



Airborne infrasound: A new way to explore the 3D acoustic wavefield

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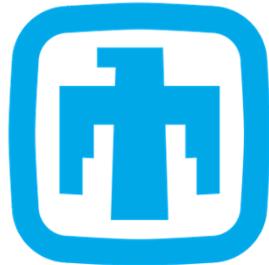
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UUR Sand #:

Multi-Discipline Collaboration



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Background: It's a big hammer!

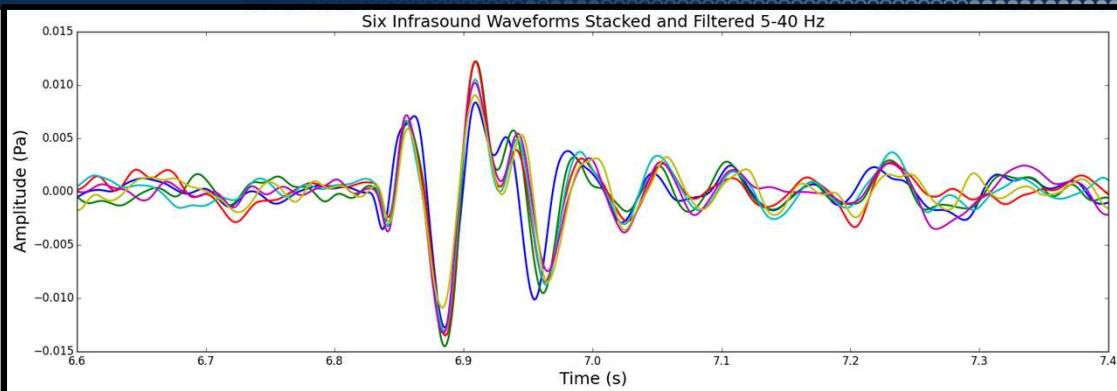
HK Exploration Seismic Hammer:

Impulsive Source can generate up to 0.19 Mega-Joules of energy by hydraulically lifting and dropping 13 metric ton mass from 1.5 m at roughly 3 shots per minute

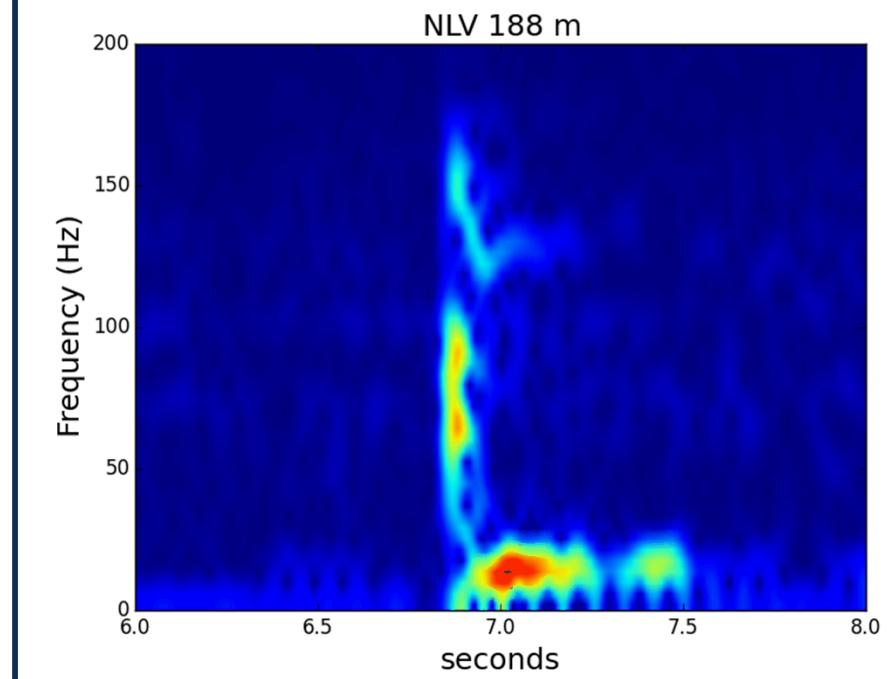


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Initial Test: North Las Vegas



- Waveforms are incredibly repeatable
- First motion is down due to initial ground deflection
- Dominant frequency is between 10 - 12 Hz



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Thor 2: Infrasound Takes Flight



- 1) Hyperion Infrasound Sensor
- 2) Octocopter Drone
- 3) Fly over seismic hammer
- 4) See what happens...



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Thor 2: Hammer in Slow-Motion



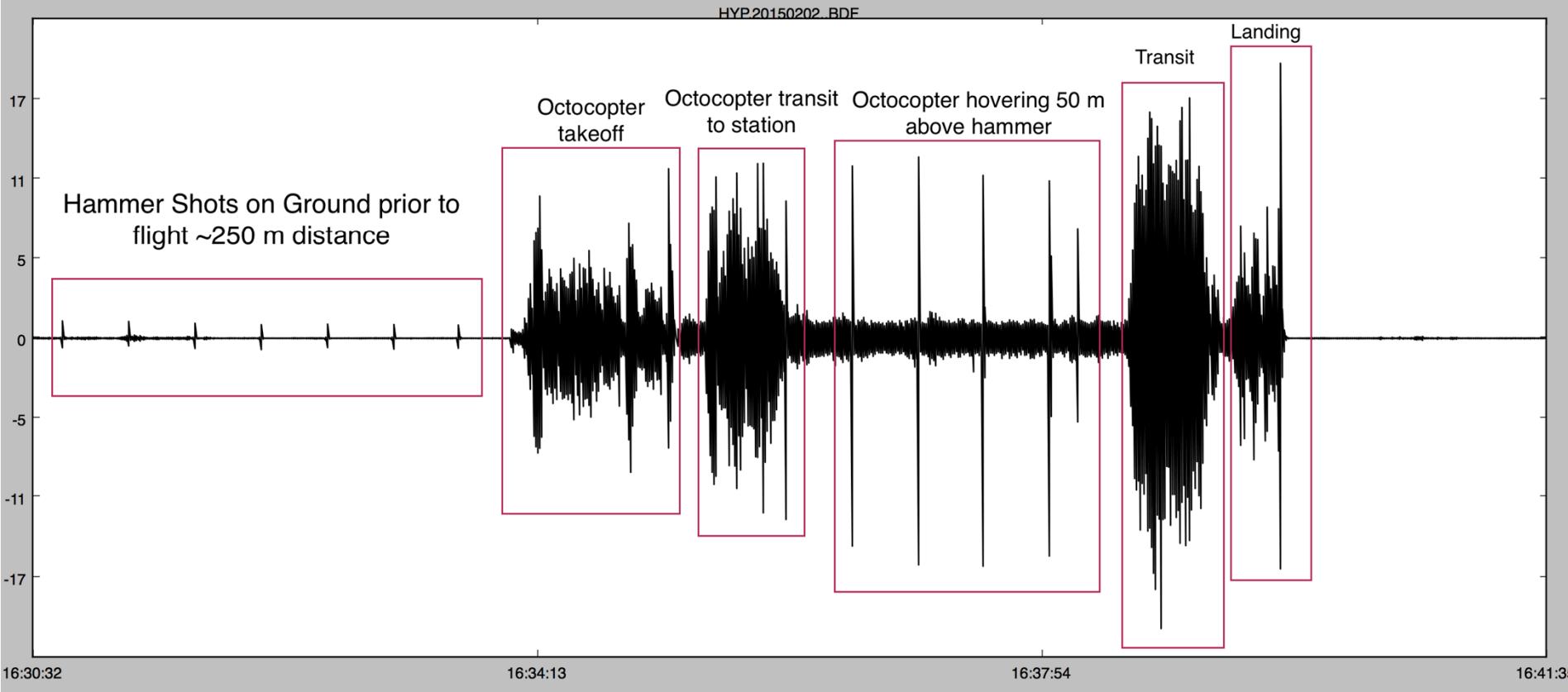
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Thor 2: Overflight



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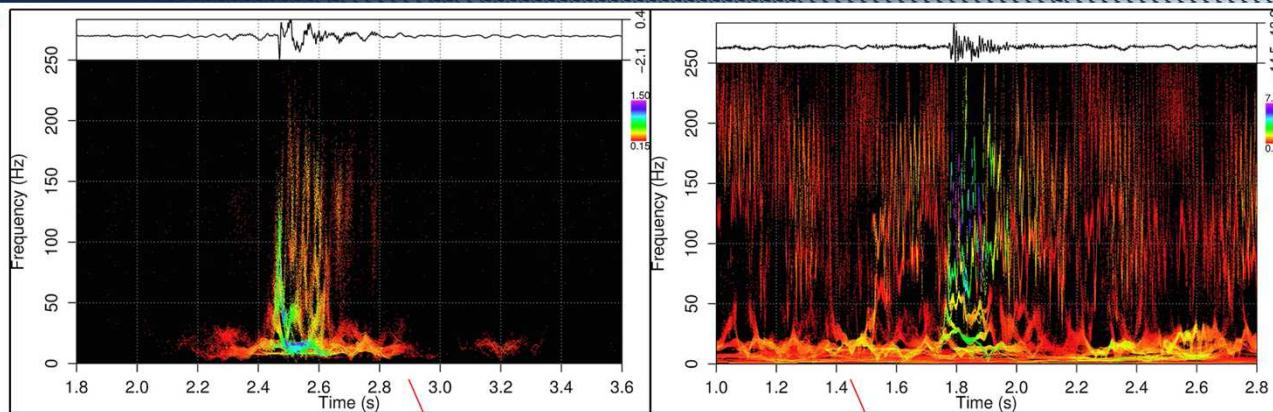
Octocopter Infrasound : Success!!



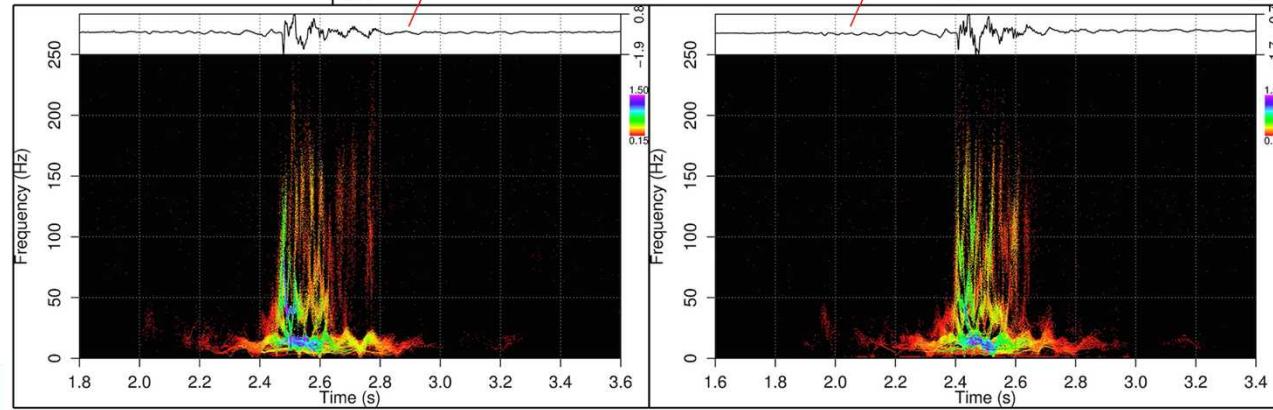
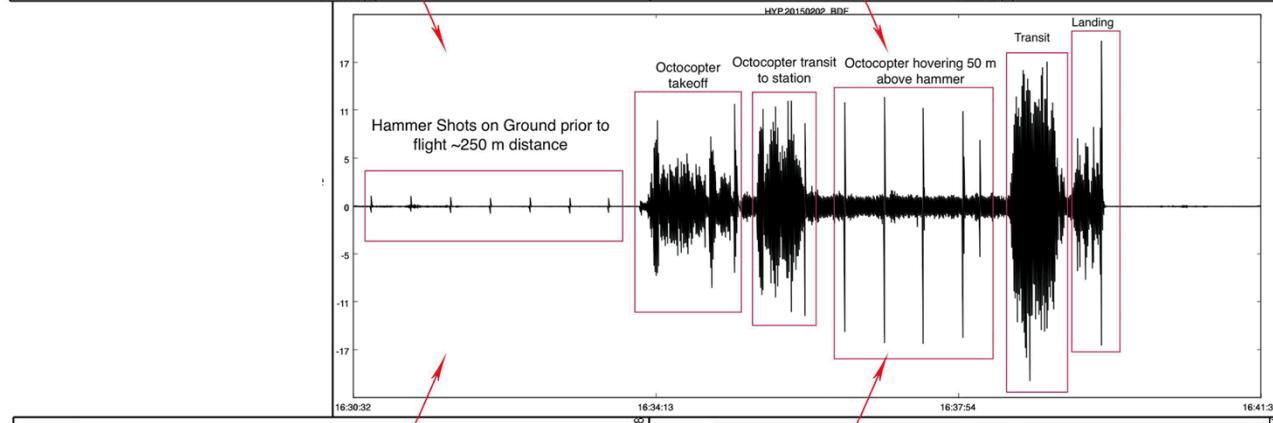
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Octocopter Infrasound : Ensemble Hilbert

Spec



Airborne
Sensor

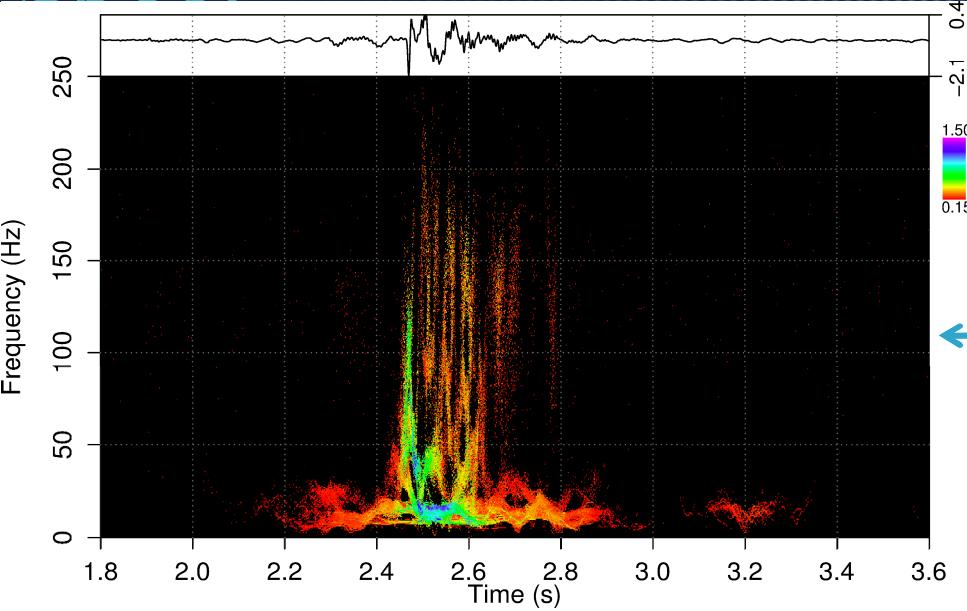


Ground
Sensor



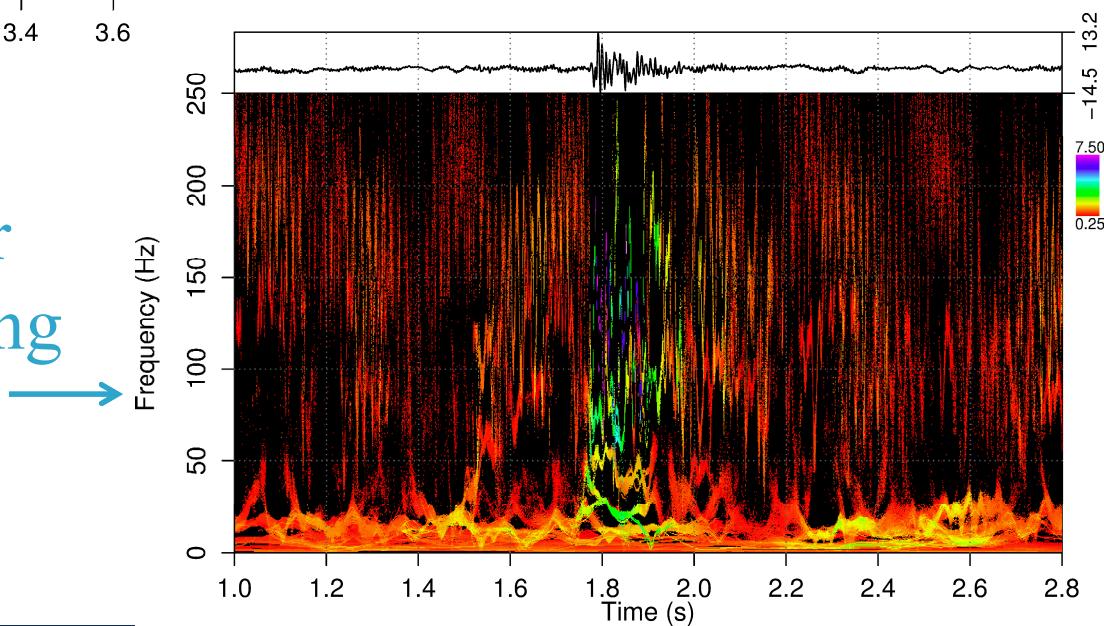
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Octocopter Infrasound : Ensemble Hilbert Spec.



EHS from octocopter
infrasound sensor before
takeoff

EHS from octocopter
infrasound sensor during
flight



Octocopter Infrasound : Flight Path

Hover Elev. 30 m

3 hover locations:

- North 30 m
- Center
- South 30 m

4 ground stations

- North 30 m
- East 30 m
- South 30 m
- West 30 m

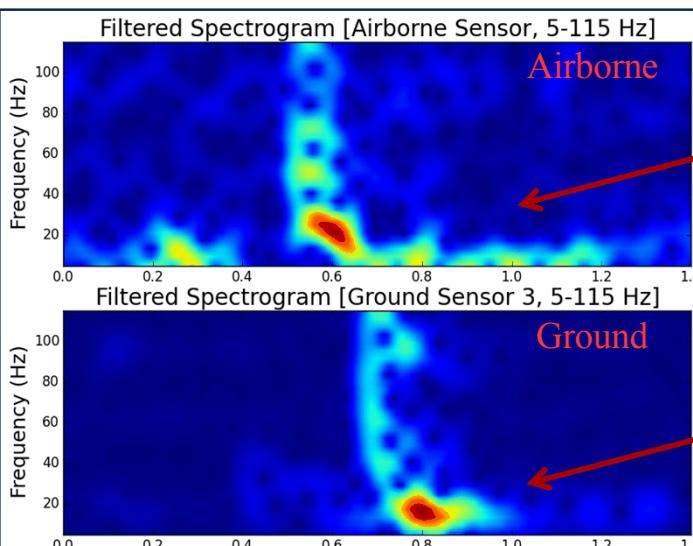
Hammer location
- center

Flight path shown in
red

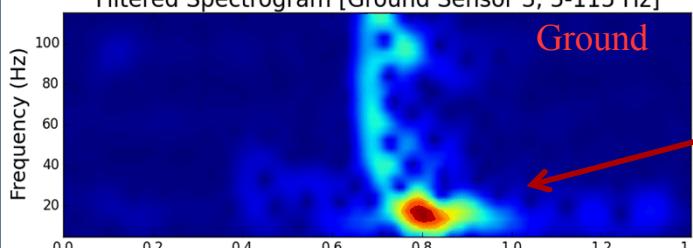


Octocopter Infrasound : Frequency Curiosity

North Hover

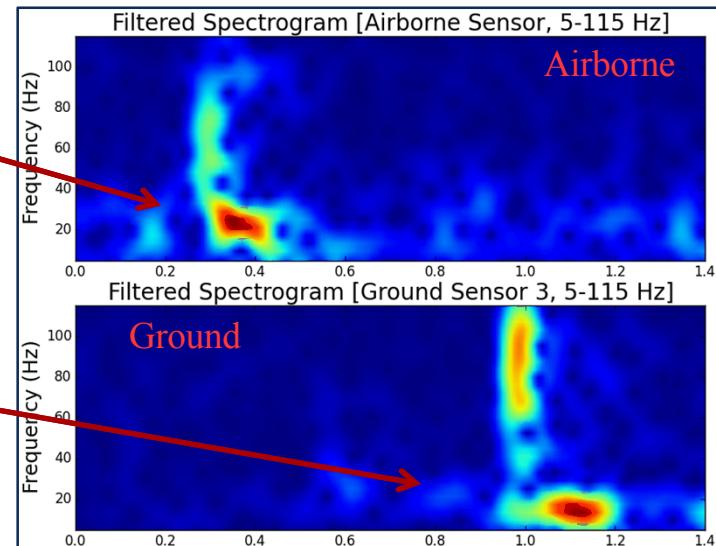


~20 Hz Peak



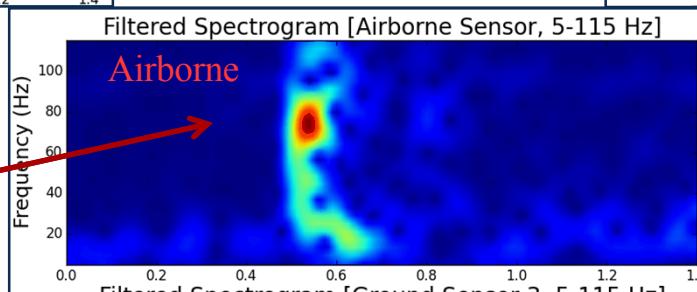
~10 Hz Peak

Center Hover



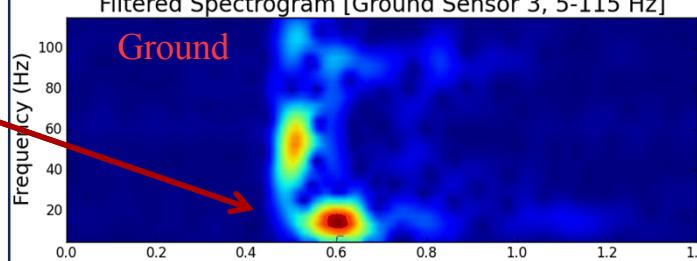
Ground

~80 Hz Peak



Filtered Spectrogram [Ground Sensor 3, 5-115 Hz]

~10 Hz Peak

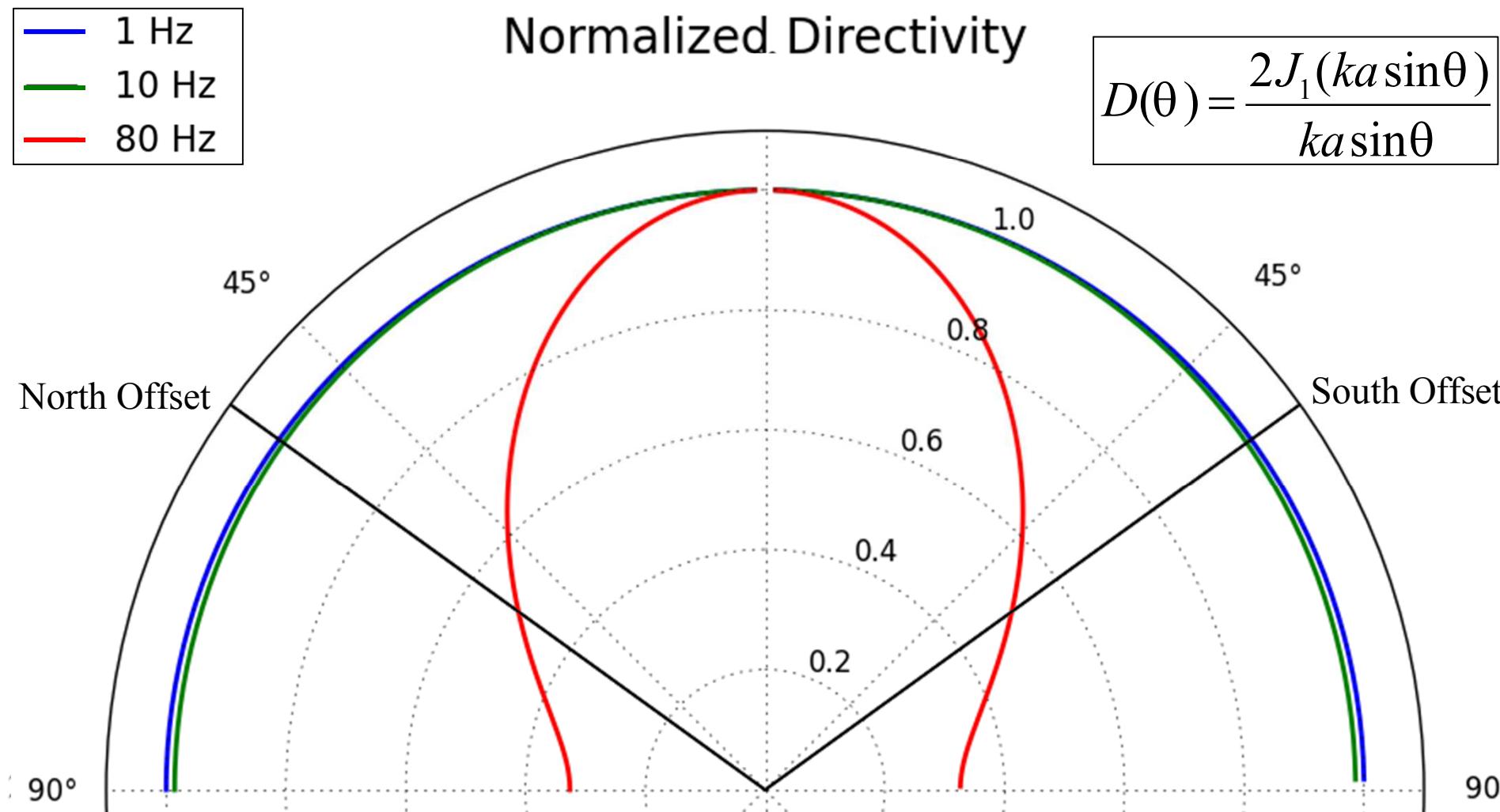


Filtered Spectrogram [Ground Sensor 3, 5-115 Hz]



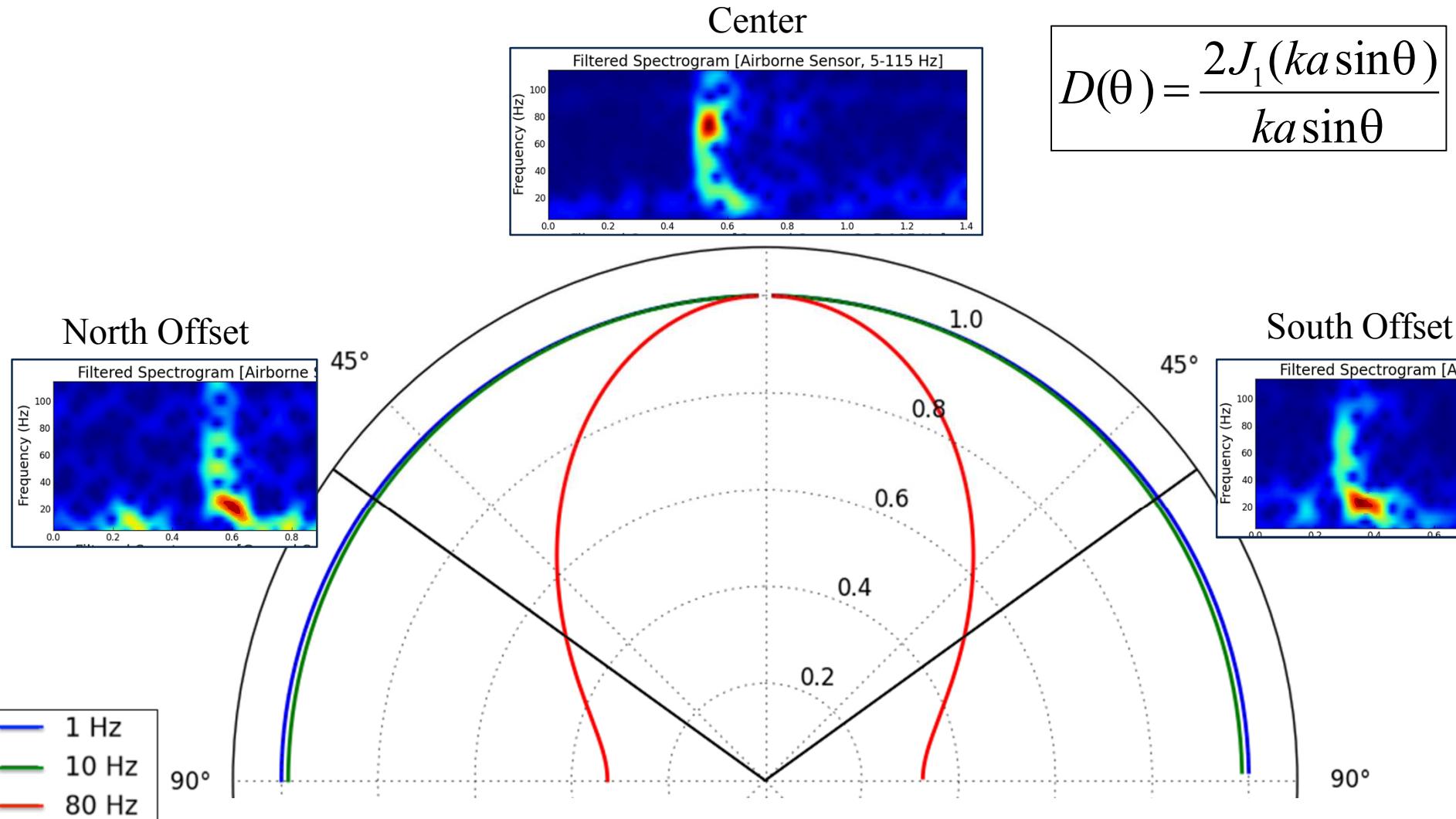
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Octocopter Infrasound : Directivity



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Octocopter Infrasound: Directivity

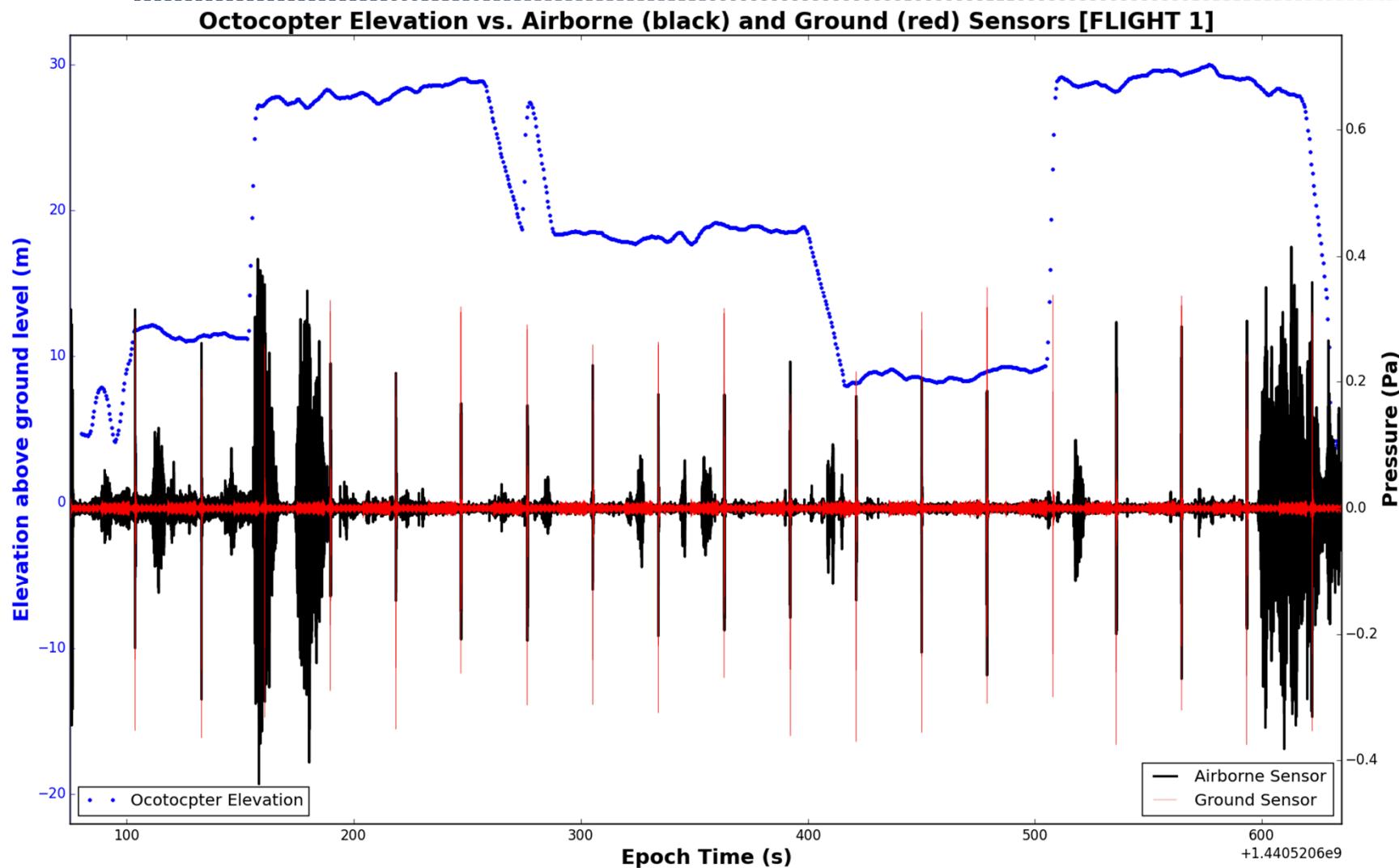


Thor 2: Infrasound Takes Flight



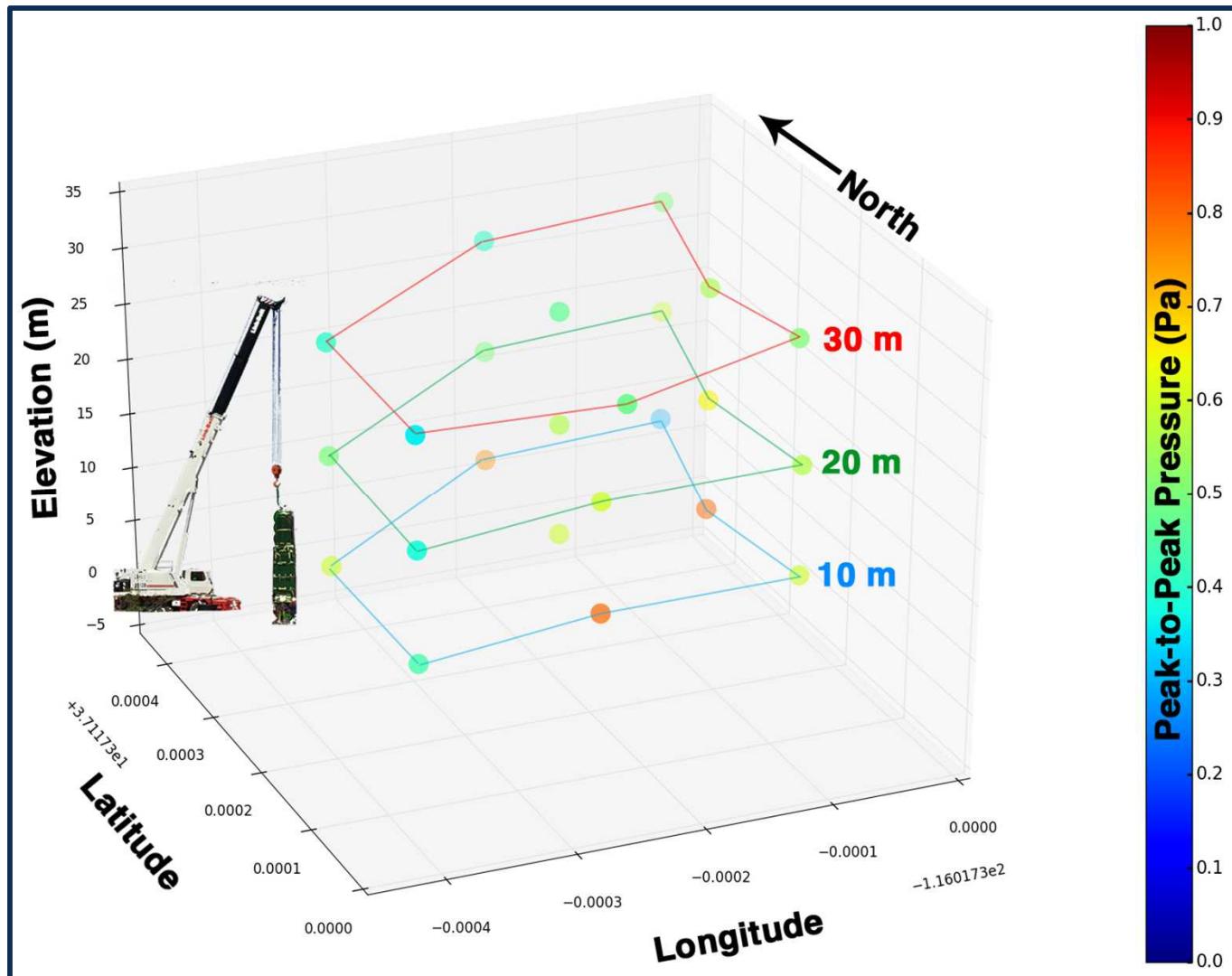
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Thor 2: Recorded Signals



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3D Mapping: Peak-to-Peak Amplitudes



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Summary

- The seismic hammer **DOES** generate infrasound signals
 - Signals have been recorded with good Signal to Noise Ratio (SNR) out to nearly 2 km
- The hammer is an incredibly **repeatable** source
 - This holds true in both the time and frequency domains
- Using an airborne infrasound system we have been able to map the acoustic wavefield in 3D
- The hammer can be used as a **seismo-acoustic in-situ array calibration source**

Questions?

- We would like to thank James Knox, NStec, and DRI.

