# Infrasound Event Detection via Free Flying Stations in the Strato

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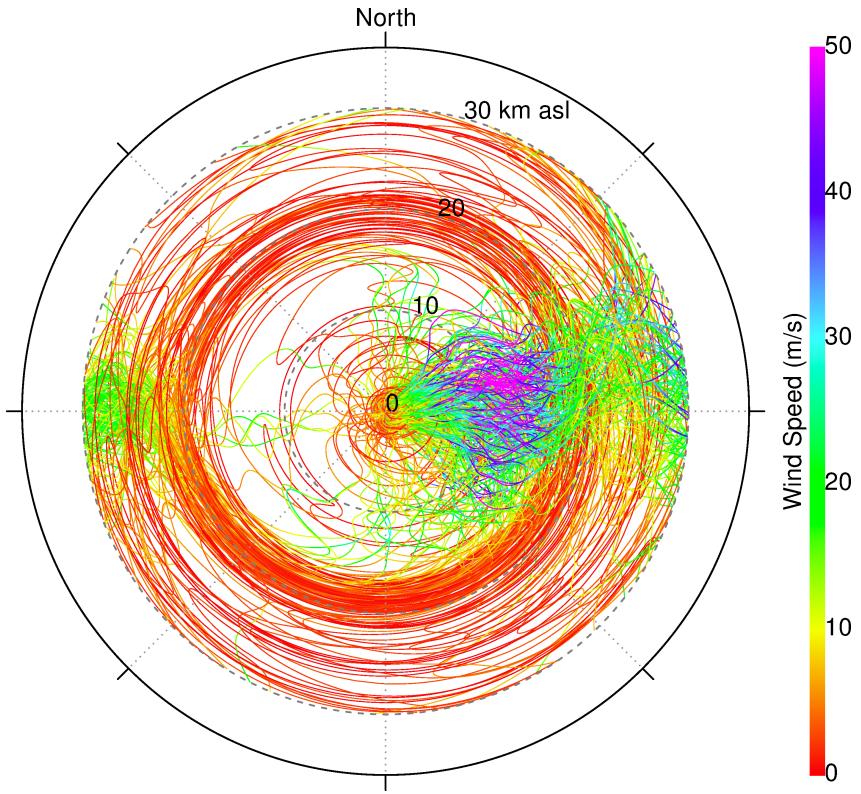
# The Lower Atmosphere

The troposphere and stratosphere are over an order of magnitude thicker than the mean depth of the ocean.

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# High Altitude Balloons: Quasi-Lagrangian Flight Systems

**Zero Pressure Helium Balloon**
Fly for hours to days
Lift 1000+ kg to 50 km+
Cost $100K+

**Solar Hot Air Balloon**
Fly for hours
Lift 1-2 kg to 20 km+
Cost $50

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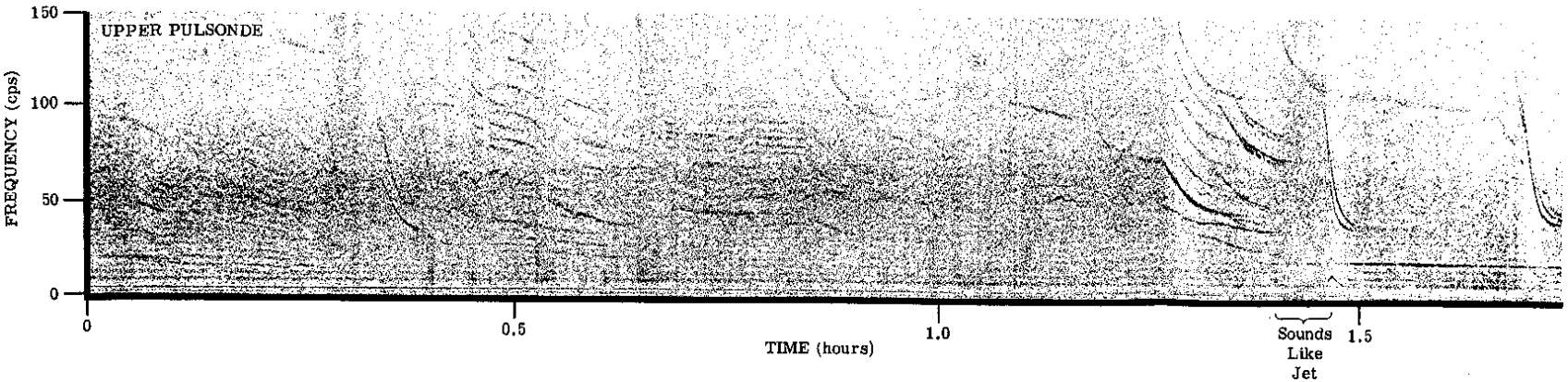
# History of Stratospheric Infrasound

**Project MOGUL**

- Detection of Soviet nuclear tests
- Active late 1940s - early 1950s
- Discontinued after Vela
- No extant data
- "Roswell Incident"

**Wescott**

- $>$ 30 flights between 15 and 22 km
- Active in early 1960s
- Doppler shifts from propeller aircraft
- Background noise from turbulence
- Other, unknown events

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# The 2014-2015 HASP Flights



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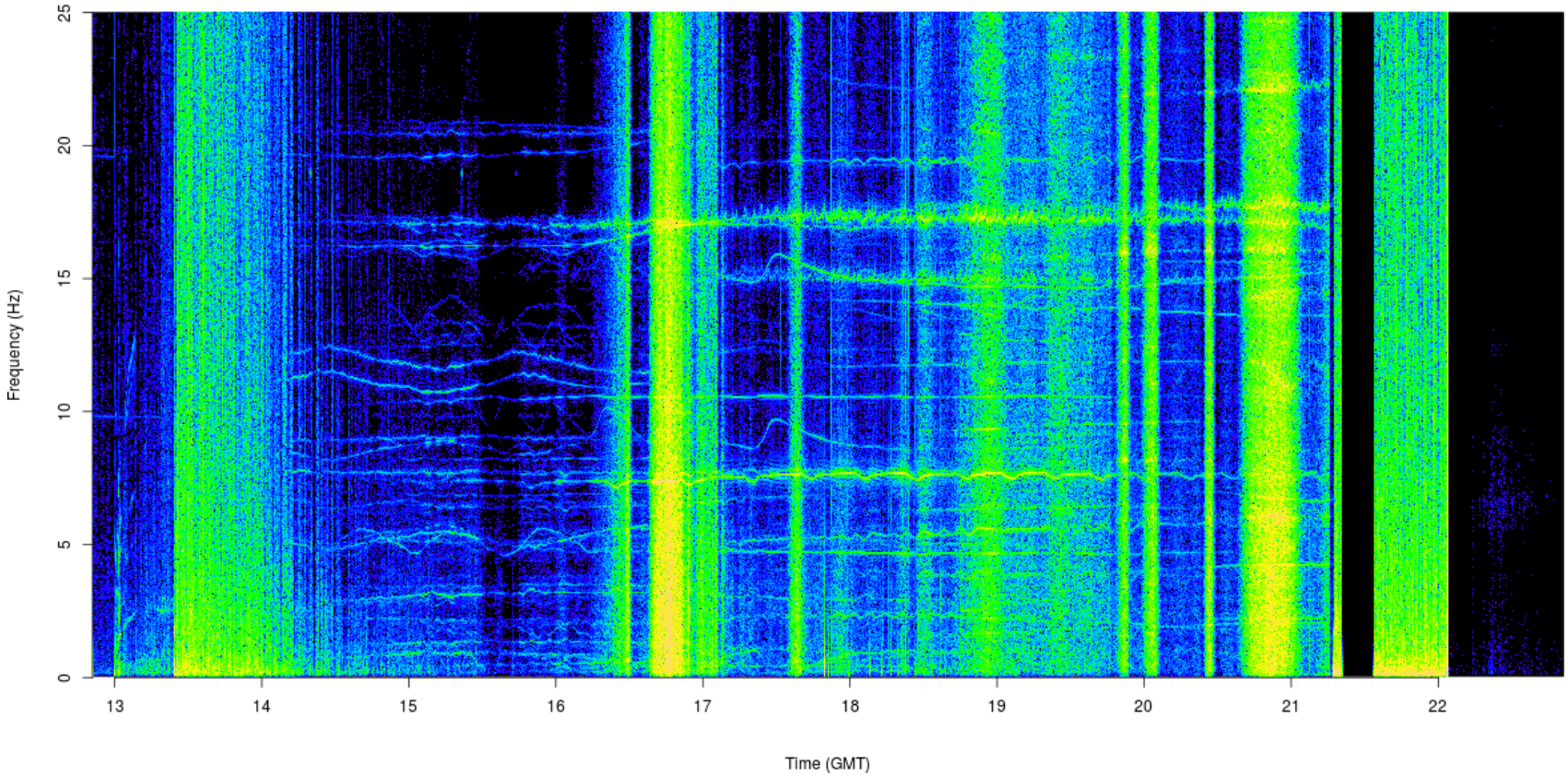
# Initial Results

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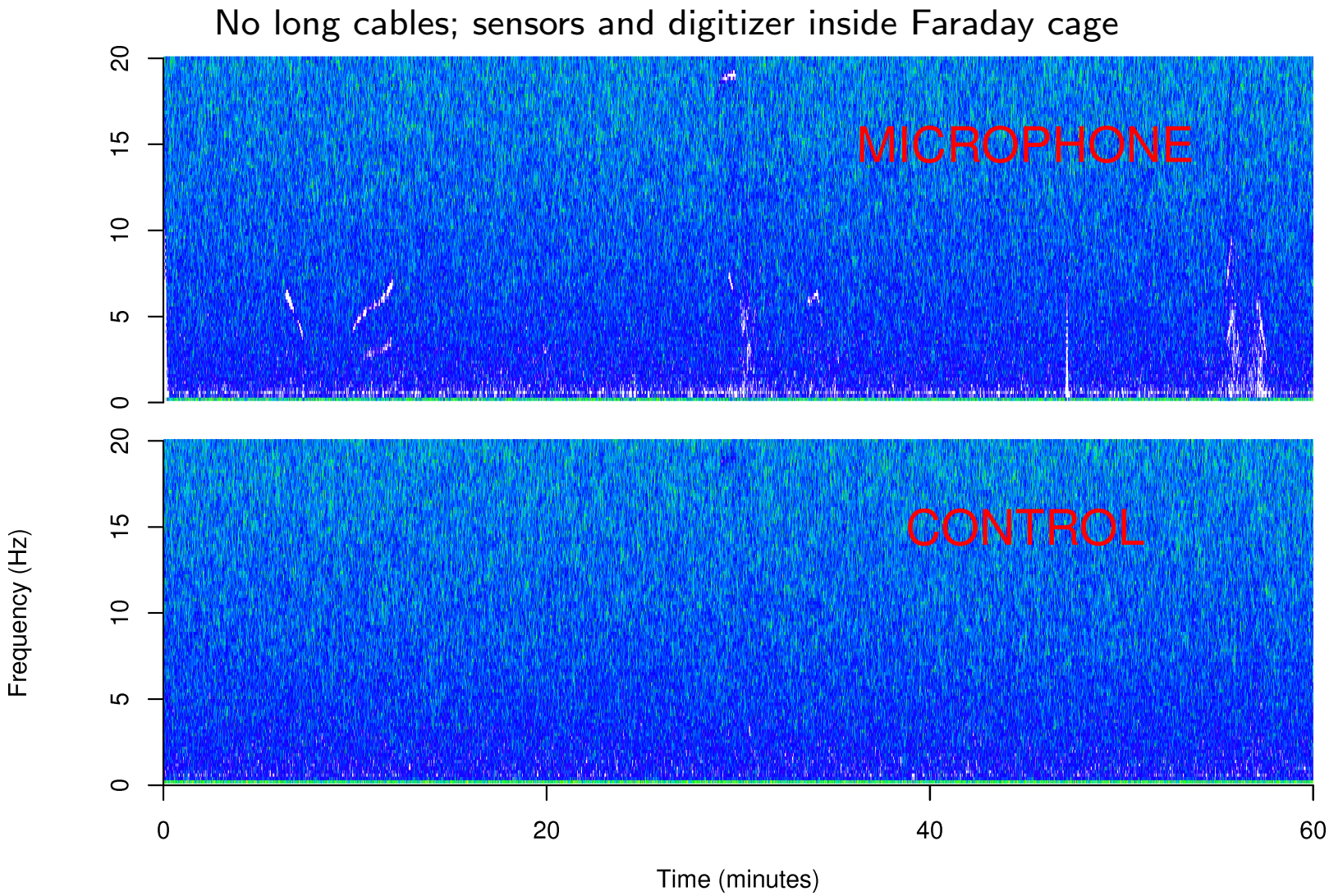
# The HASP 2016 Flight

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# The UNC-Sandia Infrasound Experiment (USIE/SISE)

## Objective: Detect a known ground source

A collaboration between **Eliot Young** (Southwest Research Institute), **Daniel Bowman** (Sandia), and **Jonathan Lees** (UNC Chapel Hill)

- Three co-located explosions
- Shot interval: 1 to 1.5 hours
- Yield: 1000 kg TNT equivalent
- Multiple on board sensors/digitizers
- Balloon at $>$ 30 km asl
- Extensive ground network

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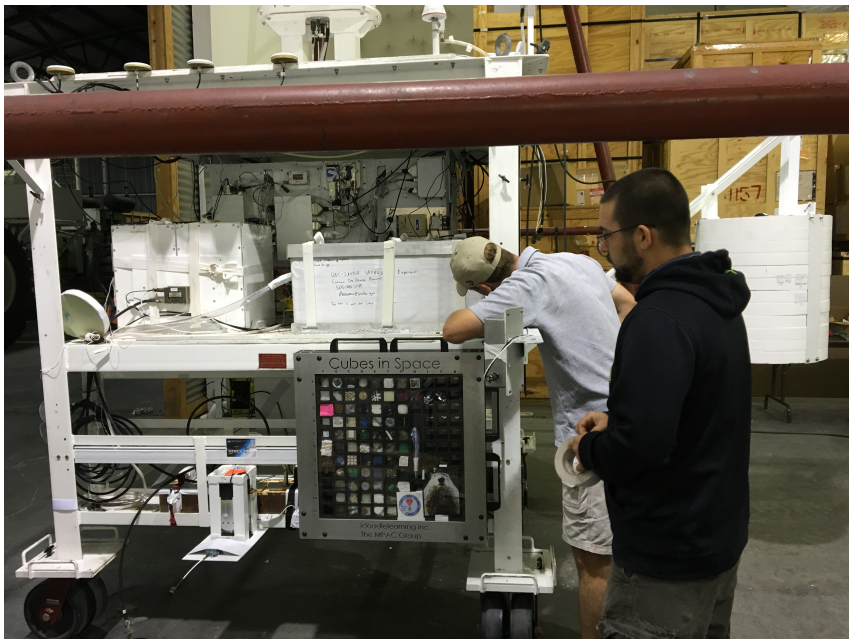
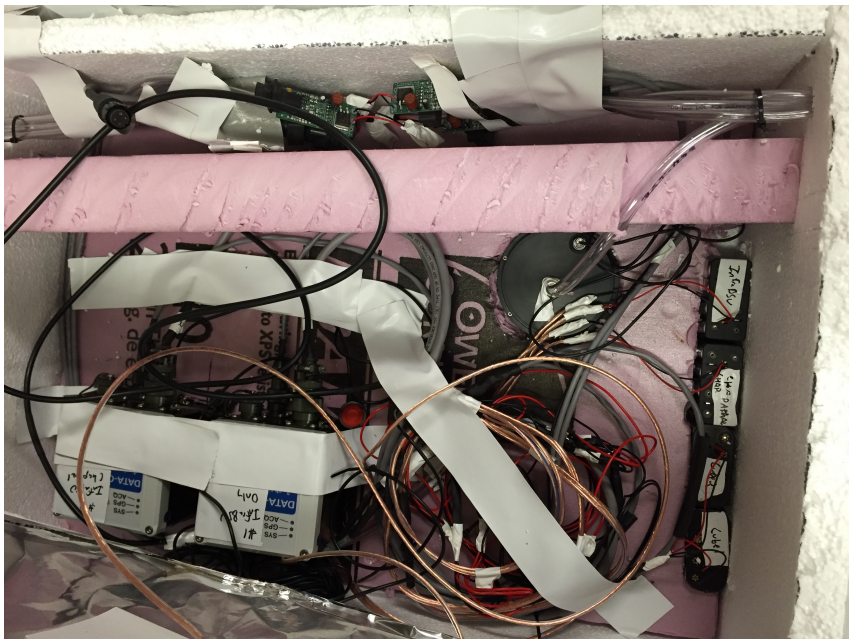
# USIE Payload Design



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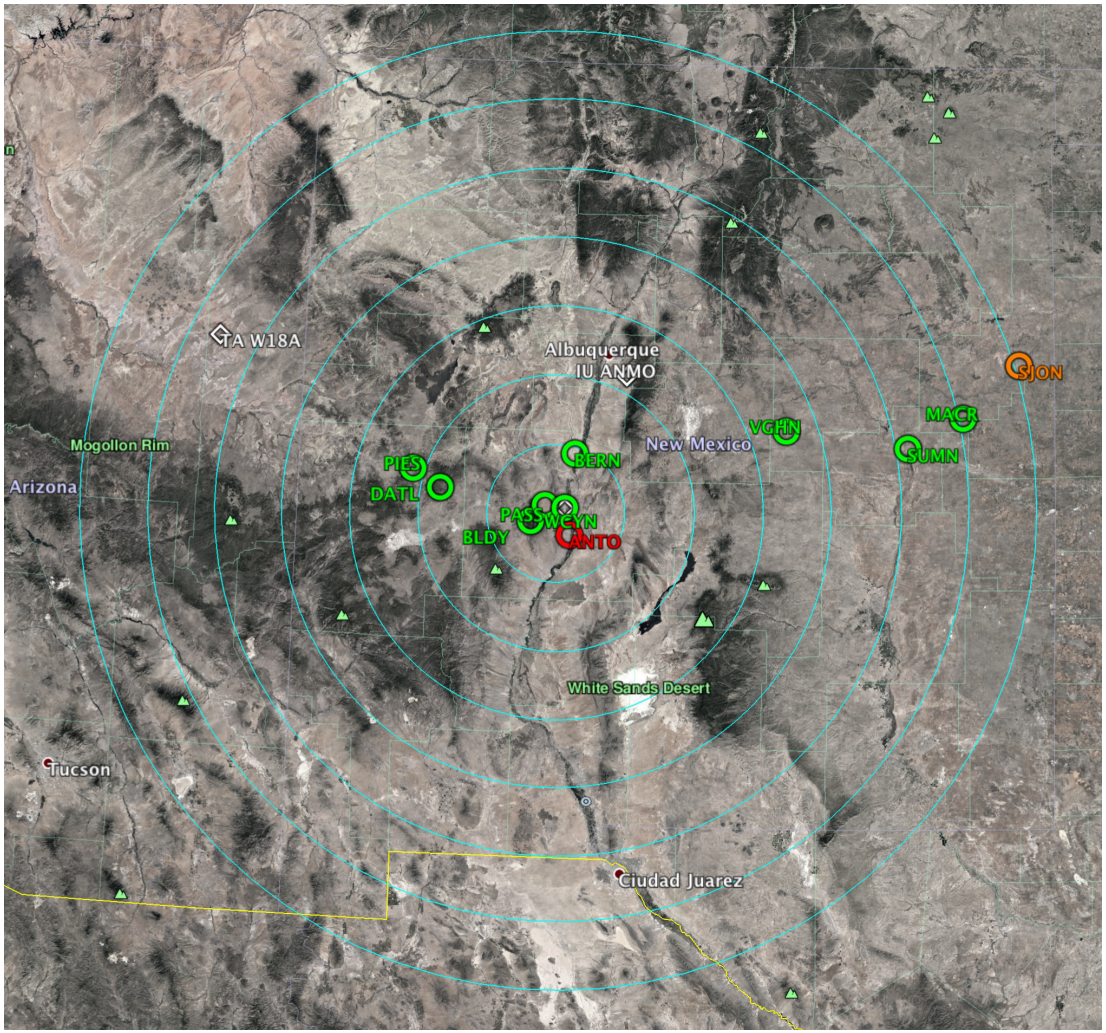
# Ground Network




9 stations for 3 shots

10 for the last 2 shots

6 to 350 km range

250 km aperture

Several permanent stations

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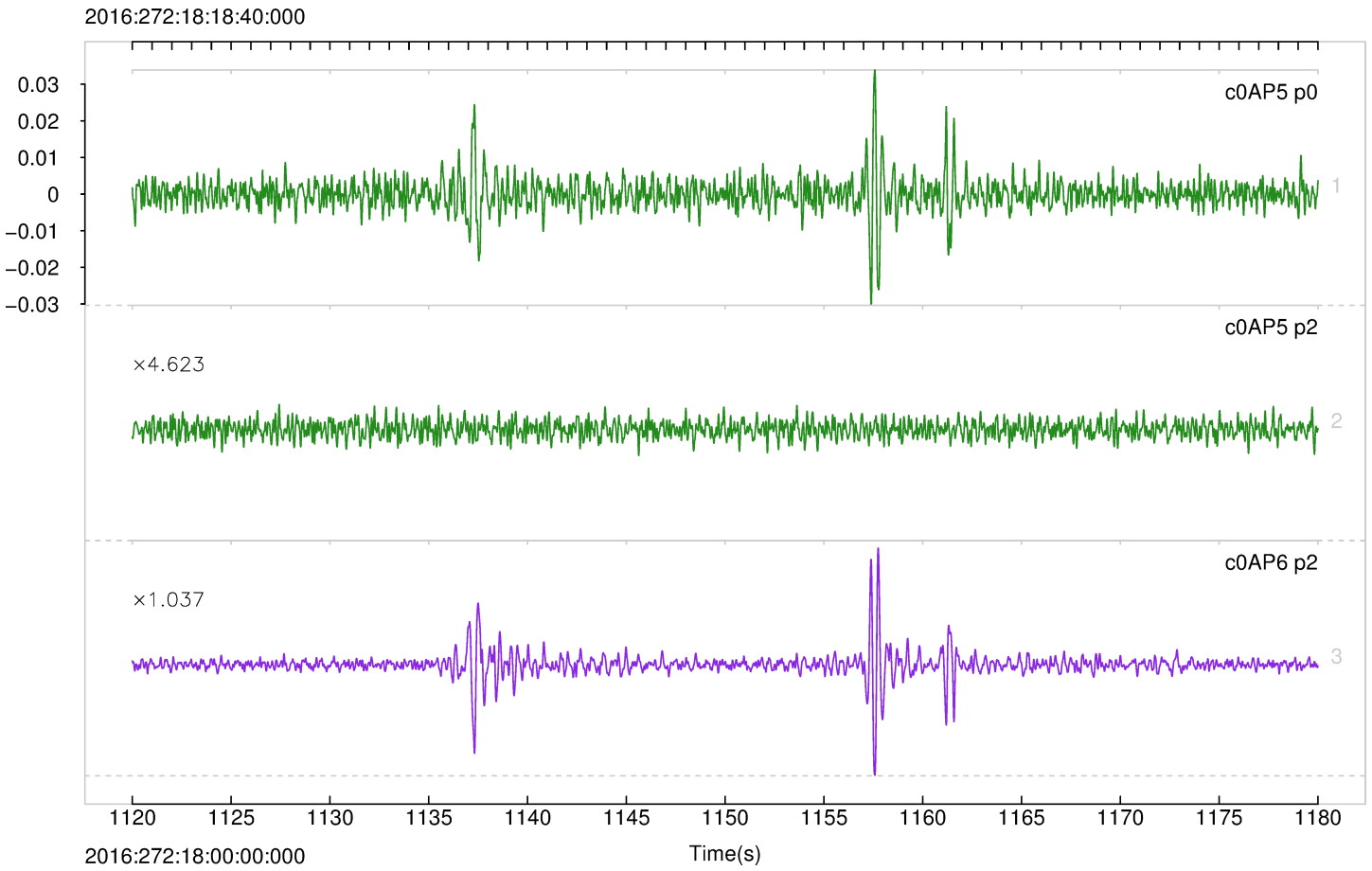
# Signal on USIE

First shot: $\approx$ 340 km range, band passed at 1-10 Hz, units in Pa.

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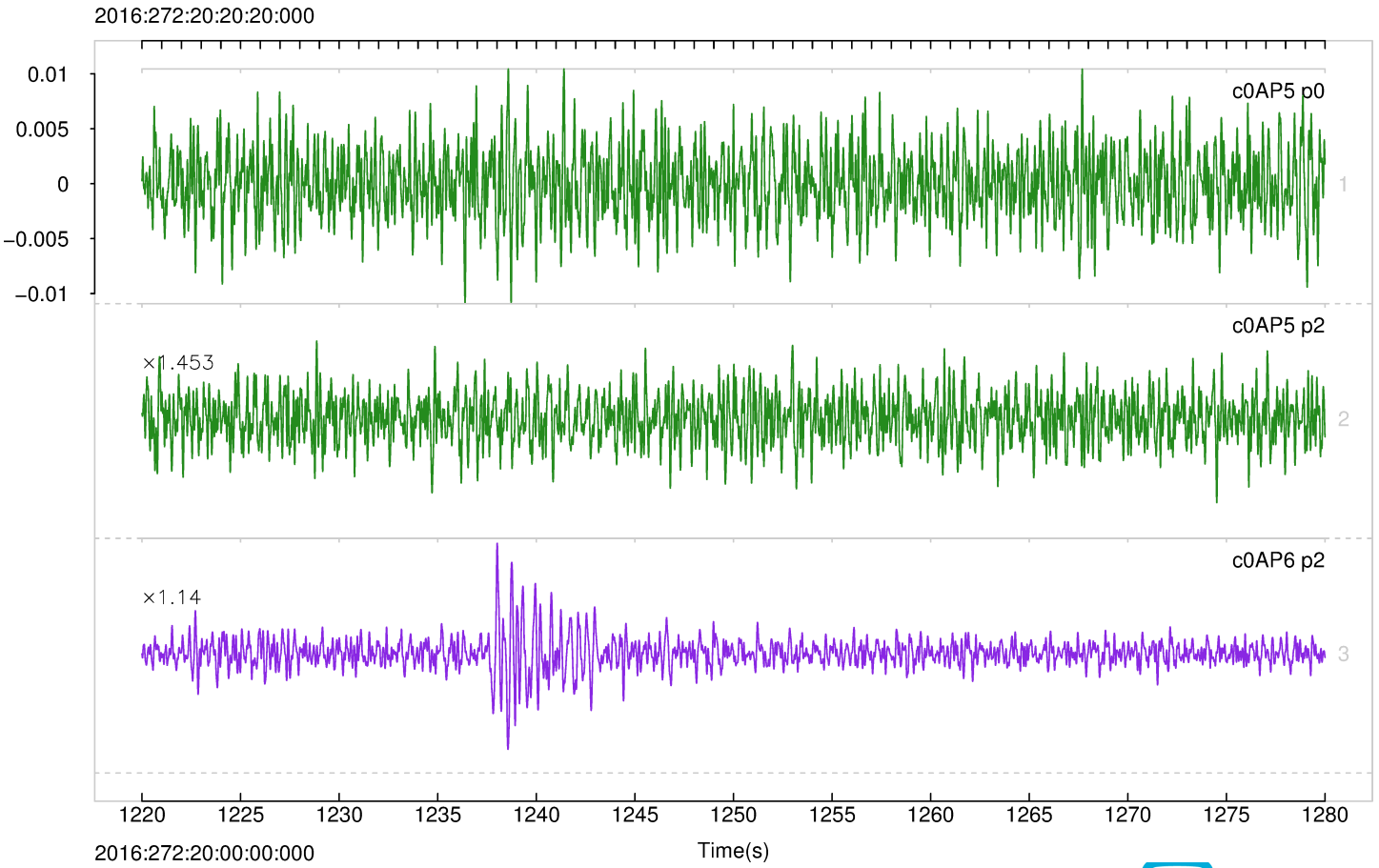
# Signal on USIE

Second shot: $\approx$ 360 km range, band passed at 1-10 Hz, units in Pa.

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# 2016 Ultra Long Duration Balloon Flight

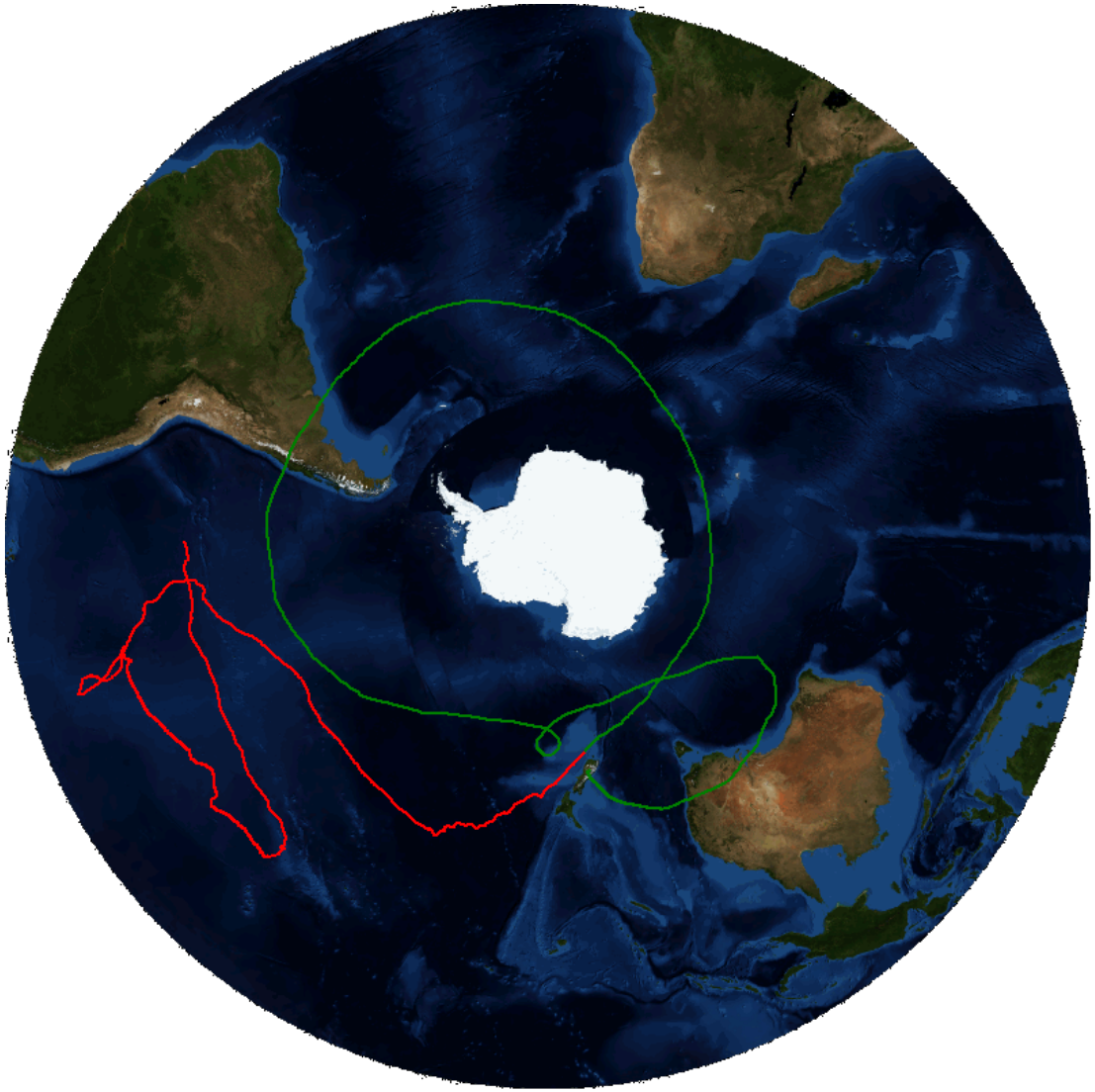

Image Credit: Columbia Scientific Ballooning Facility

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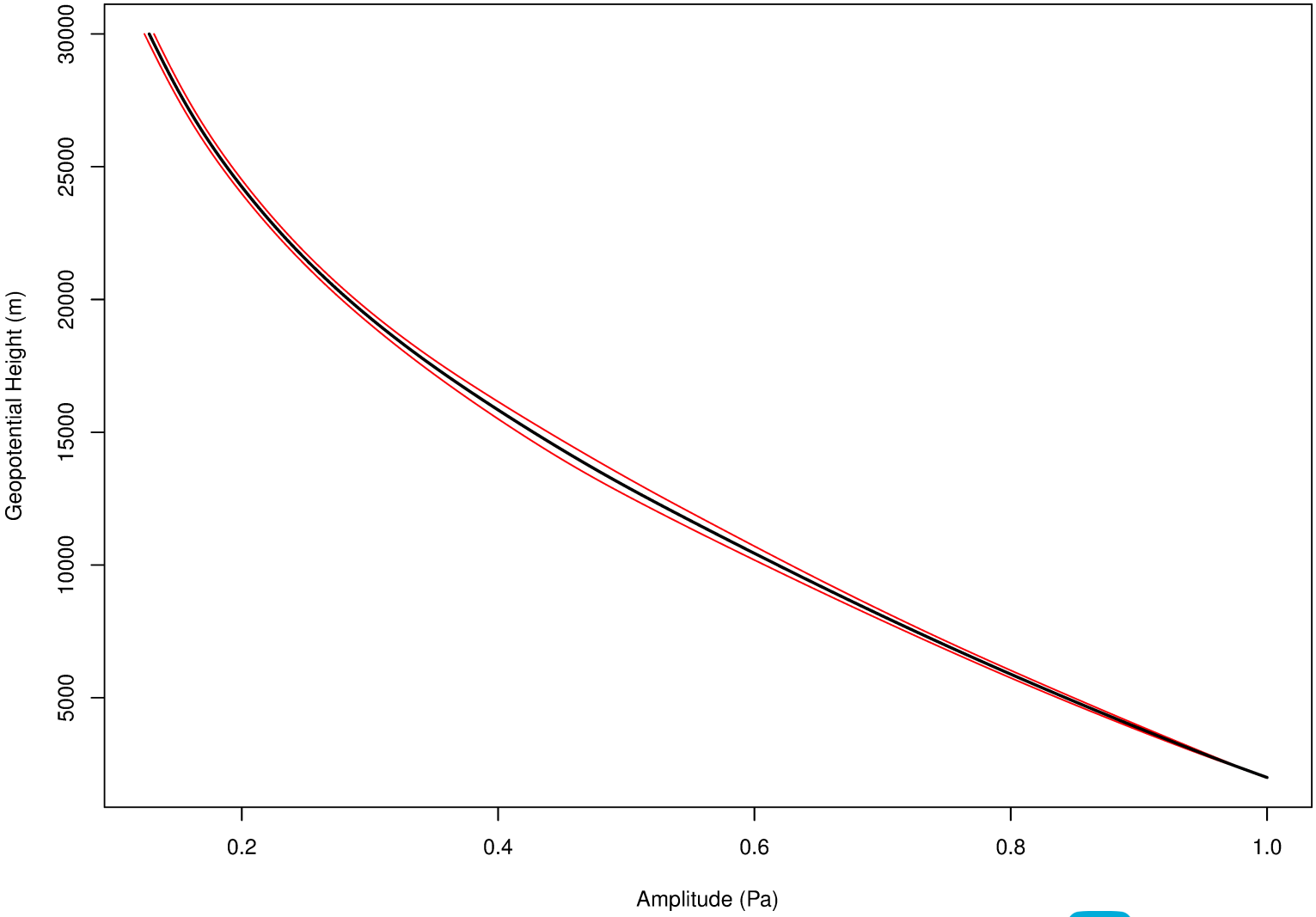
# Sensitivity Constraints

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# The Next Frontier of Infrasound?

We have demonstrated the **detection of a known source** at long range using **a single infrasound sensor**.

**Electronic noise** determines the detectability threshold, **not wind noise**.

Free floating stations can **cover vast distances**, including over the open ocean.

Flights can last for **days, months,** and perhaps **years**.

Research and development needed on **low self noise sensors** and **telemetry systems.**

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# Acknowledgments

We are very grateful to our collaborators, **Eliot Young** of the Southwest Research Institute and **Jonathan Lees** of the University of North Carolina at Chapel Hill.

We thank the NASA Balloon Program office and Columbia Scientific Ballooning Facility for accommodating our payloads.

This work began with the NASA High Altitude Student Platform, without which later projects would not have taken place.

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