



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

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*Exceptional service in the national interest*

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UUR Sand #:

# Multi-Discipline Collaboration



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*Vision • Service • Partnership*



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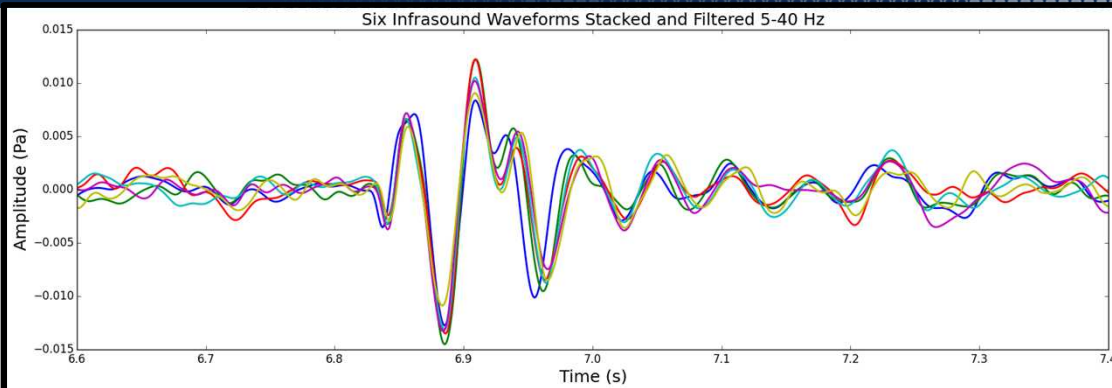
# *Background: It's a big hammer!*

## ***HK Exploration Seismic Hammer:***

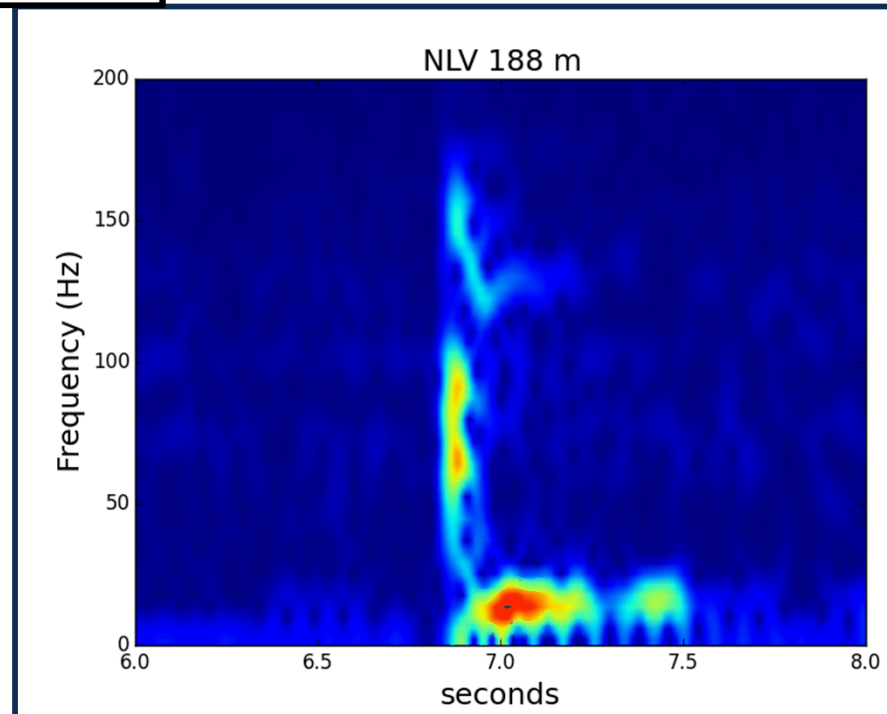
Impulsive Source can generate up to 0.19 Mega-Joules of energy by hydraulically lifting and dropping 13 metric ton mass from 1.5 m at roughly 3 shots per minute



# 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



# Thor 2: Infrasound Takes Flight



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

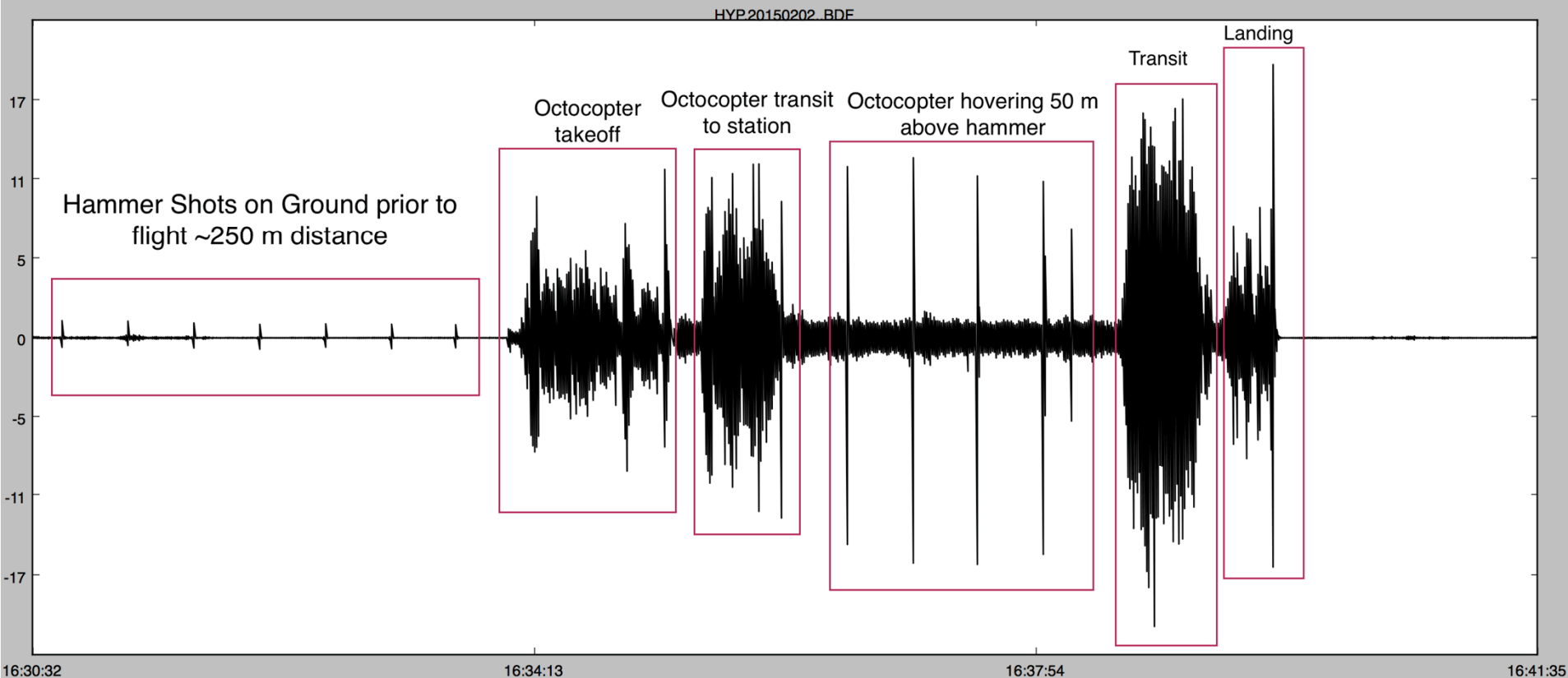
# *Thor 2: Hammer in Slow-Motion*



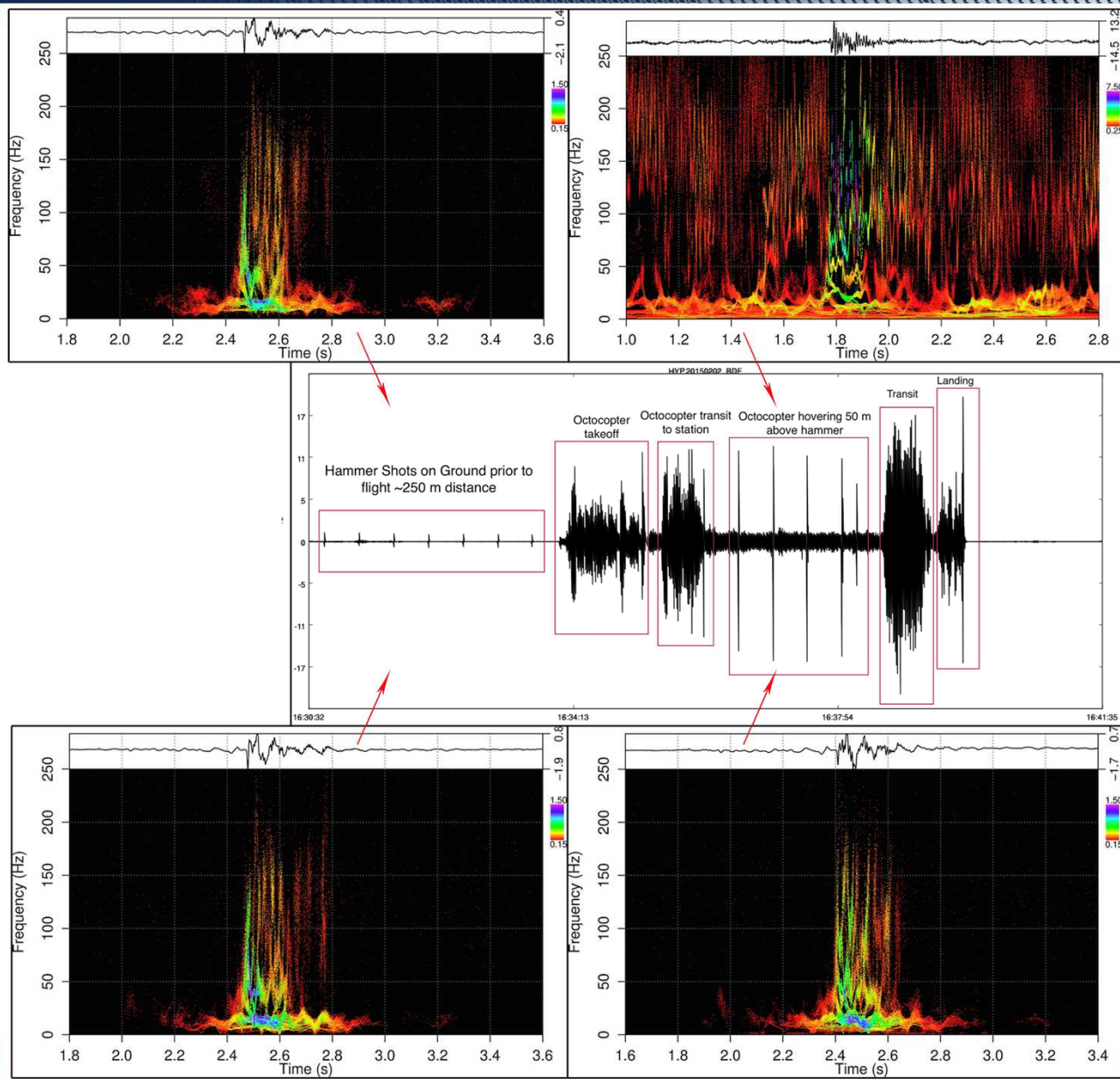
# *Thor 2: Overflight*



# Octocopter Infrasound : Success!!!



# Octocopter Infrasound : Ensemble Hilbert Spec



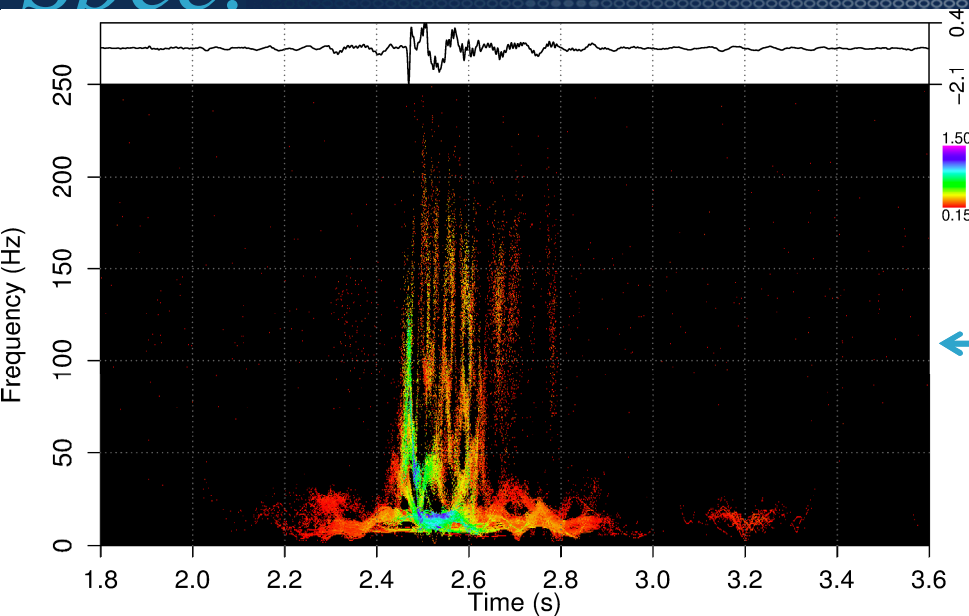
*Airborne  
Sensor*

*Ground  
Sensor*



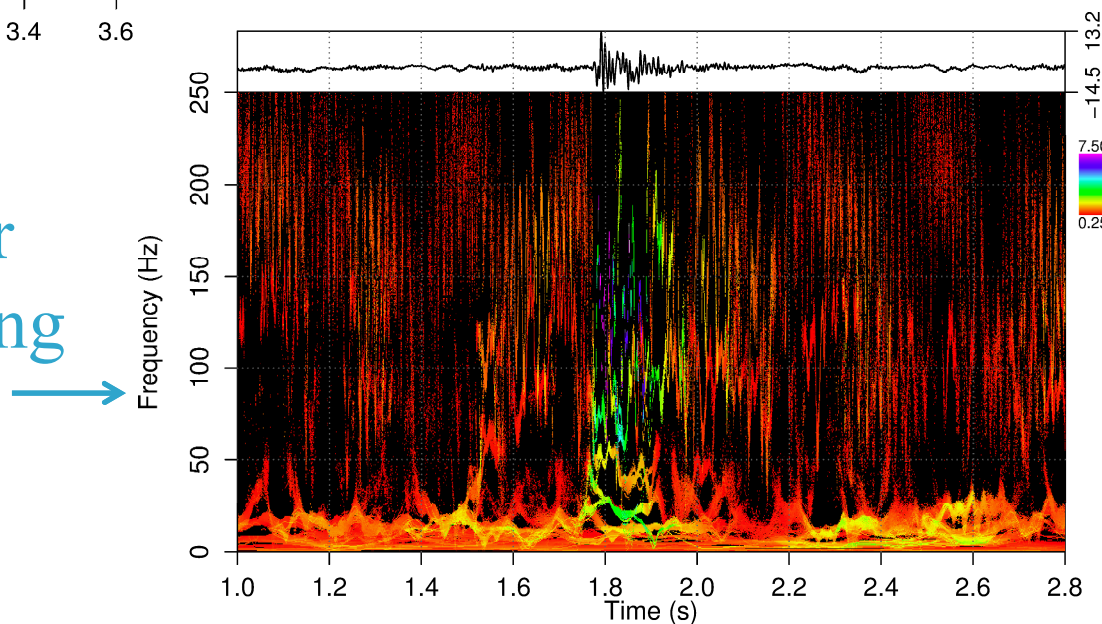
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# Octocopter Infrasound : Ensemble Hilbert Spec.



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

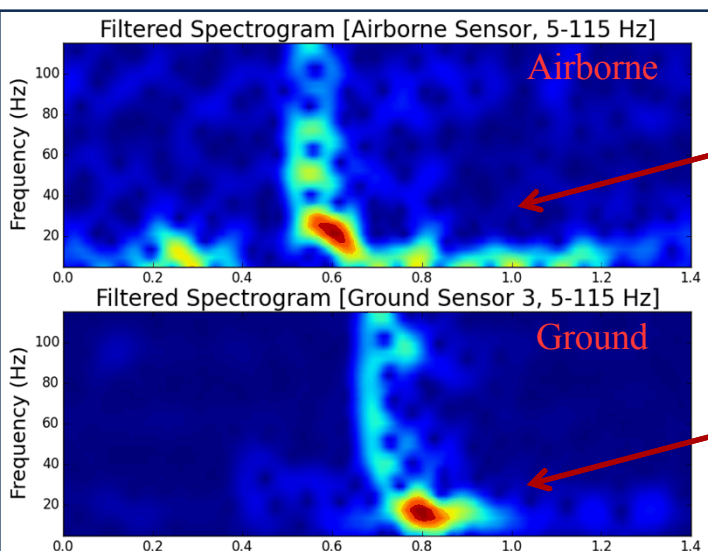
Flight path shown in red



# Octocopter Infrasound : Frequency

## Curiosity

### North Hover



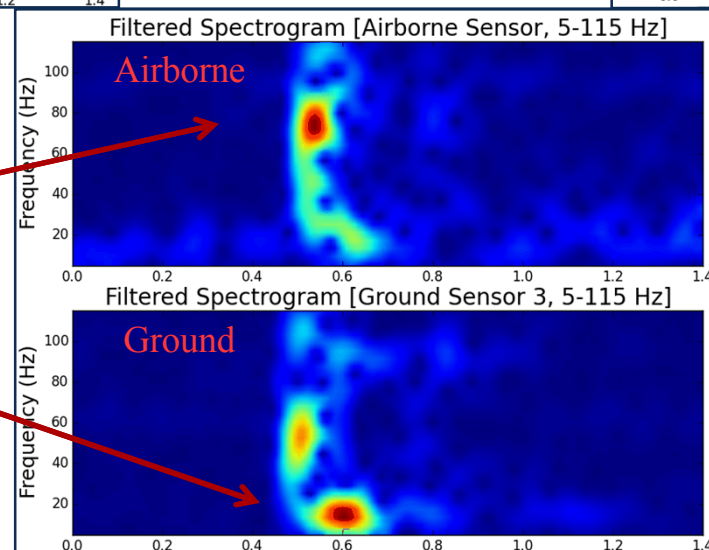
**~20 Hz Peak**

**~10 Hz Peak**

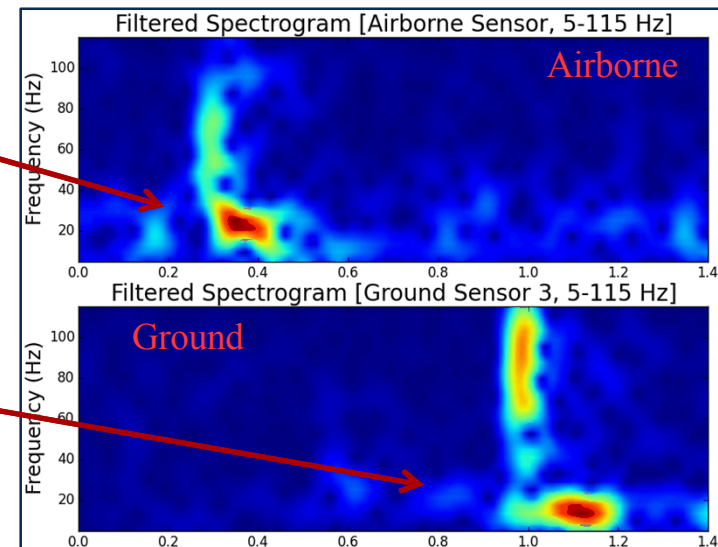
### Center Hover

**~80 Hz Peak**

**~10 Hz Peak**

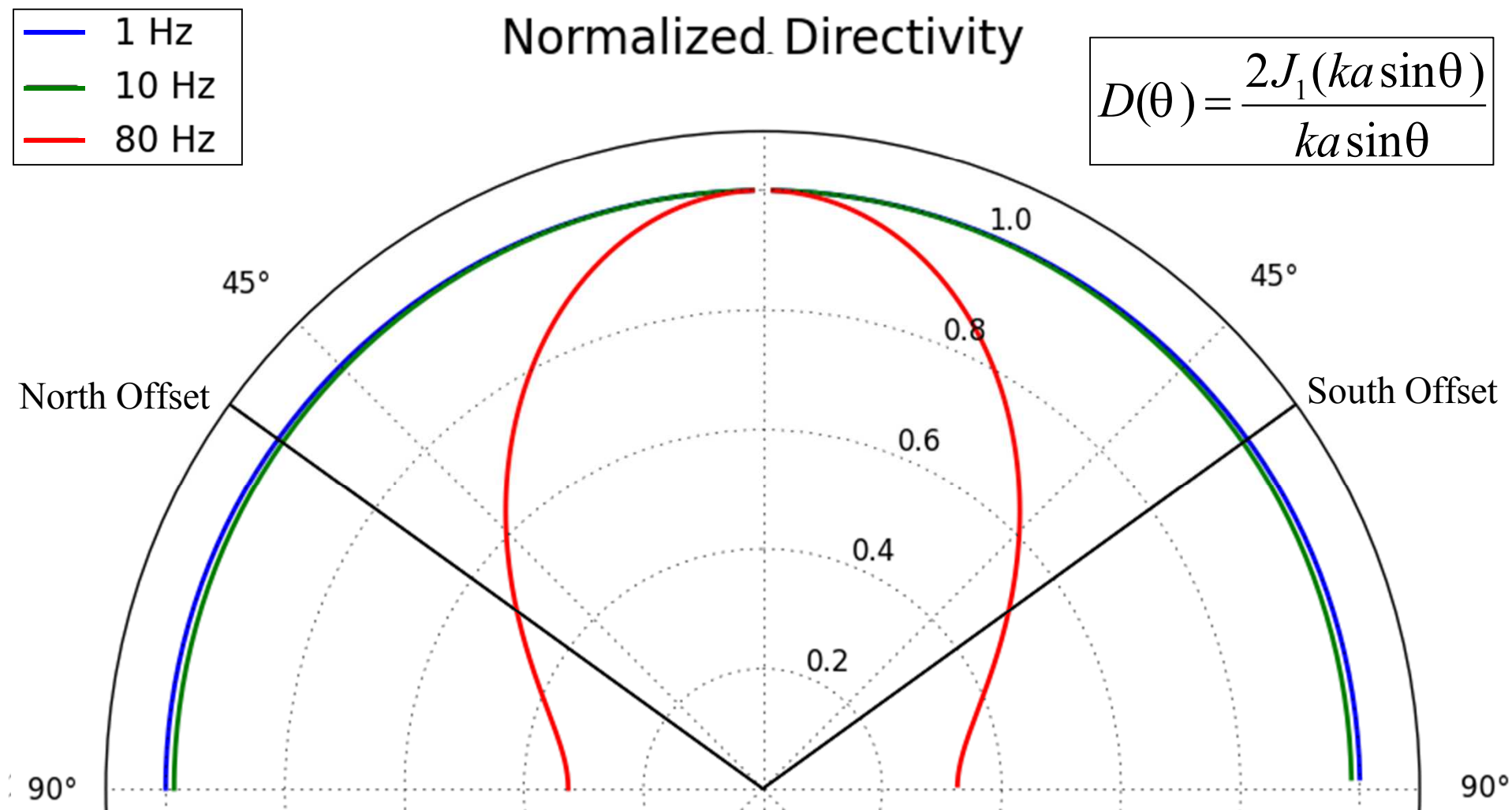


### South Hover



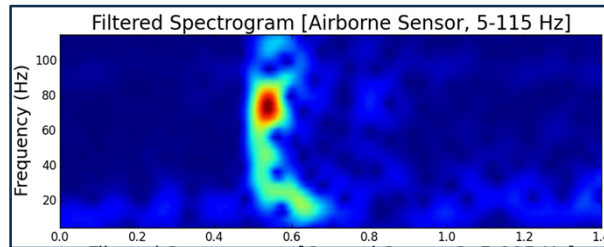
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# Octocopter Infrasound : Directivity



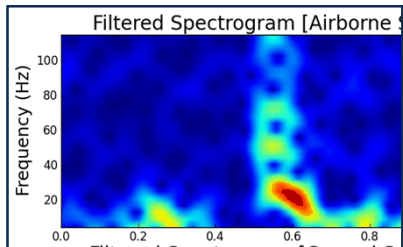
# Octocopter Infrasound : Directivity

Center

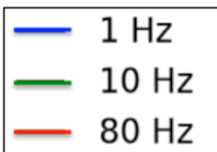
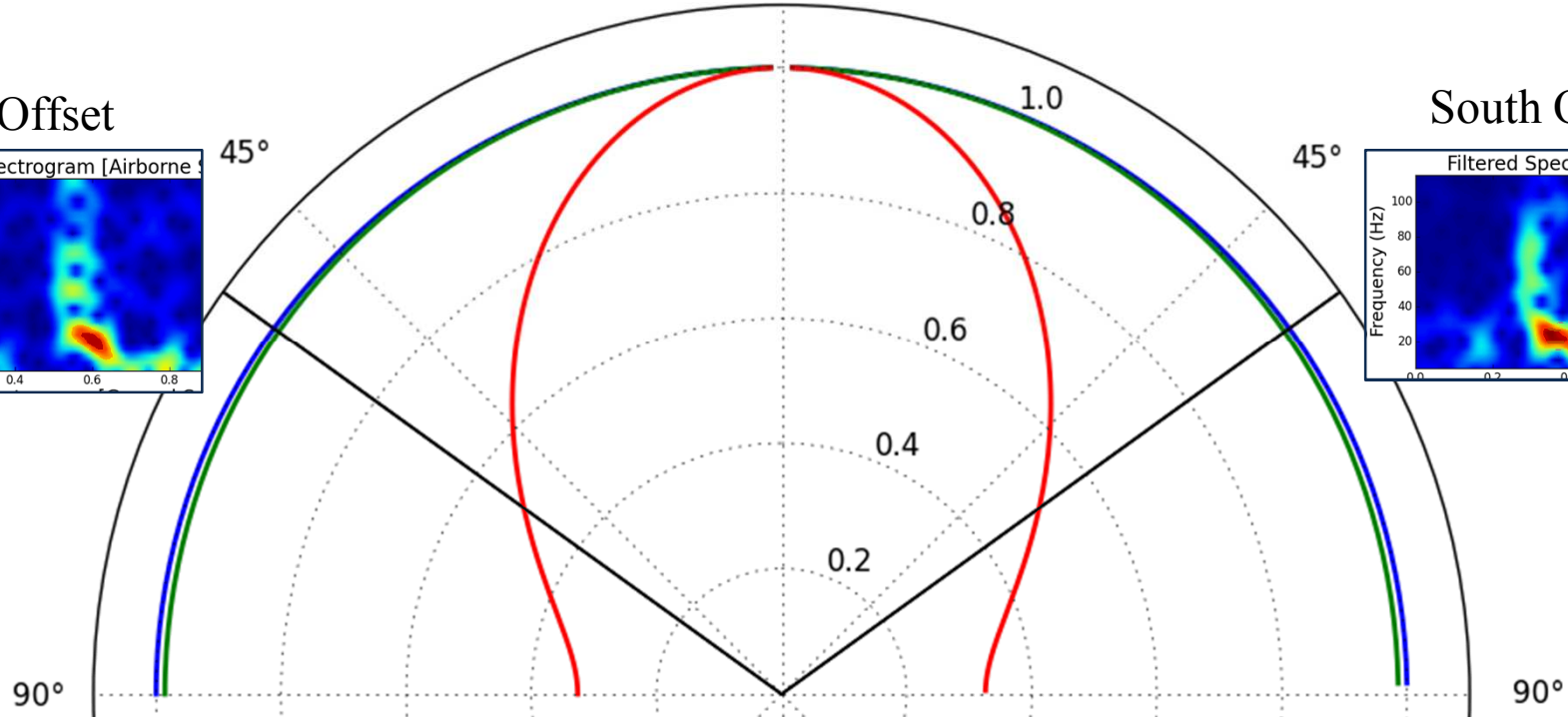
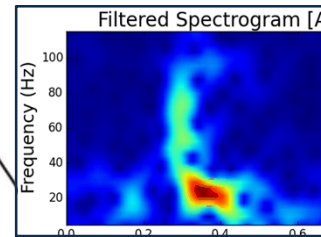


$$D(\theta) = \frac{2J_1(ka \sin\theta)}{ka \sin\theta}$$

North Offset



South Offset

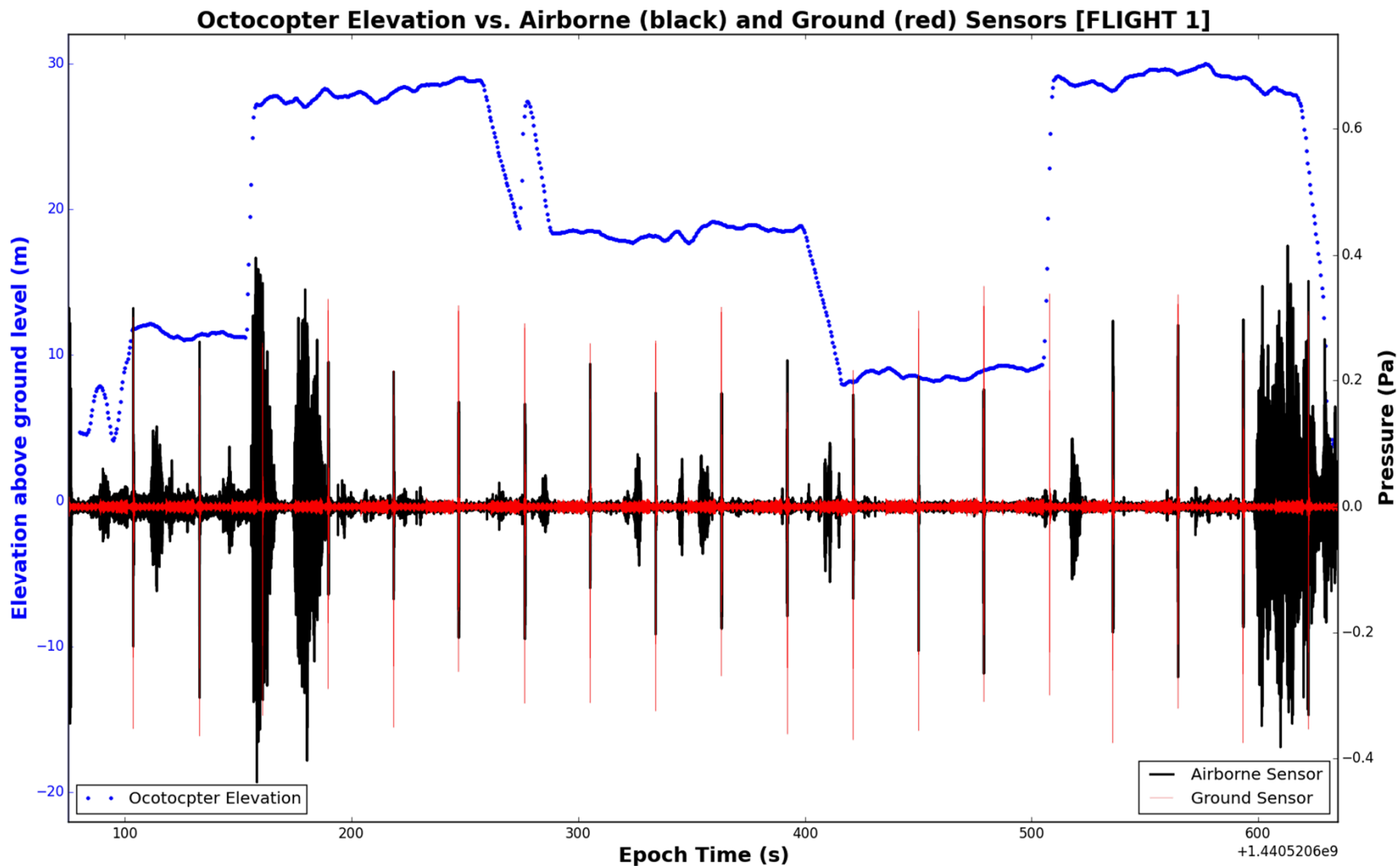


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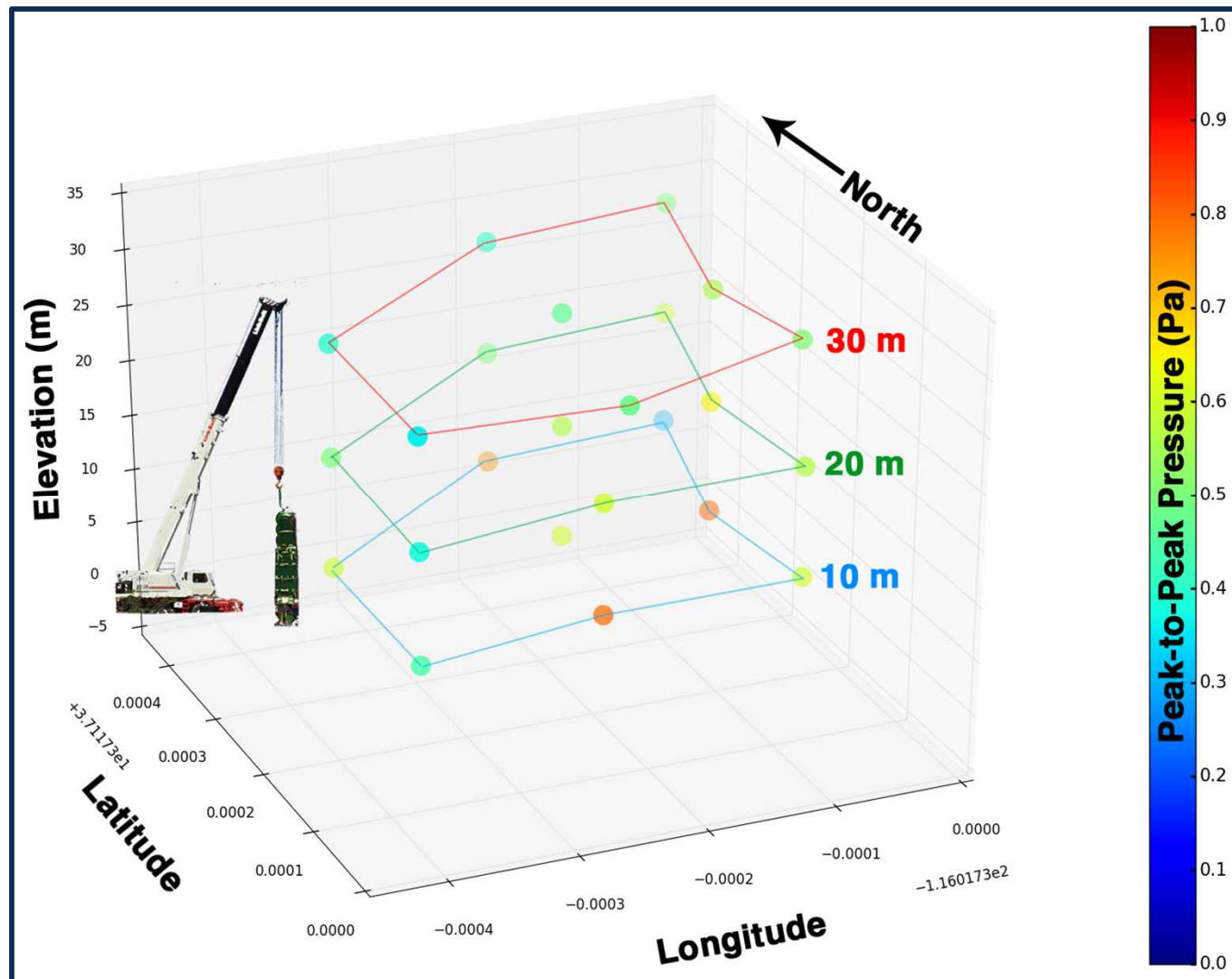
# Thor 2: Infrasound Takes Flight



# Thor 2: Recorded Signals



# 3D Mapping: *Peak-to-Peak Amplitudes*



# 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.

