MONITORING INDUCED SEISMICITY USING LOW-COST SEISMOMETERS: A CASE STUDY IN CENTRAL KANSAS

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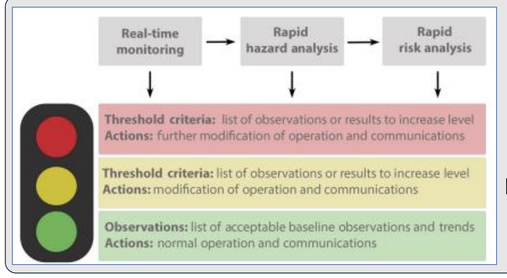
Regional Earthquake Detection Comparing the USGS, KGS, and Raspberry Shake Recorded data

Abstract

The state of Kansas has recently experienced an unprecedented increase in seismic activity. Studies have identified high-rate wastewater injections as the primary cause of induced seismicity. With growing interest in geologic carbon dioxide (CO_2) sequestration, there is concern that such projects might also induce earthquakes. To address this, the Department of Energy, in collaboration with the National Risk Assessment Partnership (NRAP), has established standard guidelines for new CO_2 sequestration projects in the United States. The NRAP recommends a series of steps to be taken before injection operations commence, including the establishment of an active, local seismic network to monitor background seismicity for 6-12 months. To better understand the susceptibility of potential sequestration sites, efficient and affordable earthquake monitoring equipment is needed. This study utilizes the low-cost Raspberry Shake 3D seismometer and readily available components, such as wireless modems, solar panels, and weather-resistant housing. Currently, five Raspberry Shake seismometers have been successfully installed and are operational near Bushton in the Central Kansas. Each station comes at a cost of approximately $3,500, offering a significant advantage over commonly used broadband seismometers that can cost more than $30,000 per station. Since the completion of the installation, the network has detected small local seismic events occurring at distances of only a few kilometers, events that went unnoticed by state and regional monitoring networks.

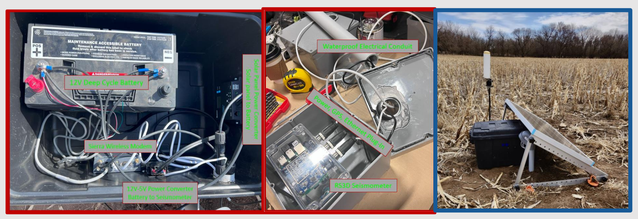


Traffic Light System

Criteria threshold, recommended by the NRAP, to best mitigate seismic risk.

Network Setup

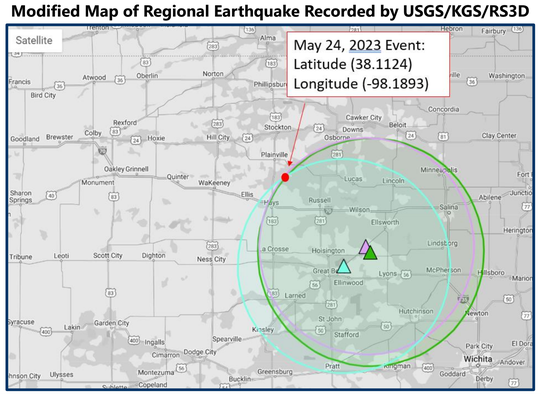
The RS3D seismometer installed in weatherproof housing.



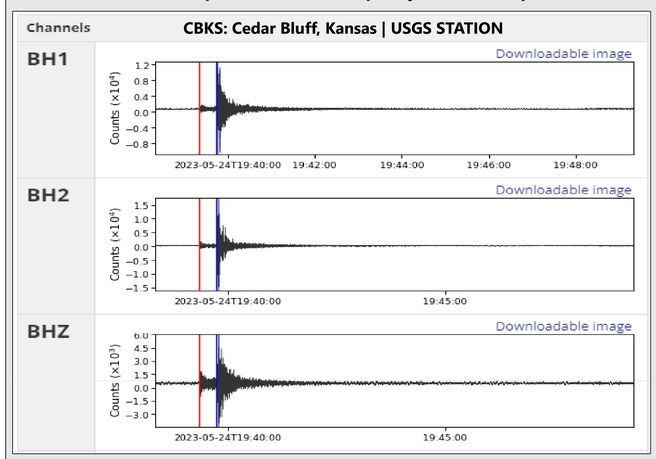
Power & Connectivity **Seismometer** **Field Instillation**

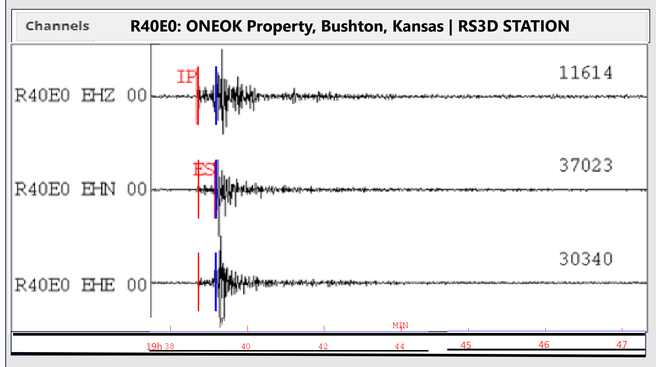
Detected Regional Earthquake Event

Modified Map of Regional Earthquake Recorded by USGS/KGS/RS3D



Waveform Comparison: USGS VS Raspberry Shake 3-Component

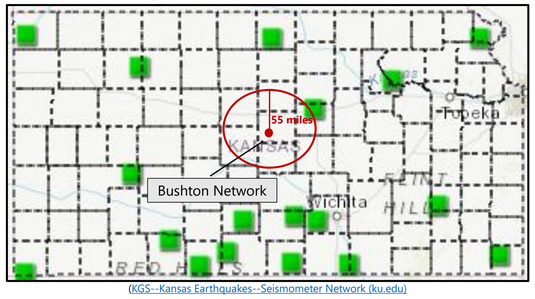




Waveform comparison of the M3.2, May 24, 2023, earthquake event recorded by both the USGS broadband seismometers and the low-cost, Raspberry Shake 3-Component seismometers.

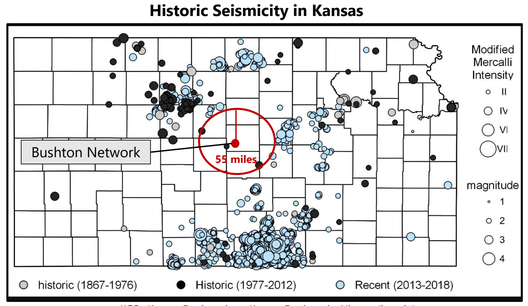
Detected Local Earthquake Event

Kansas Geological Survey Broadband Station Locations



(KGS--Kansas Earthquakes--Seismometer Network (ku.edu)

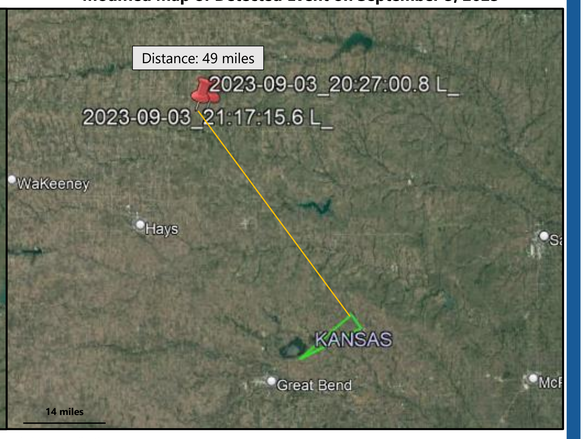
Historic Seismicity in Kansas



KGS--Kansas Earthquakes--Kansas Earthquake History (ku.edu)

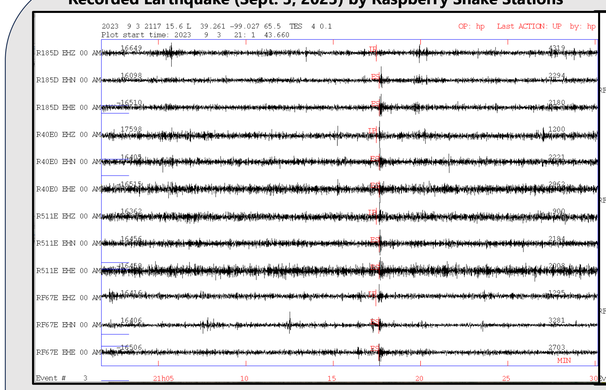
Modified Map of Raspberry Shake Seismometer Station Locations

Modified Map of Detected Event on September 3, 2023

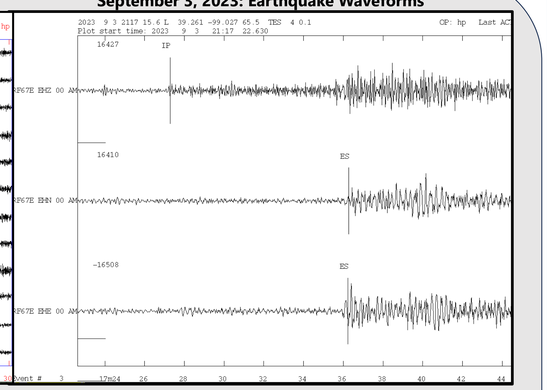


Maps created using Google Maps application

Recorded Earthquake (Sept. 3, 2023) by Raspberry Shake Stations



September 3, 2023: Earthquake Waveforms



Shown above, the recorded and processed data on September 3, 2023, shows a clear earthquake event recorded by the Bushton monitoring network. This event was not reported by KGS, nor USGS.
Local - Earthquake Event occurred at the time (UTC 21:17:06) and 4-miles north of Natoma, Kansas.

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References:
Templeton, D.; Schoenball, M.; Layland-Bachmann, C.; Foxall, W.; Guglielmi, Y.; Kroll, K.; Burghardt, J.; Dilmore, R.; White, J. Recommended Practices for Managing Induced Seismicity Risk Associated with Geologic Carbon Storage; NRAP-TRS-I-001-2021; DOE.NETL-2021.2839; NRAP Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Pittsburgh, PA, 2021; p 80. DOI: 10.2172/1834402

Summary and Conclusions

- The low-cost seismic station installation using RS3D seismometers appears capable of monitoring both local and regional seismicity.
- The network is expected to detect local seismicity near Bushton, Kansas for a complete, 12-month earthquake catalog.