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Sandia National Laboratories

PROXIMAL OBSERVATIONS OF EPICENTRAL INFRASOUND GENERATED BY SHALLOW, LOW-MAGNITUDE EARTHQUAKES IN THE PERMIAN BASIN, TEXAS

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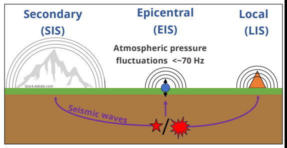
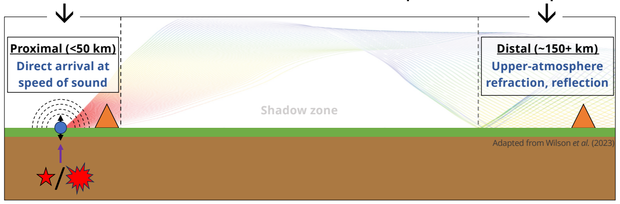
INTRO & MOTIVATION

- Earthquakes generate infrasound (<20 Hz sound) via vertical displacement of ground surface at epicenter **(EIS)**, at/near receiver **(LIS)**, or topographic features **(SIS)**



No observations after earthquake of any size

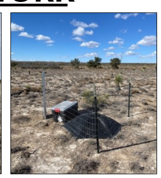
Well-studied, many observations, after earthquakes and explosions

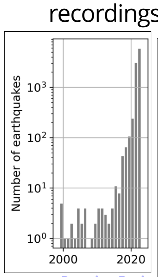


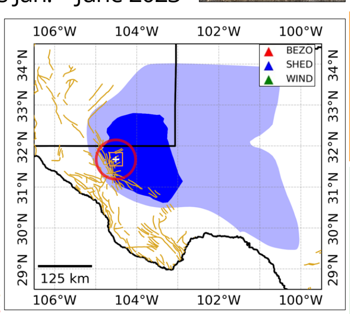
Do small, shallow earthquakes generate laterally-propagating epicentral infrasound waves?

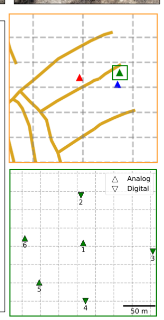
PECOS INFRASOUND NETWORK

- 17 instruments, among 3 ~100 m aperture arrays
- Each array co-located with TexNet seismic station
- Continuous infrasound recordings Jan. – June 2023





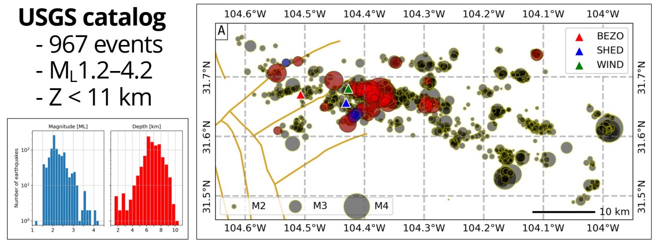




Permian Basin
Delaware Basin
Mapped faults
50 km radius

DATA & METHODS

USGS catalog
- 967 events
- M_L1.2–4.2
- Z < 11 km

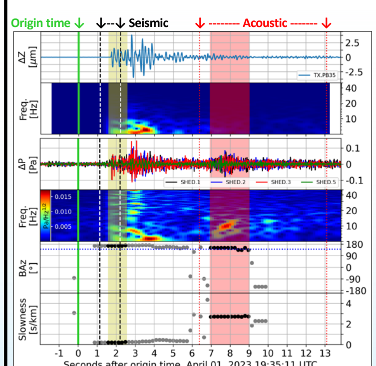


1. **Calculate predicted arrival times of infrasound signals**
   V_P = 3.5–5.0 km/s (Huang *et al.*, 2017, 2019)
   V_{sound} = 320–360 m/s (Negraru *et al.*, 2010)
2. **Search 5–50 Hz bandpassed waveforms, spectrograms**
3. **Compare co-located infrasound and seismic data**
4. **Run array processing: find trace velocity, backazimuth**

RESULTS & INTERPRETATIONS

- **LIS following 45 events (2.5 ≤ M_L ≤ 4.2)**
- **EIS following 2 events (both M_L2.9)**

Event TX2023GJYC (M_L2.9, Z=6.1±0.7 km)
- Recorded 2.7±0.8 km away on 4 elements of SHED array



Seismic/infrasound comparison
→ Simultaneous seismic, infrasonic signals in predicted seismic window
→ Infrasonic signal only in predicted acoustic window

Array processing
→ BAz = 150° (true=140°)
→ Wavefront propagation = 370 m/s

CONCLUSIONS

- Evaluated infrasound following 84 of 207 2.5 ≤ ML ≤ 4.2 shallow earthquakes in the Permian Basin of West Texas
- 45/84 events produced LIS signal (5-50 Hz)
- 7/84 events produced possible EIS signal (7-20 Hz)
  - Confirmed EIS arrivals following 2/7 events

First proximal observations of laterally-propagating earthquake EIS

Event		1st arrival					2nd arrival				
ID	BAZ [°]	V_{app} [km/s]	BAZ [°]	ΔBAZ [°]	ΔP [Pa]	ΔZ [μm]	V_{app} [km/s]	BAZ [°]	ΔBAZ [°]	ΔP [Pa]	ΔZ [μm]
GJPM	155	3.288	171	16	0.24	2.15	0.352	152	3	0.10	0.38
GJYC	140	4.851	166	26	0.1	1.7	0.369	150	10	0.08	0.65

*** Paper '*Observations of epicentral infrasound from shallow low-magnitude earthquakes in the Permian Basin*' under revision**

IMPLICATIONS & FUTURE WORK

- **Determine generation mechanisms**
  - Consider physics of laterally-propagating infrasound generation
  - Understand effects of focal mechanism, local geology on generation and detection
- **Compare with observations of explosions**
- **Highlight importance of seismic–infrasound co-location**
- **Assess how many signals were not detected**

ACKNOWLEDGEMENTS

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