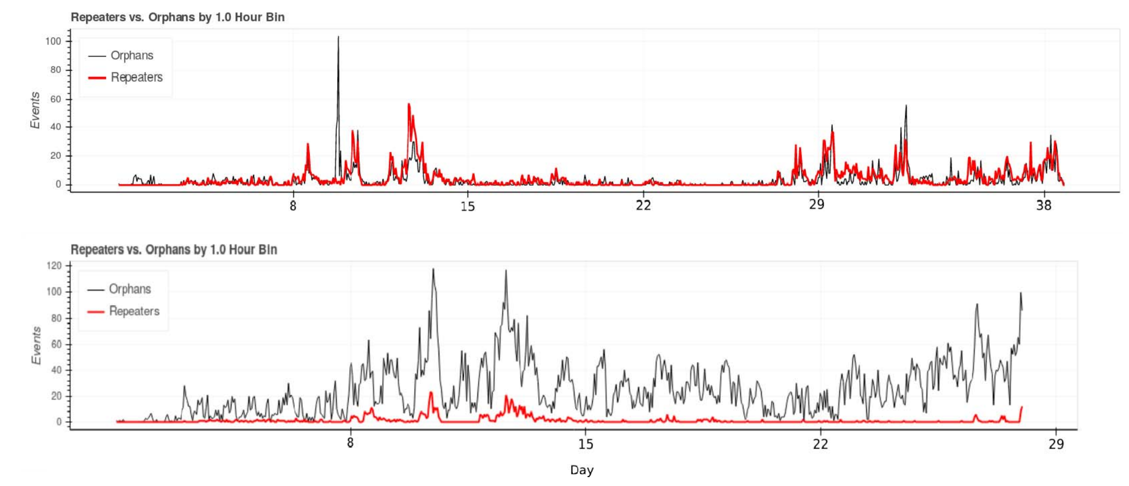
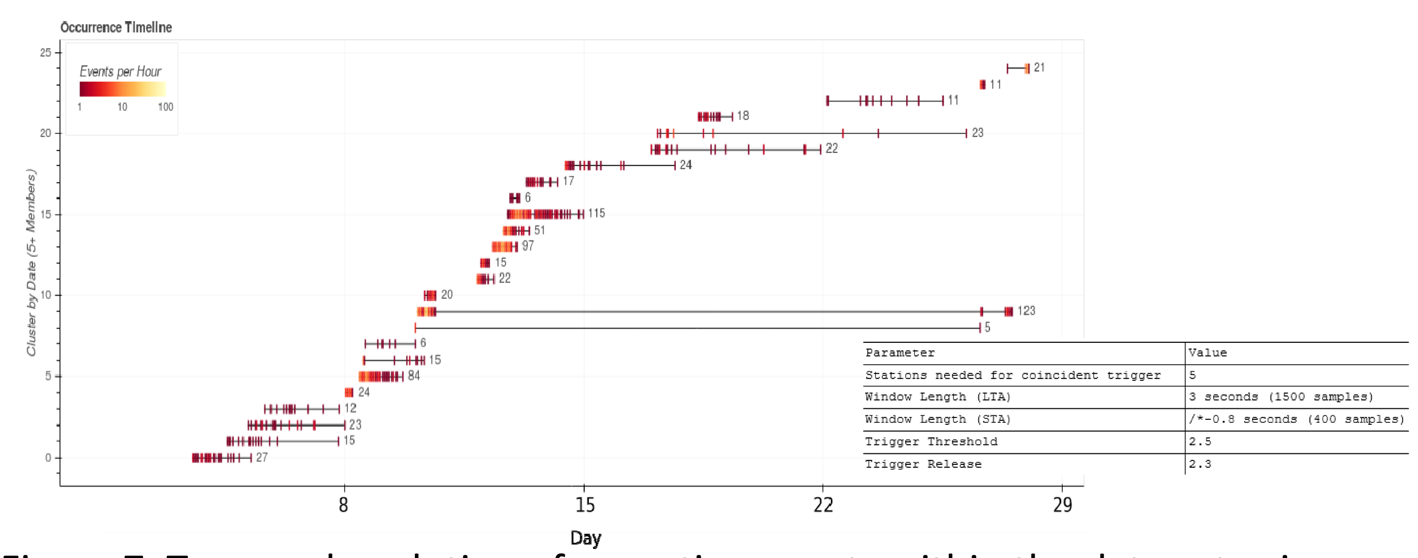


Figure 6.The number of events per hour detected using REDPy with parameters (in the table below) , orphans shown in black and repeaters in red. The data is band-passed filtered between 1 and 70 Hz (Upper). The data is processed using deconvolution, in addition to filtering and scaling (Lower). Note the x-axes are on different scales and so cannot be directly compared.



Parameter	Value
Stations needed for coincident trigger	5
Window Length (LTA)	3 seconds (1500 samples)
Window Length (STA)	/*-0.8 seconds (400 samples)
Trigger Threshold	2.5
Trigger Release	2.3

Figure 7. Temporal evolution of repeating events within the data set using deconvolved data. Each horizontal bar represents one group of repeaters, with events identified as red-yellow on a colour scale dependent upon the number of events occurring per hour (red = few). The number of events per family is shown at the end of the line. Only families with greater than 5 events per family are shown here.

i. Using this methodology, we have been able to increase the number of detected seismic events within the dataset from 3700 events, to over 17,000,

ii. Almost all of the ``new'' events are classified as orphan events (i.e. they have no similarities in terms of waveform shape or characteristics to any other waveform in the database),

iii. either all of the repeating earthquakes had already been detected using REDPy, or that deconvolved data is not suitable for the detection of repeating events. Further investigation is required to see whether template matching can identify any more events within the deconvolved data.

Hauser, Soren, Bettina Heise, and Gabriele Steidl (2014). “Linearized Riesz transform and quasi-monogenic shearlets”. In: International Journal of Wavelets, Multiresolution and Information Processing 12.03, p. 1450027.

Hotovec-Ellis, AJ and C Jeffries (2016). “Near real-time detection, clustering, and analysis of repeating earthquakes: Application to Mount St. Helens and Redoubt volcanoes”. In: Seismological Society of America Annual Meeting.

Leinbach,Jim(1995).“Wiener spiking deconvolution and minimum-phase wavelets: A tutorial”. In: The Leading Edge 14.3, pp. 189–192.

Margrave, Gary F (2007). “Methods of seismic data processing”. In: Geophysics 557.657, p. 856.

Margrave, GF,M B Bertram, K L Bertram, K W Hall, K A H Innanen, DC Lawton, LE Mewhort, and TM Phillips (2012). “A low-frequency seismic field experiment” In: SEG Technical Program Expanded Abstracts 2012. Society of Exploration Geophysicists, pp. 1–5..

Paes, A and David W Eaton (2018). “Energy-stack and Kurtosis: the dynamic duo for microseismic event identification”. In: Microseismic Industry Consortium Annual research report, 9.

Salvage, Rebecca O and David W Eaton (2019). “Investigating the evolution of microseismicity associated with the Tony Creek Dual Microseismic Experiment, Alberta, Canada”. In: Microseismic Industry Consortium Annual Research Report 2019 This Volume.

Trnkoczy, Amadej, Peter Bormann, Winfried Hanka, L Gary Holcomb, Robert L Nigbor, Masanao Shinohara, Hajime Shiobara, and Kiyoshi Suyehiro (2002). “Site selection, preparation and installation of seismic stations”. In: Bormann, P.(ur.)

Weir,R, A Poulin,and D Eaton(2018).“Can continuously recorded seismic data be improved with signal processing?”In: Microseismic Industry Consortium Annual research report, 9.

Withers, Mitchell, Richard Aster, Christopher Young, Judy Beiriger, Mark Harris, Susan Moore, and Julian Trujillo (1998). “A comparison of select trigger algorithms for automated global seismic phase and even detection”. In: Bulletin of the Seismological Society of America 88.1, pp. 95–106.

The authors would like to thank the sponsors of CREWES and the Microseismic Industry Consortium for financial support. We thank Signature Seismic for the use of their processing software and computer cluster which allowed this work to take place. We are grateful to Schlumberger for providing the VISTA software used in this study and to Seisware for the use of their interpretation software. This work was funded by NSERC (Natural Science and Engineering Research Council of Canada) through grants CRDPJ 461179-13,CRDPJ474748-14,IRCPJ/485692-2014,and IRCSA 485691, as well as through CREWES. RW would like to thank The SEG Earl D. and Reba C. Griffin Memorial Scholarship. ROS would like to thank Mitacs for financial support, as well as Alicia Hotovec-Ellis (USGS) for support when using REDPy

Contact information: ronald.weir@ucalgary.ca

NSERC CRSNG

UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
Department of Geoscience