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Presentation title

A novel approach to automated, in-field seismic exploration and monitoring via seismic interferometry with ambient noise

Abstract

High-resolution seismic imaging, i.e., "reflection seismology," is traditionally performed by recording artificial seismic sources (e.g., chemical explosions or vibra

convergence can be assessed, and messages can be sent that summarize the arrays̓ performance, data metrics, and state of health.

In 2016-17 we built a prototype 20-node array and tested it at the Soda Lake Geothermal Field in June 2017. The array successfully performed real-time, in-field processing and produced virtual source gathers after each hour of data acquisition. We are now implementing a few changes to the array design and will build a 150-node array to be tested at a geoth

A novel approach to automated, in-field seismic exploration and monitoring via seismic interferometry with ambient noise

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Seismic Interferometry

- Traditional seismic exploration methods use “controlled seismic sources” (e.g., explosions, Vibroseis, hammer blows) to interrogate the subsurface. This approach can be expensive, intrusive, and damaging to the environment.

- Seismic interferometry (SI) is a relatively new field in seismology – The term interferometry is borrowed from radio astronomy. It can be divided into ambient noise interferometry and controlled source interferometry.

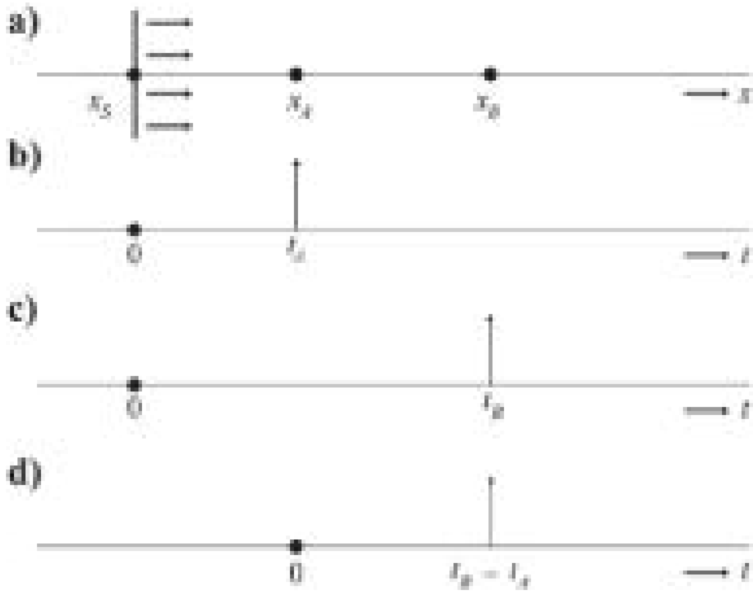
- Ambient Noise Seismic Interferometry -

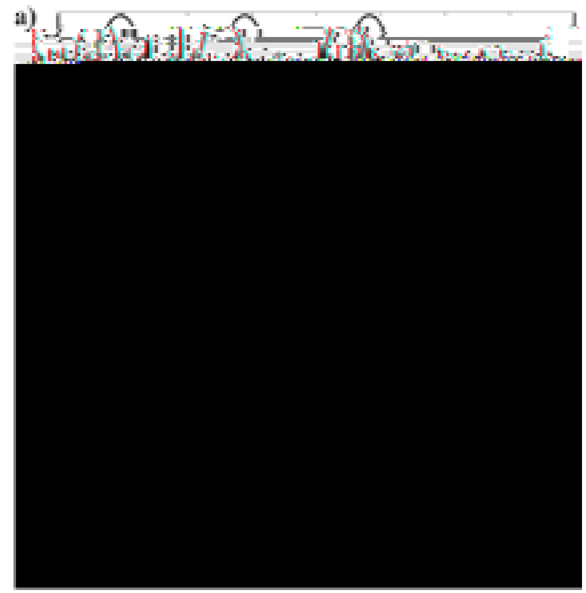
Seismic Interferometry: Basics

The goal: to create a new seismic record from the recorded ambient noise.

How: by cross-correlating the response recorded at seismometer A with that recorded at seismometer B. The source is at an unknown location at Xs

The result is that by cross-correlating we have ‘moved’ the source to XA

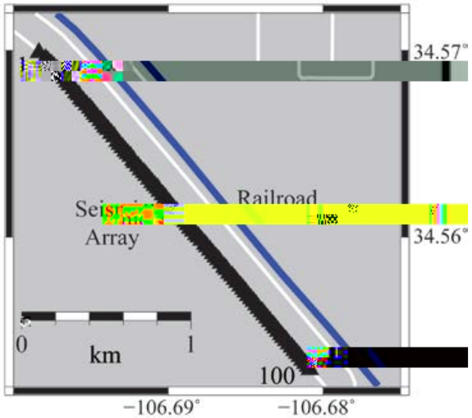




Response observed at XB as if there was an impulsive source at XA

Response observed at XB as if there was a noise source at XA

Seismic Interferometry: Example Rio Grande Rift



Figures from Quiros et al (2016) Geophys. J. Int.

(1) Build and test a new-generation seismic system that is capable of acquiring, transmitting, and processing seismic data in near-real-time Æ”Raspberry Pi Enhanced REFTEK” (RaPiER).

(2) Apply the new technology in a geothermal field setting to investigate the possibility of extracting supplementary seismic parameter information from ambient seismic noise surveys by exploiting opportunities for adapting survey acquisition parameters provided by near-real-time data processing.

(3) The project is divided into 2 phases

Methods/Approach - RaPiER Overview

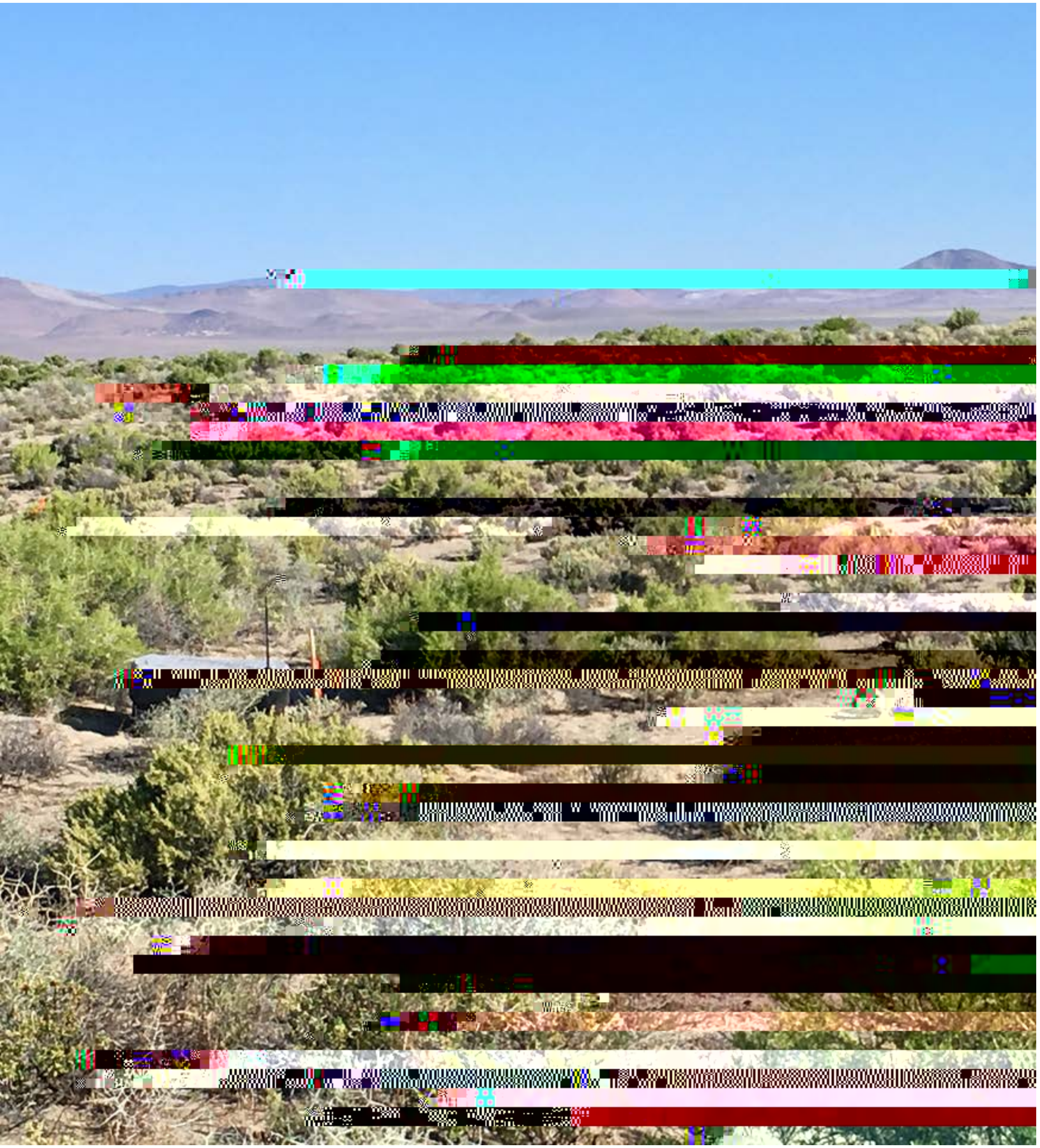
Trimble REF TEK 130S-01 Broadband
Seismic Recorder

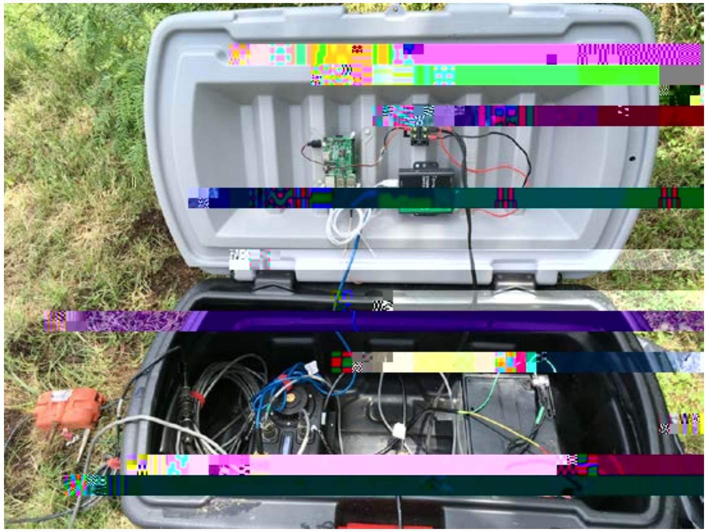
Raspberry Pi 3

Automated, in-field processing may be able to produce Green’s functions in near-real-time, allowing for the immediate evaluation of results and enabling operators to alter data acquisition parameters before demobilizing instruments.

Methods/Approach -- RaPiER Overview

Methods/Approach - Overview





Methods/Approach - Challenges

- To our knowledge,
  - a Raspberry Pi had never been integrated with a REF TEK 130 digitizer;
  - Apache Cassandra & MSNoise had never been implemented on a Raspberry Pi
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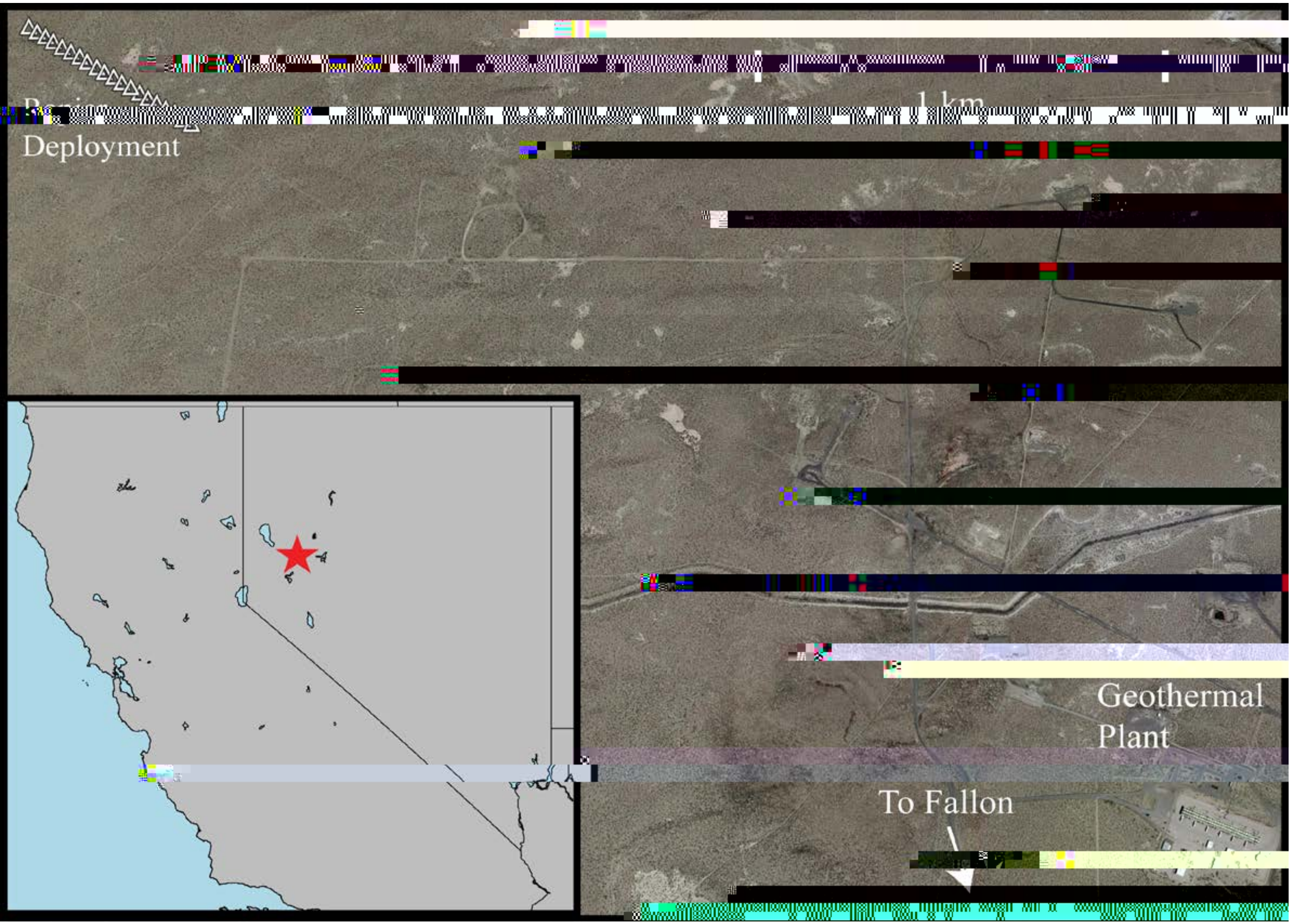
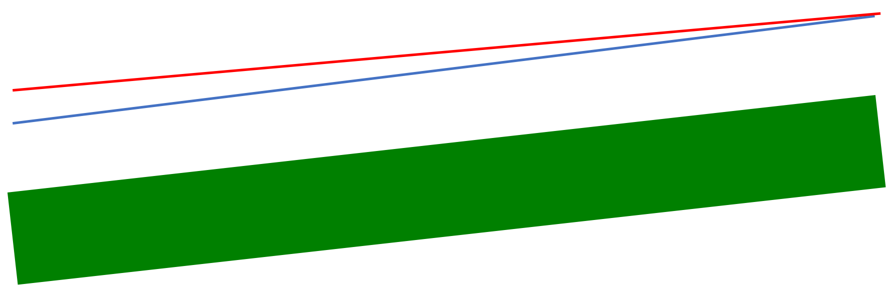
  - No one seems to have resolved the problem of o(y)0.7(7.(7)-65cn(l)3.3(4-2u1(m 4-1( )5)-a3.16(e)-


Deployment
Geothermal Plant
To Fallon

Virtual Source Gather for “Source” 121

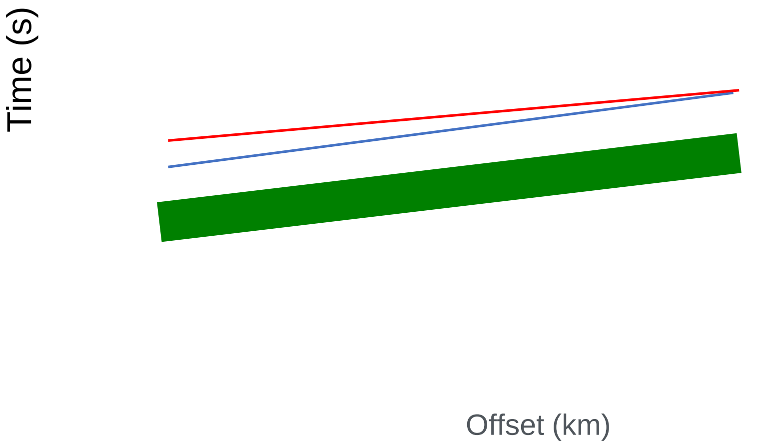


Virtual Source Gather for “Source” 129

Green’s function convergence

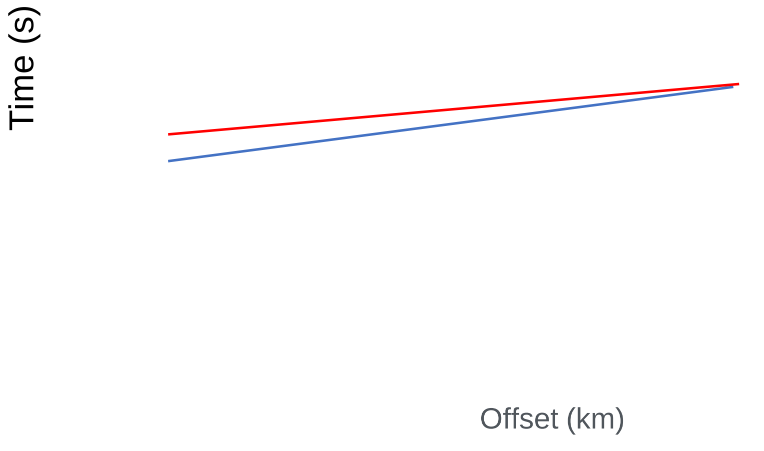
L2norm

Virtual source at 122 after 45 hours



L2norm

Virtual source at 122 after20 hours



Future Directions - Plans for Phase 2

- Hardware: Finalize solutions to
  - Wi-Fi network compartmentalization Æ Better equipment has been identified

  Once those issues are settled we will build 130 additional RaPiER nodes
- Modeling
  - Compute surface (Rayleigh) wave group velocity dispersion
  - Model dispersion curves to find 1D Vs beneath Soda Lake array
- Software
  - Determine viability of real-time computation of surface (Rayleigh) wave group velocity dispersion
  - Implement on RaPiER nodes if it is deemed viable
- Field test prep
  - Settle on site for the large-scale field test
  - Obtain permits to perform field test
- Perform field test with 150-node array
  - Interpret and write up results

Summary Slide

- Automated, real-time, in-field seismic interferometry with ambient noise is feasible for small arrays.
  - Benefits include flexibility in data acquisition, which should lead to greater success rates and lower costs.

- A strategy that expands the functionality of existing, industry-standard instrumentation has been developed and field-tested.
  - Many other applications of embedded micro-processors in seismic arrays (e.g., seismic site characterization, aftershock monitoring and location, surface wave modeling, etc.
- Whether this same strategy is feasible for larger arrays with greater aperture will be determined in Phase 2.