Seismo-acoustic ground coupling: Wave types, transfer efficiency, and near-surface structure

Results from a small-scale acoustic ground coupling experiment

EGU2020-7484

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Motivation

• How sensitive are geophone nodes to acoustic perturbations?

• Can we use them to locate acoustic sources at height?
Experiment field site
Experiment field site

Instrumentation

100 FairField Zland Geophone nodes (3C, 5Hz)

4 Hyperions IFS-5111 Infrasound sensors (seismically decoupled)
Wind noise reduction "system"

Design 1
Hyperion IFS-5111
Infrasound sensor below bucket

Co-located seismic & infrasound sensors
△ = hammer beats

= flying rockets

★ = buried rockets

● = firecrackers

75 g NEM

= 5 g NEM

Acoustic Sources
Why look at rocket signals?

- Moving source - can we track it acoustically using geophone nodes?

- Test run for thunder analysis with geophone nodes

- Can we locate/separate sources along lightning strike?
Waveforms are strikingly similar!

1.7 µm/s per Pa

Surface geophone
(beware geophone polarity: positive values = DOWNward motion)

amplitudes are normalized
Lift off

Explosion

Lift off close-up

Explosion close-up

Buried geophone

(beware geophone polarity: positive values = DOWNward motion)

Waveforms are still very similar!

Buried geophone amplitudes are normalized.
Wave types:

Acoustic source at height (firecracker)

Seismic source at surface (hammer beat)

What kind of wave types do acoustic sources induce in the ground?

- Slow acoustic arrival
  - Air-coupled (slow) Rayleigh wave (ground roll)
  - Slow Biot wave? (inside pores?)
Coupling efficiency:

Having co-located seismic and infrasound sensors we can calculate the energy transmission into the ground:

Conversion from acoustic energy to seismic energy ~ 1%
Having co-located seismic and infrasound sensors we can infer near surface elastic parameters:

\[ U_x = \frac{-iV_{\text{air}}p_0}{2\omega(\lambda + \mu)} \]
\[ U_z = \frac{-V_{\text{air}}p_0}{2\omega(\lambda + \mu)} \left( \frac{\lambda + 2\mu}{\mu} \right) \]

Measuring dynamic air pressure, and 3D seismic displacement allows to infer Lamé parameters!

Doing this for different frequencies allows for a depth profile!

Estimating soil parameters:

Results:

(a) Box plots for Lambda

(b) Box plots for Mu
This was only a brief preview ...

Got interested?

Await the upcoming paper in **GJI** (submitted):

*Acoustic-to-seismic ground coupling: coupling efficiency and inferring near-surface properties*

**Artemii Novoselov, Florian Fuchs, Goetz Bokelmann**

Check out the comprehensive dataset and experiment description document:

https://doi.org/10.25365/PHAIDRA.111

Watch out for waveform data soon being made available at EIDA, using network code 6A (2019)

https://www.orfeus-eu.org/data/eida/