SAND2022-4032C

Sandia National Laboratories

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AtmoSOFAR

Verifying the Presence of an Acoustic Duct with Balloon-borne Infrasound

Sarah Albert

Daniel Bowman, Fransiska Dannemann Dugick, Elizabeth Silber

22 April 2022

Seismological Society of America Annual Meeting 2022

SAND2022-XXXXC

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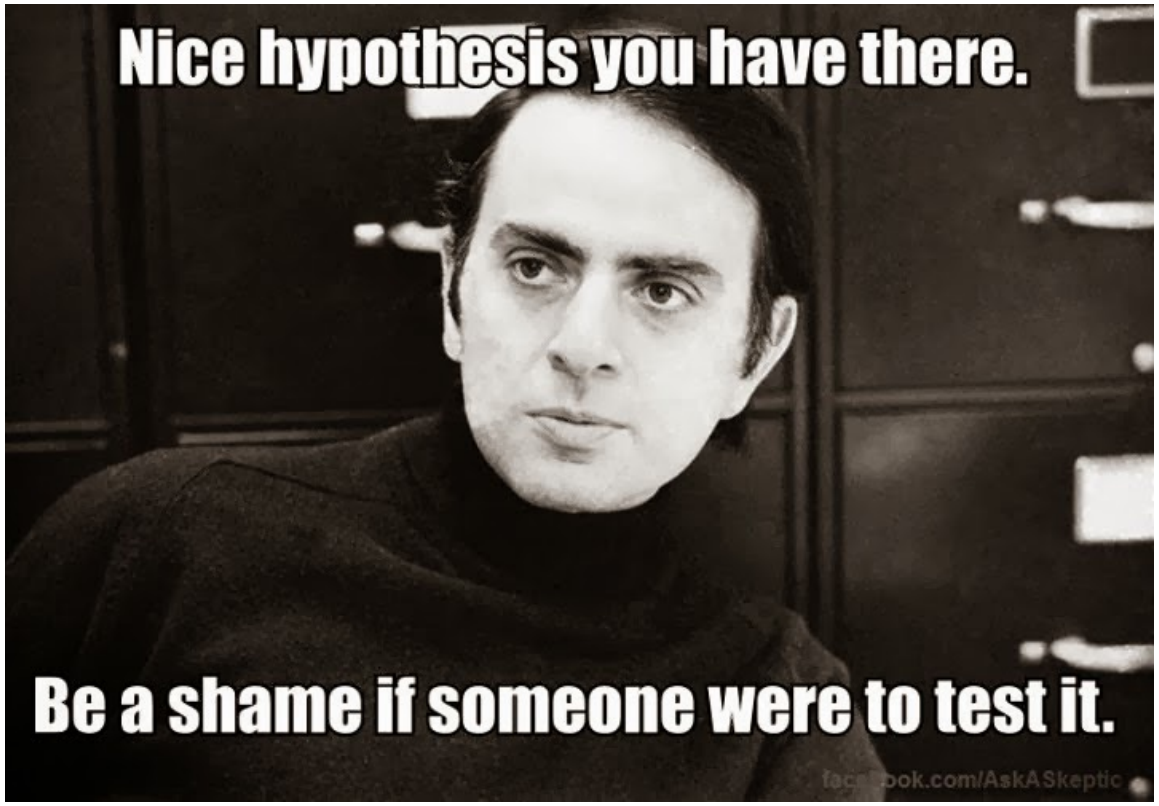
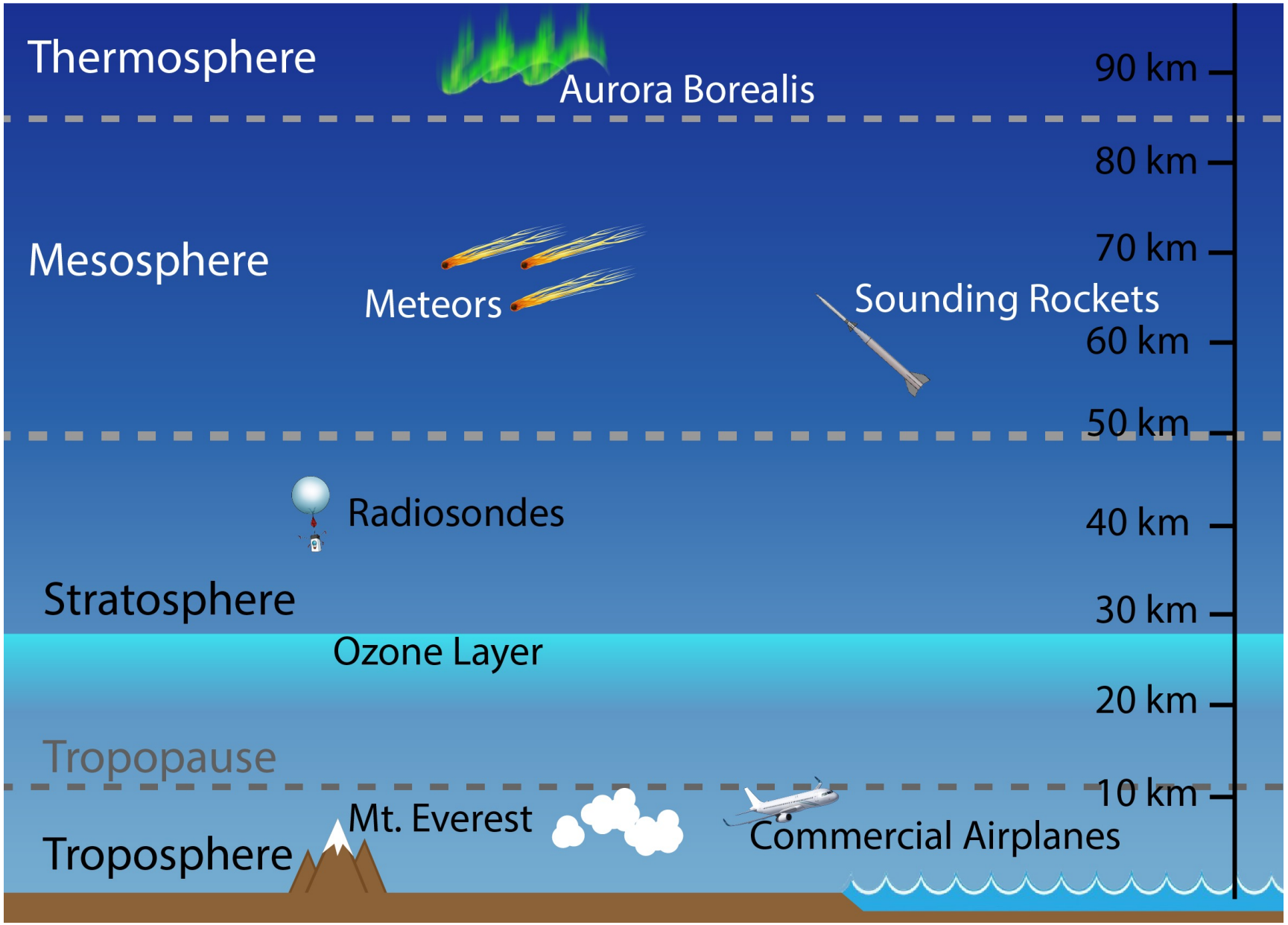
Reality Check and Impact

Us to the customer: “Within minutes of recovering the data we’ll be able to tell you if the rocket was detected.”



This work proves the ability to **detect events of interest in the AtmoSOFAR channel** and highlights a **surprisingly complex acoustic background** structure at altitude.

Layers of the Atmosphere



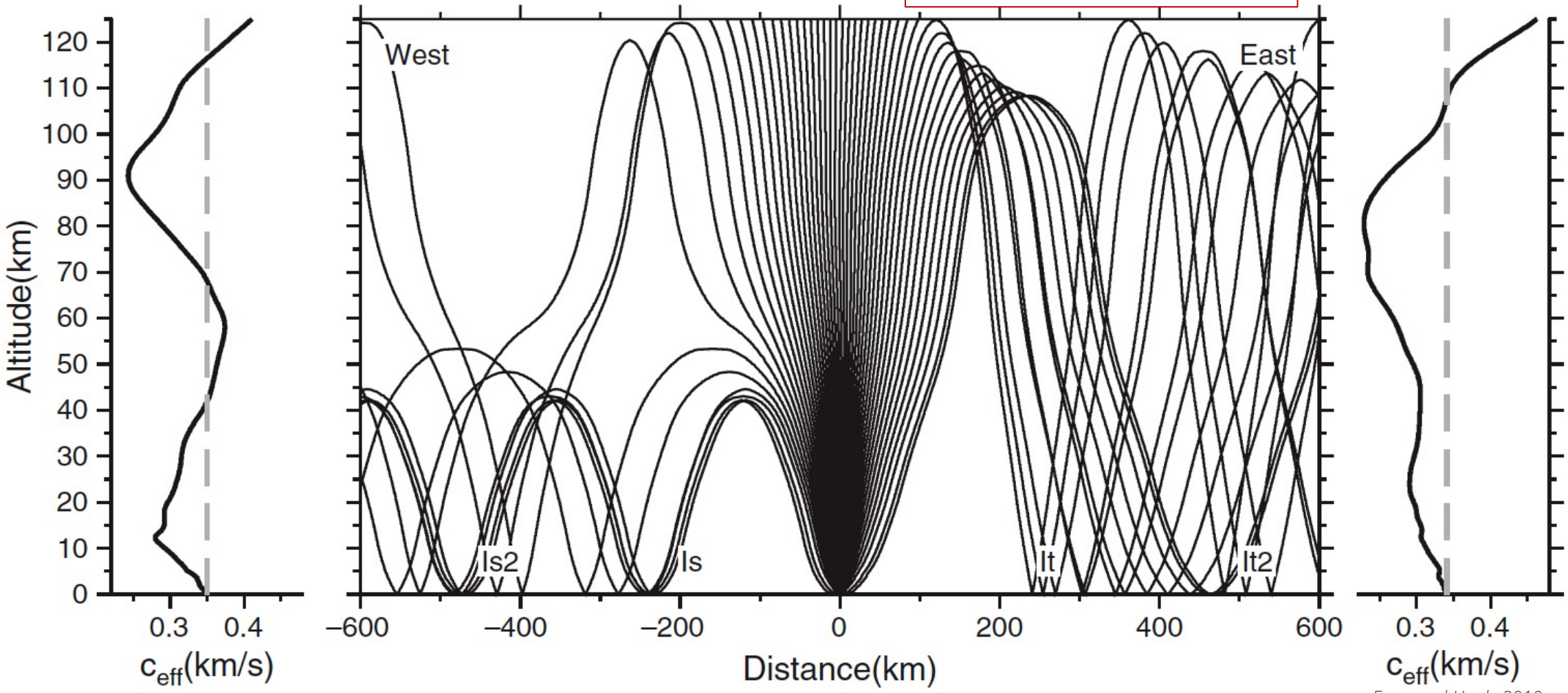
Infrasound Propagation

Wave "turning height" depends on effective sound speed

$$c_{eff} \approx 20.04\sqrt{T} + \vec{n} \cdot \vec{w}$$

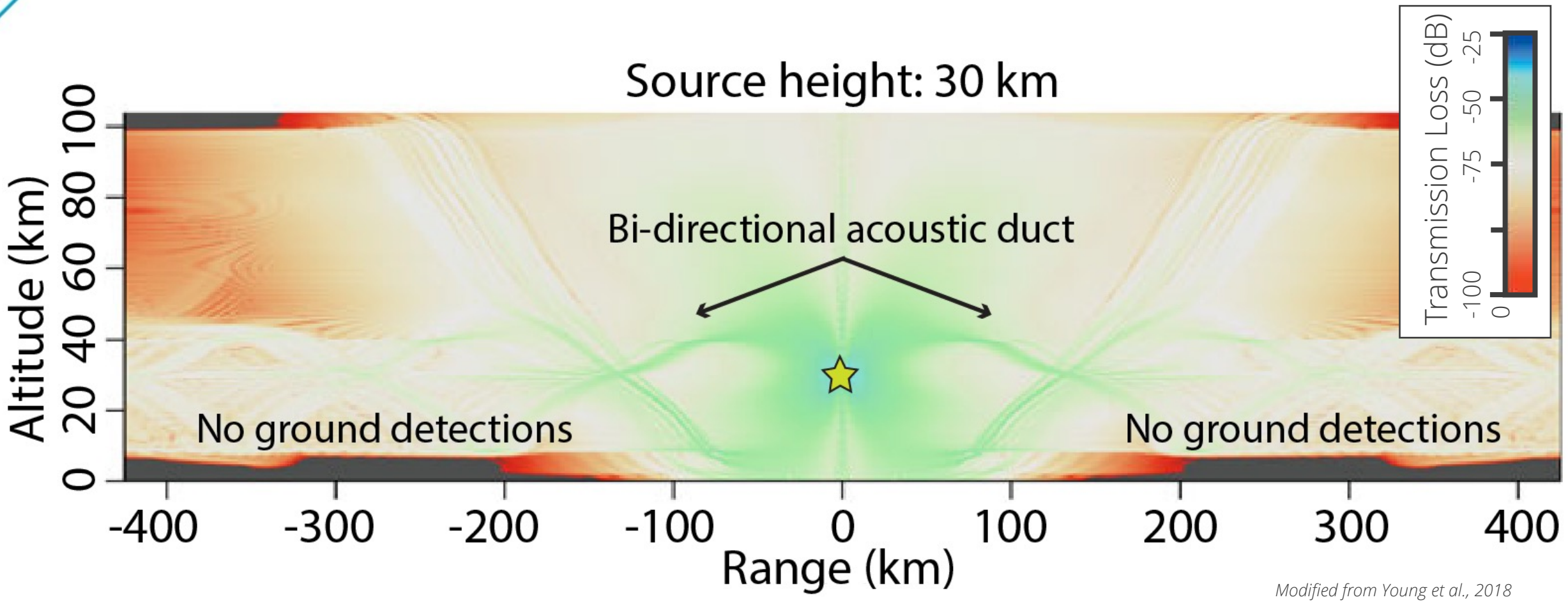
wind component

temperature component



Evers and Haak, 2010

Atmospheric SOFAR (AtmoSOFAR) Channel



Modified from Young et al., 2018

Solar Balloon Design

Bowman et. al, 2020

6 m Heliotrope Solar Balloon

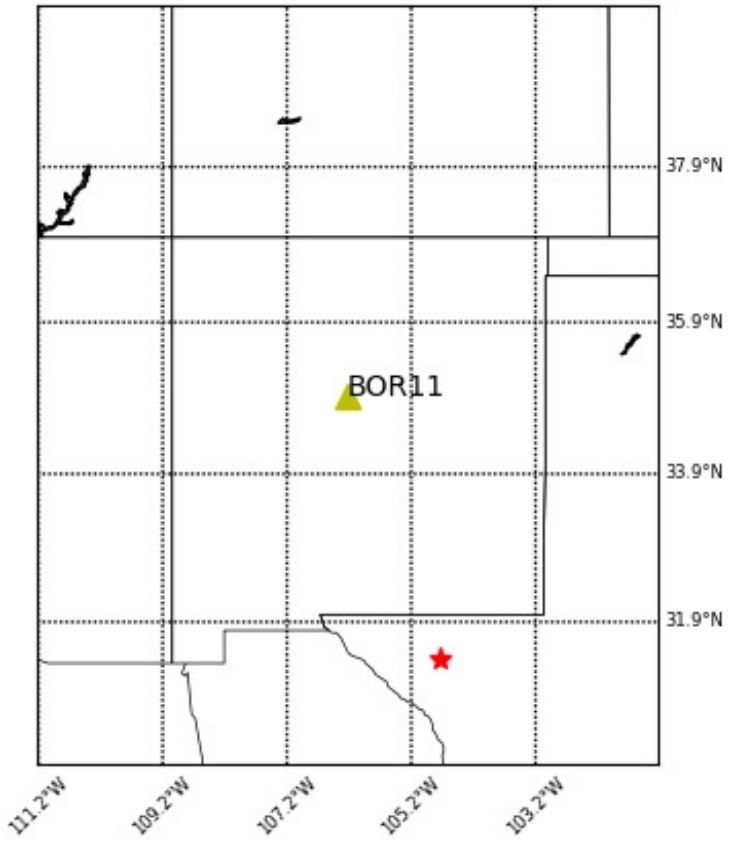
- Lightweight, plastic, balloon – darkened with charcoal powder
- Infrasound sensor/digitizer, GPS tracking, temperature sensor
- High-resolution GEM infrasound logger, when possible
- Two flight campaigns

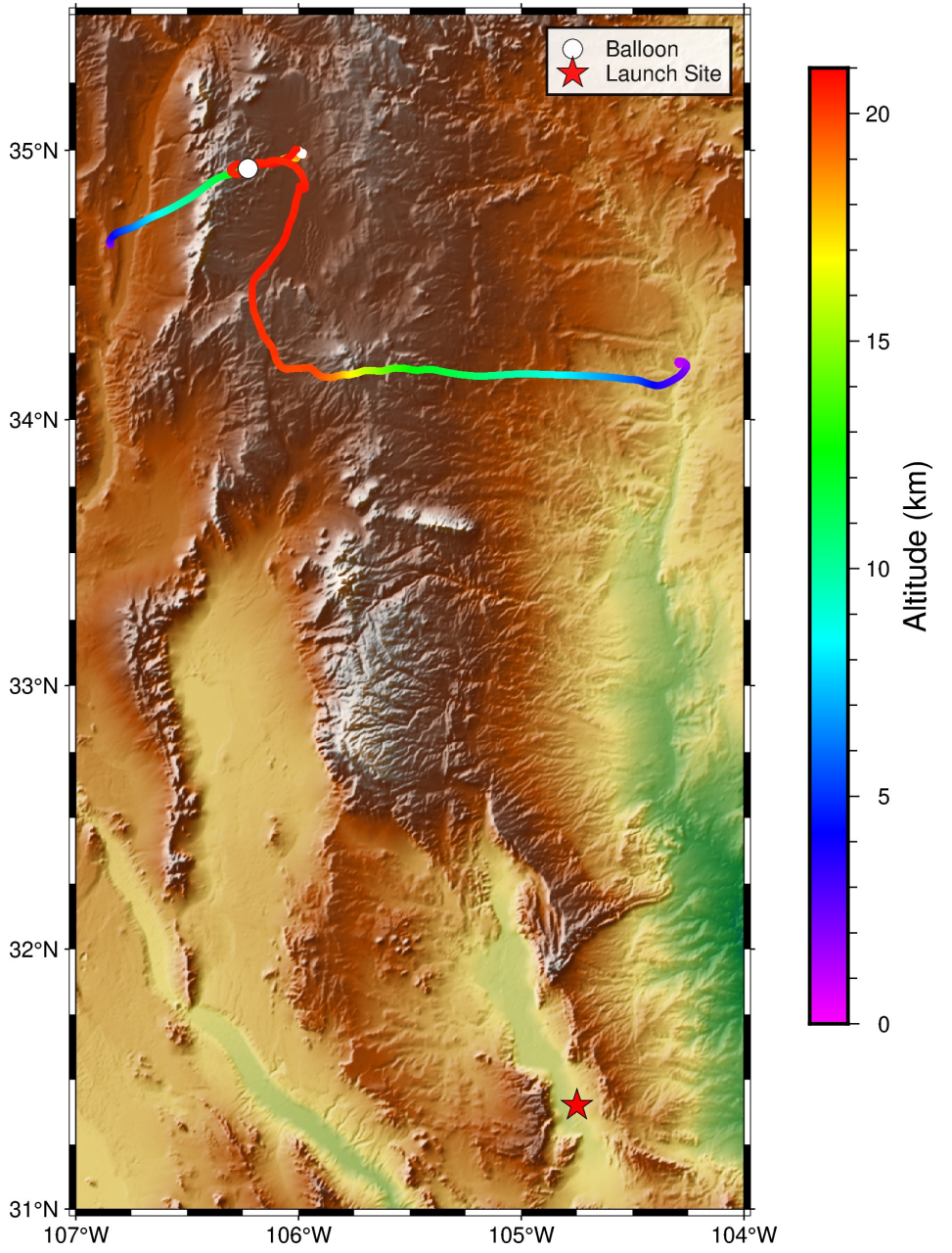
Blue Origin NS-15

Launch Information

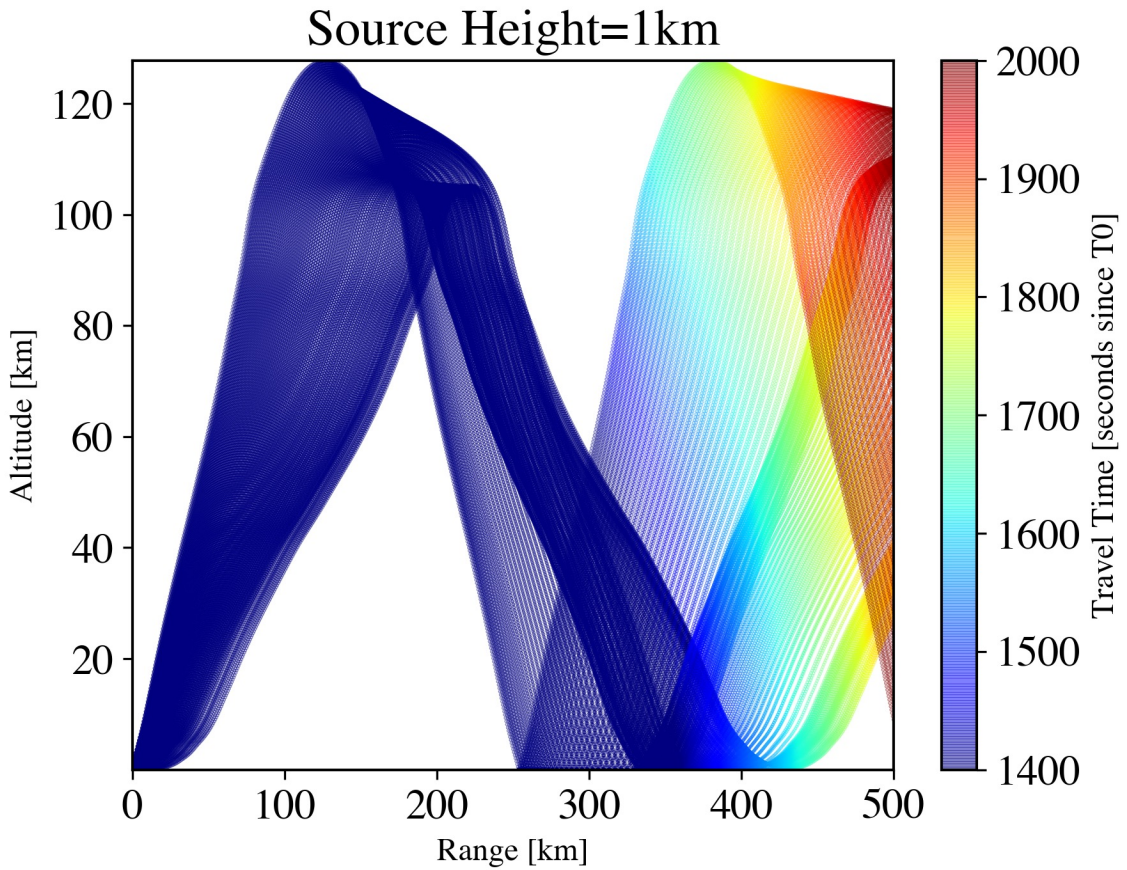
Blue Origin NS-15

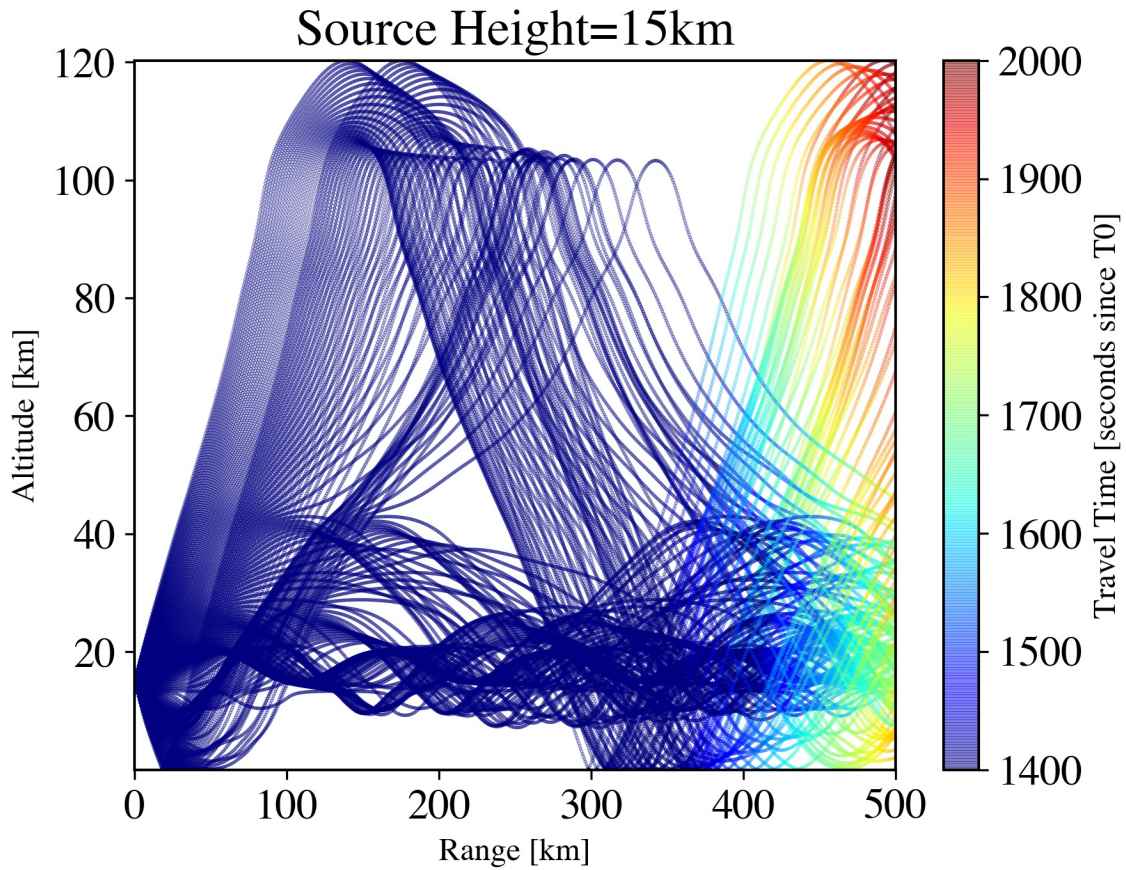
- April 14, 2021
- Uncrewed test flight
- 1 balloon
- ~415 km range





Propagation Modeling

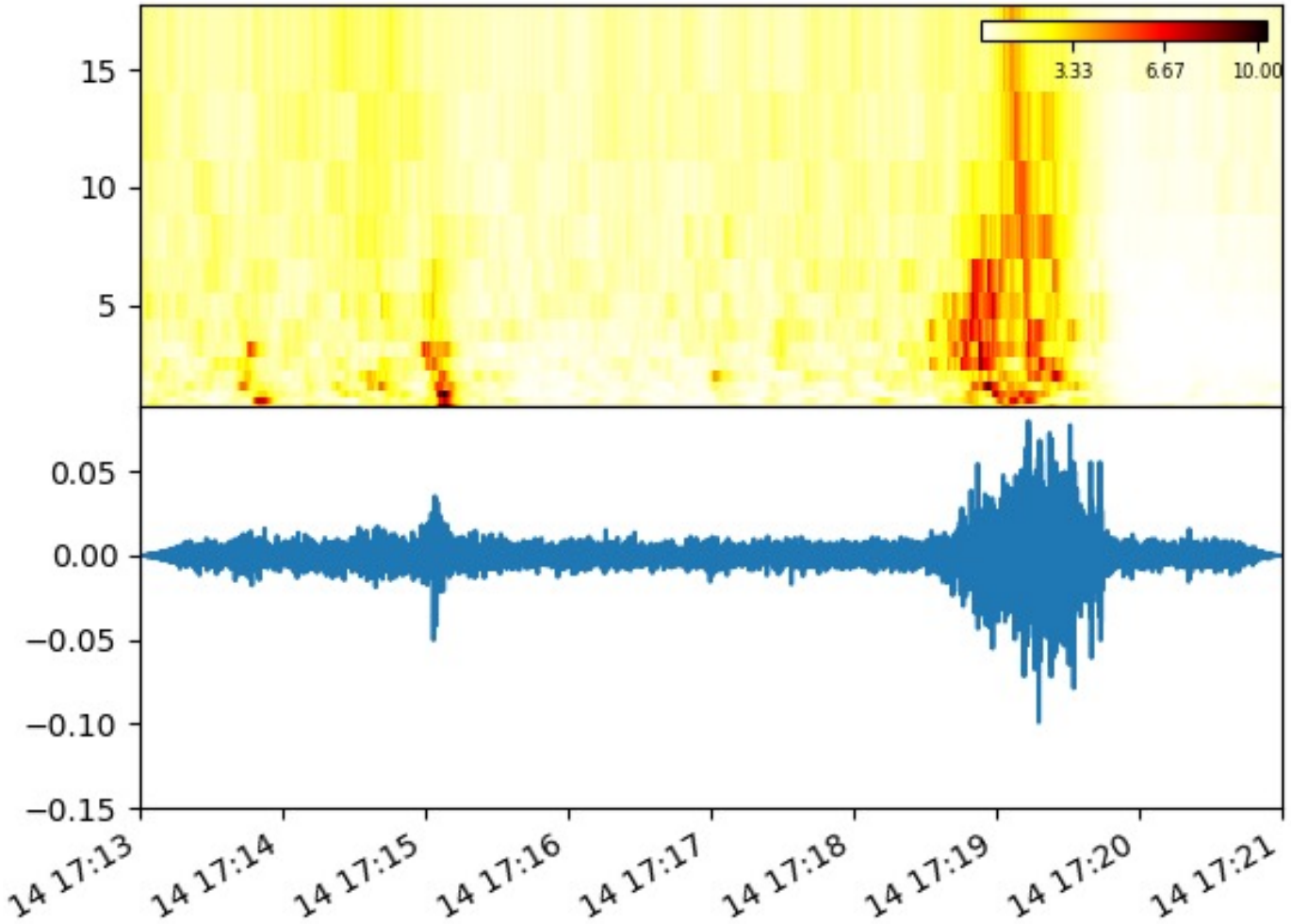




Blue Origin NS-15

ULA Landsat 9

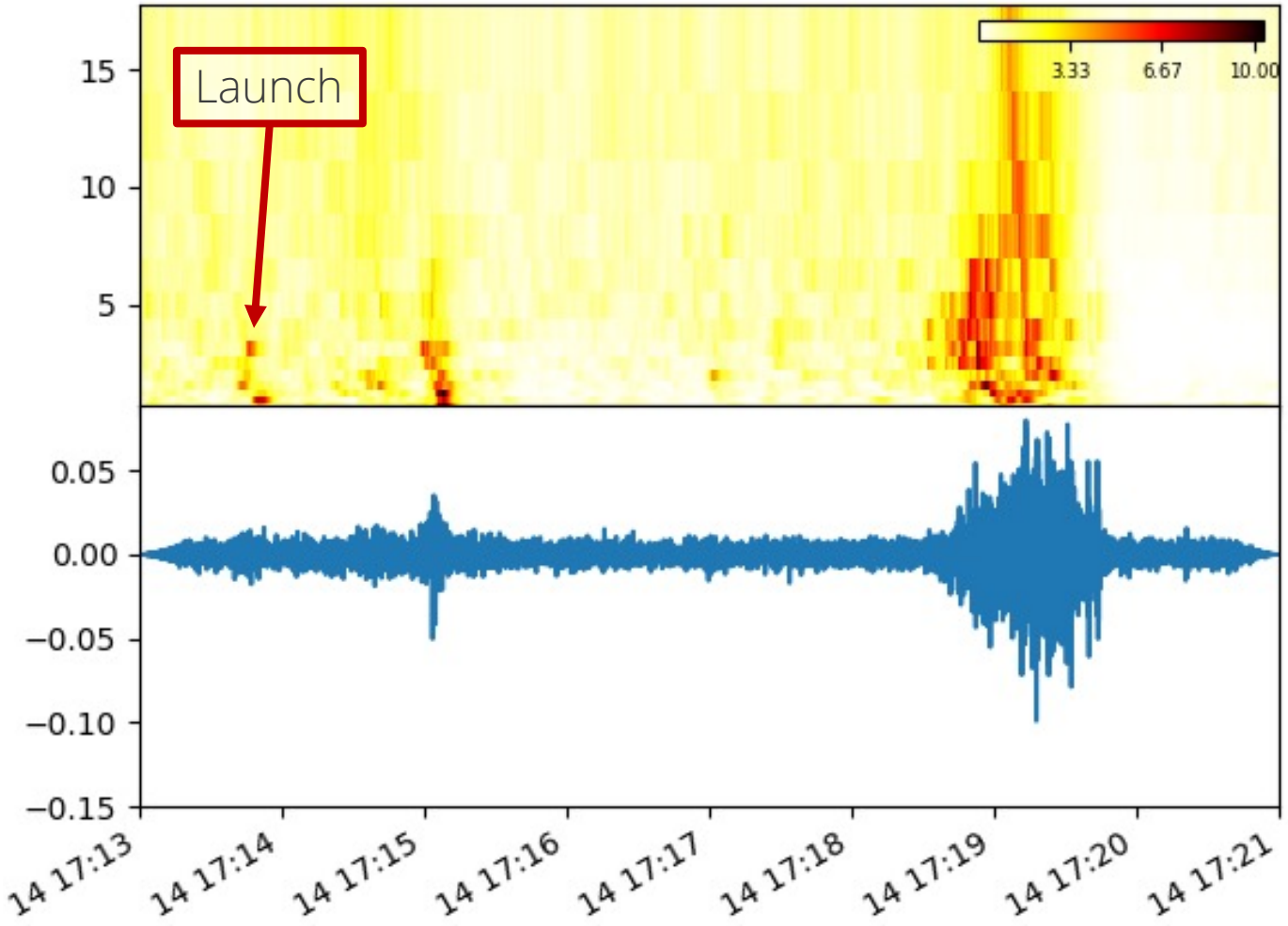
Time Series Analysis

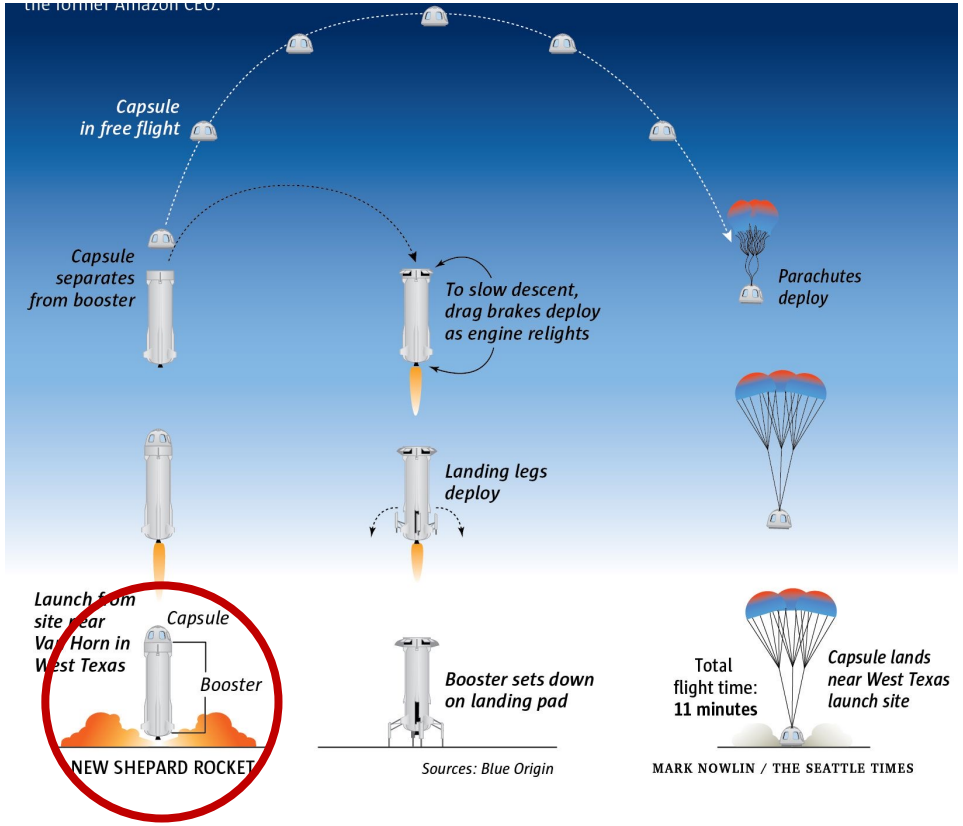


Blue Origin NS-15

ULA Landsat 9

Time Series Analysis





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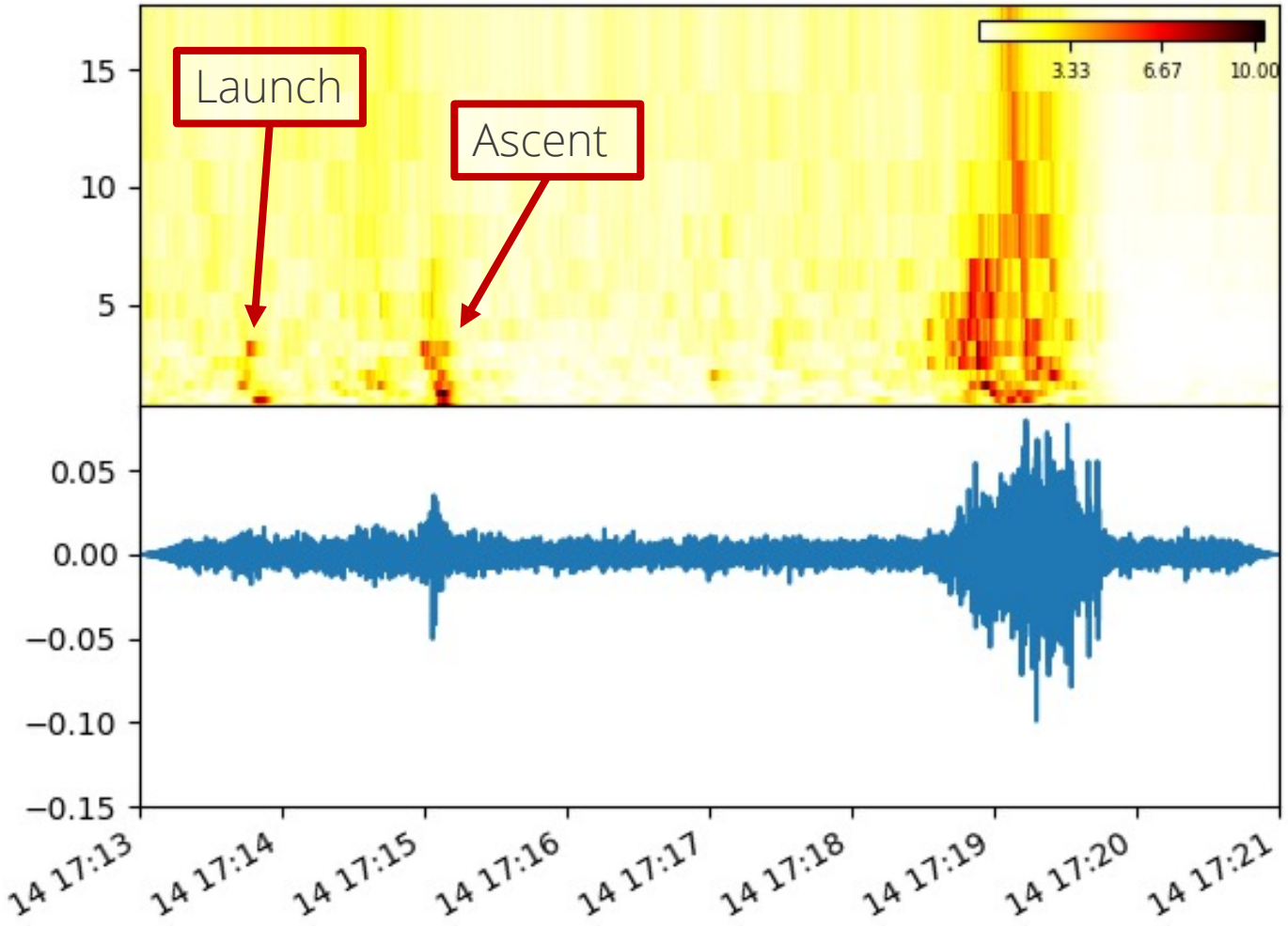
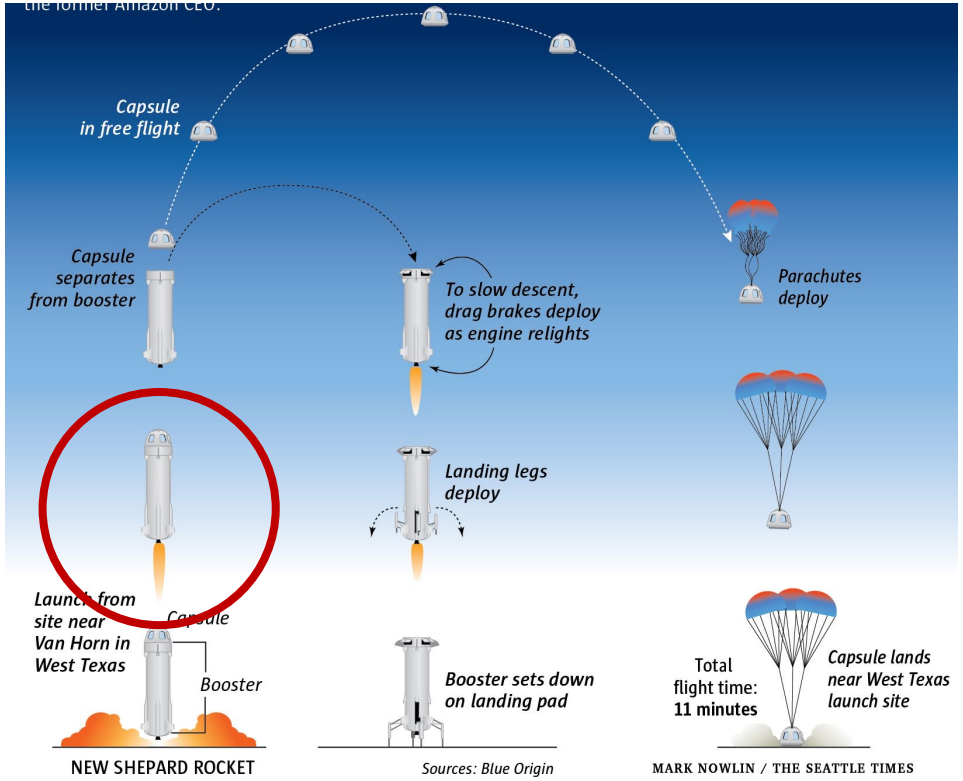
ULA Landsat 9

Time Series Analysis





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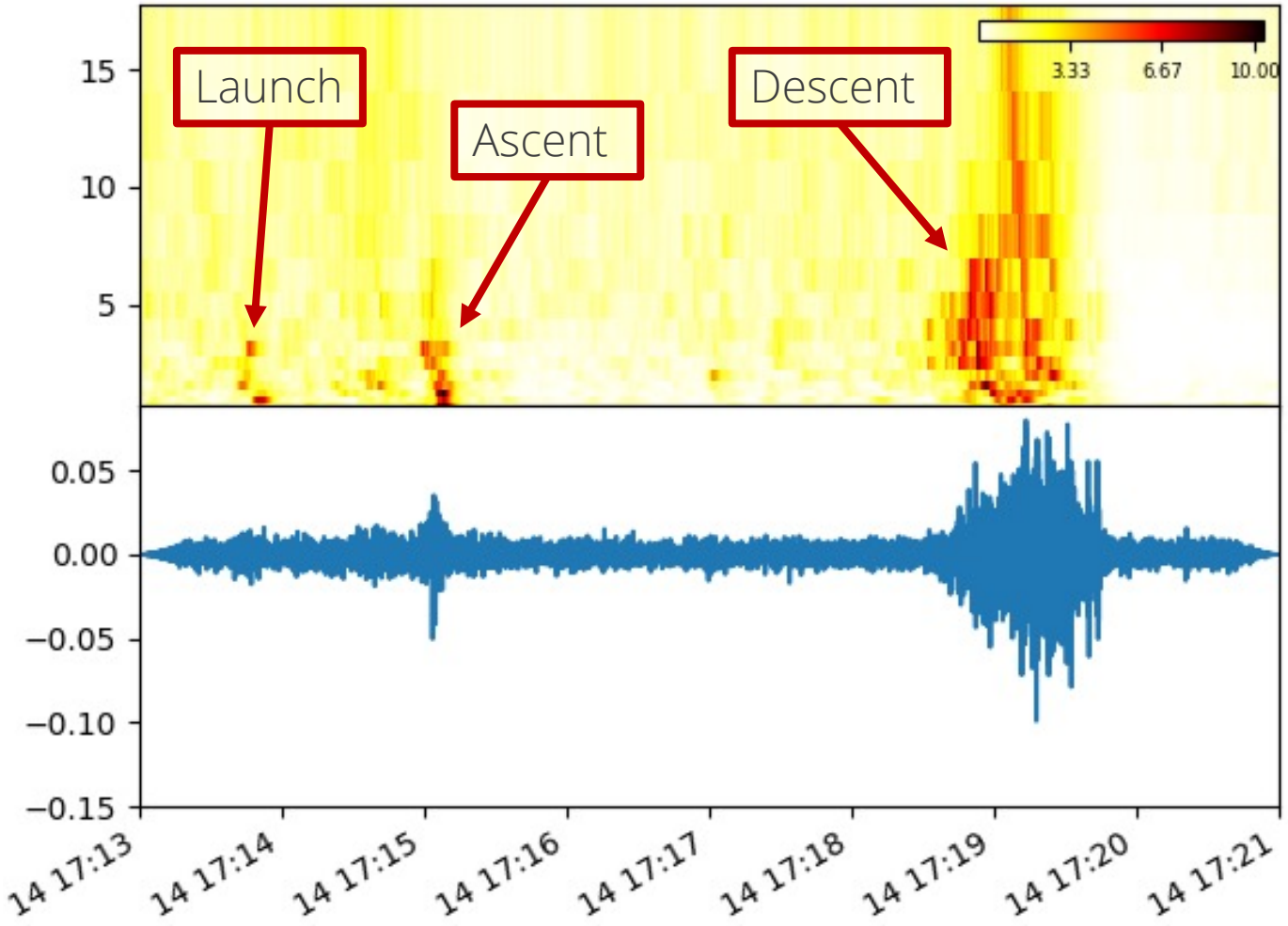
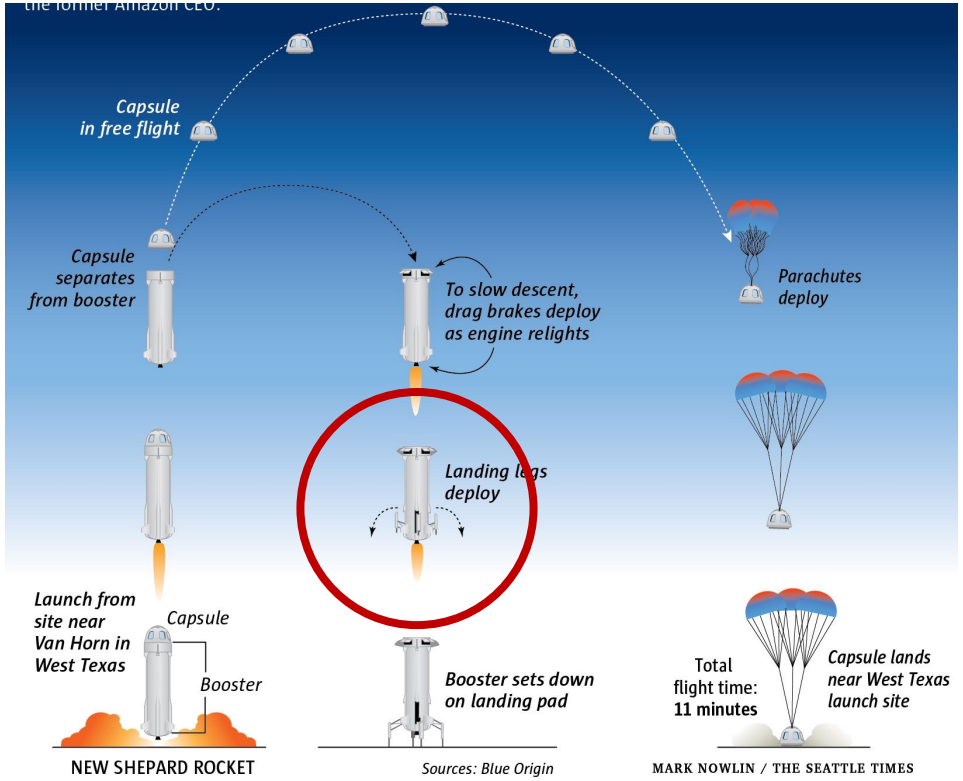
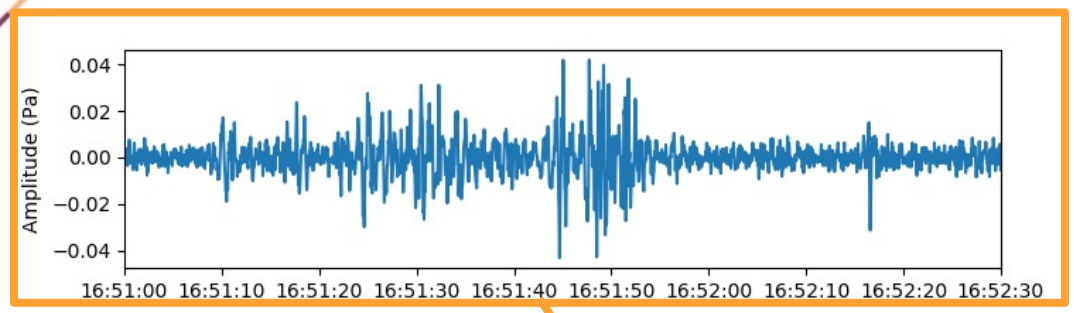


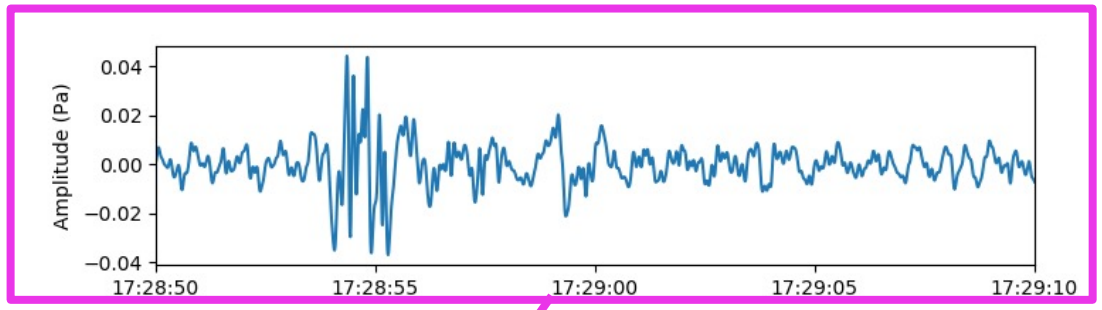


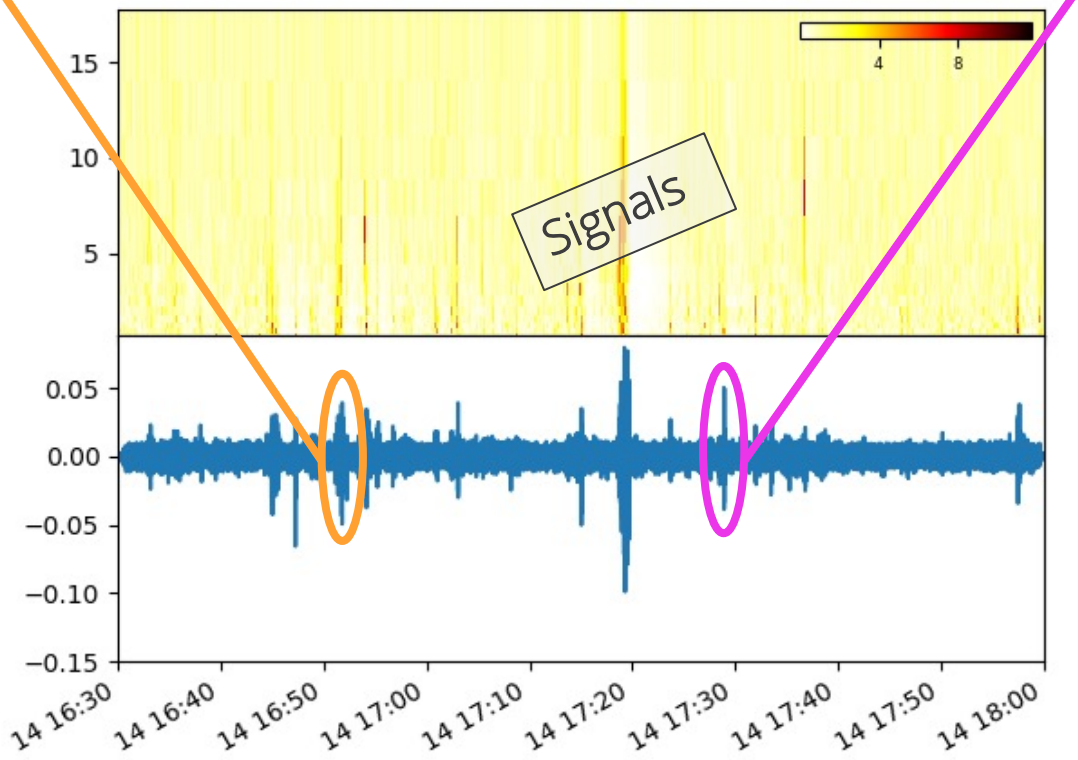
Blue Origin NS-15

ULA Landsat 9

Background Noise







Blue Origin NS-15

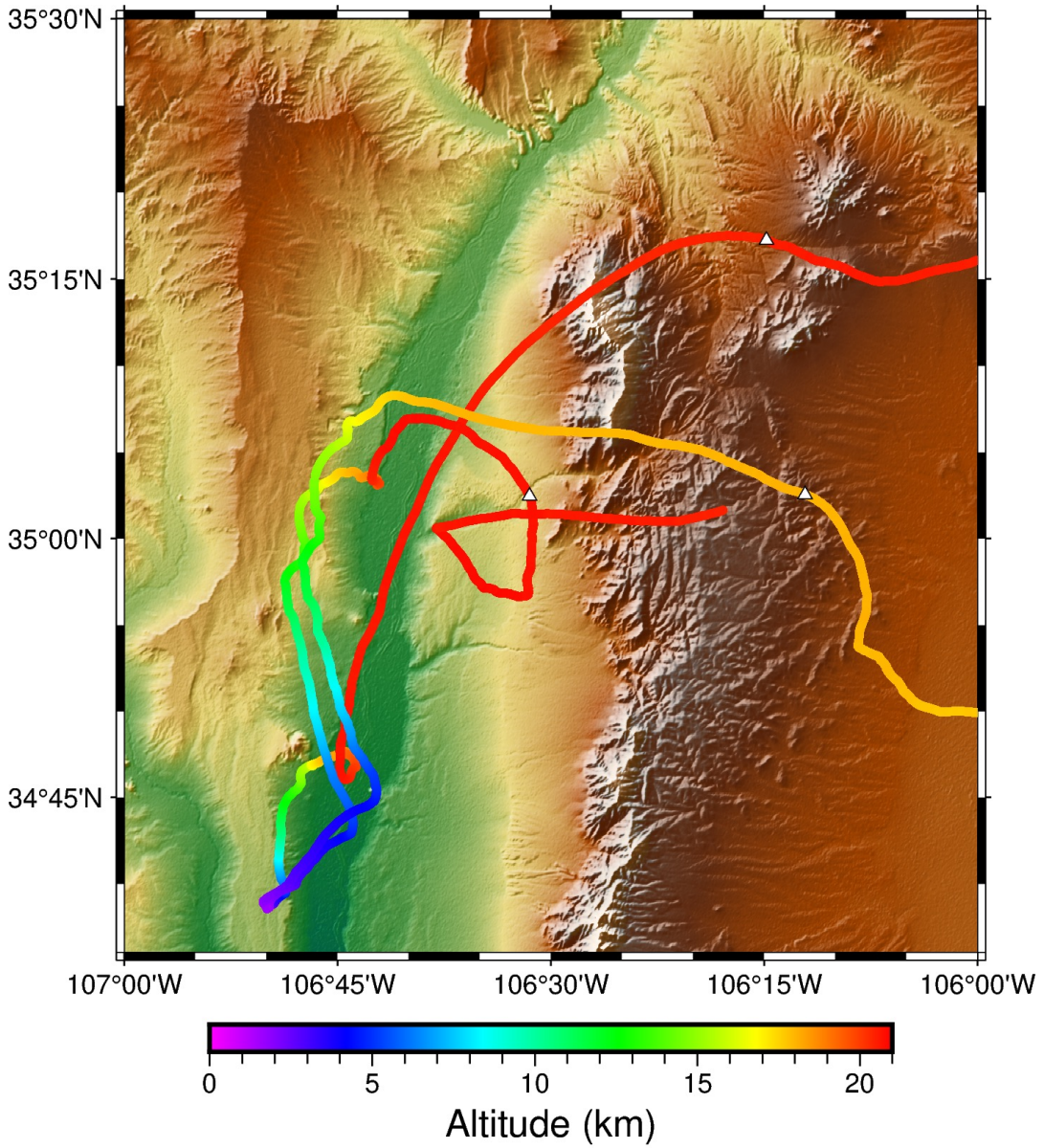
ULA Landsat 9

ULA Landsat 9

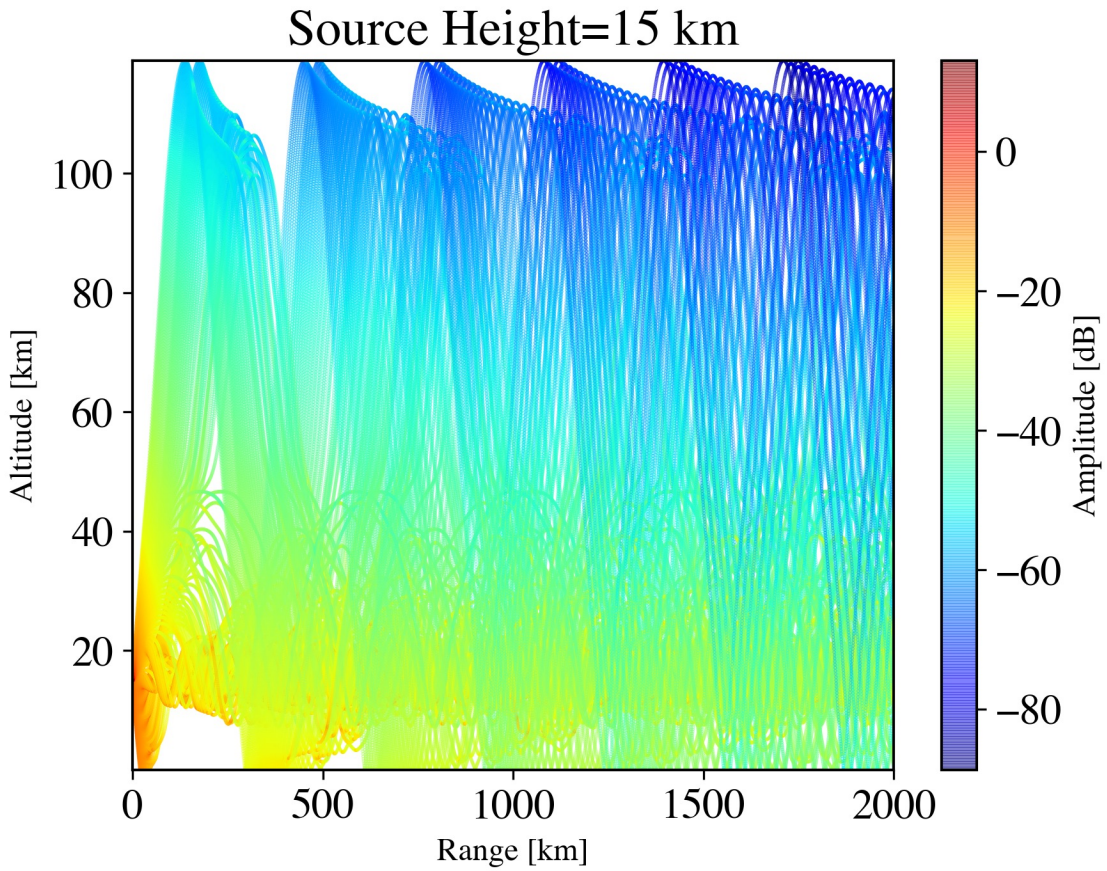
Launch Information

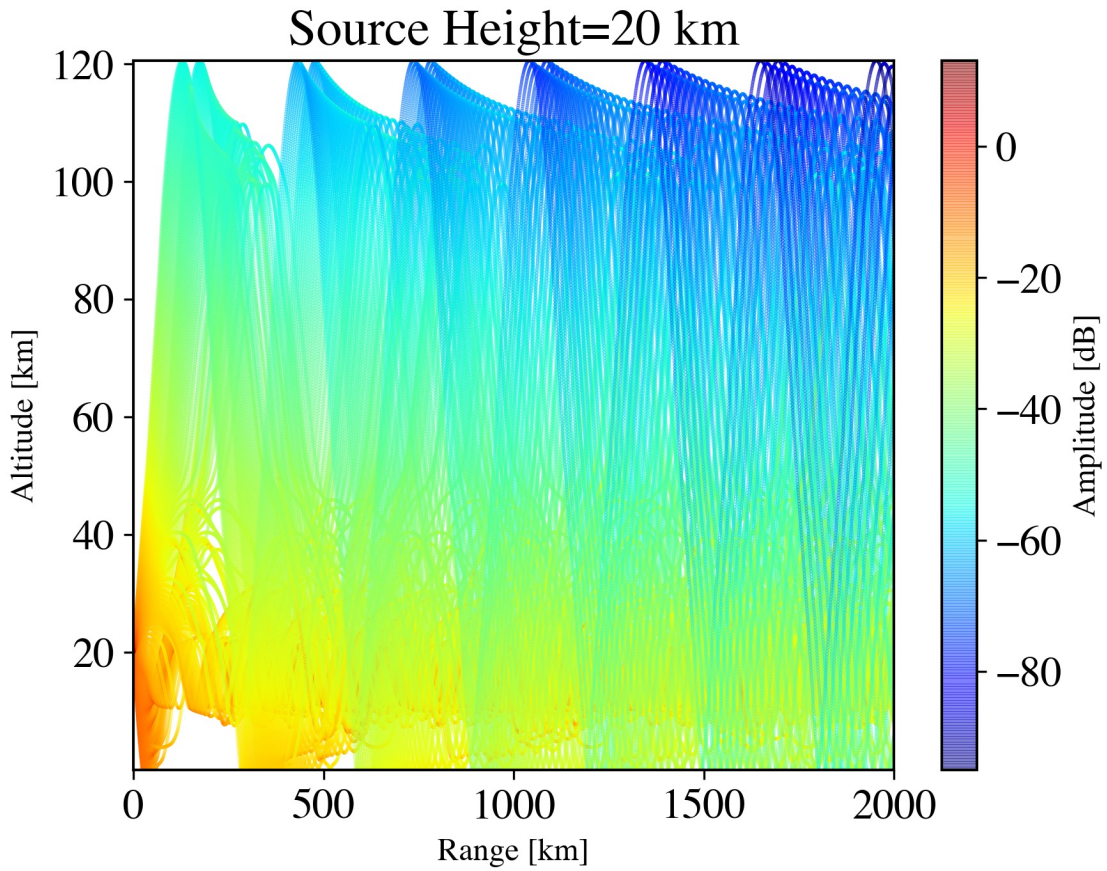
ULA Landsat 9

- September 27, 2021
- Science payload
- Atlas V rocket
- 4 balloons:
  - Balloon 1: GEM infrasound sensor
  - Balloon 2: GEM infrasound sensor
  - Balloon 3: iPhone with Redvox - not yet analyzed
  - Balloon 4: Datacube infrasound logger
- ~1300 km range



Propagation Modeling





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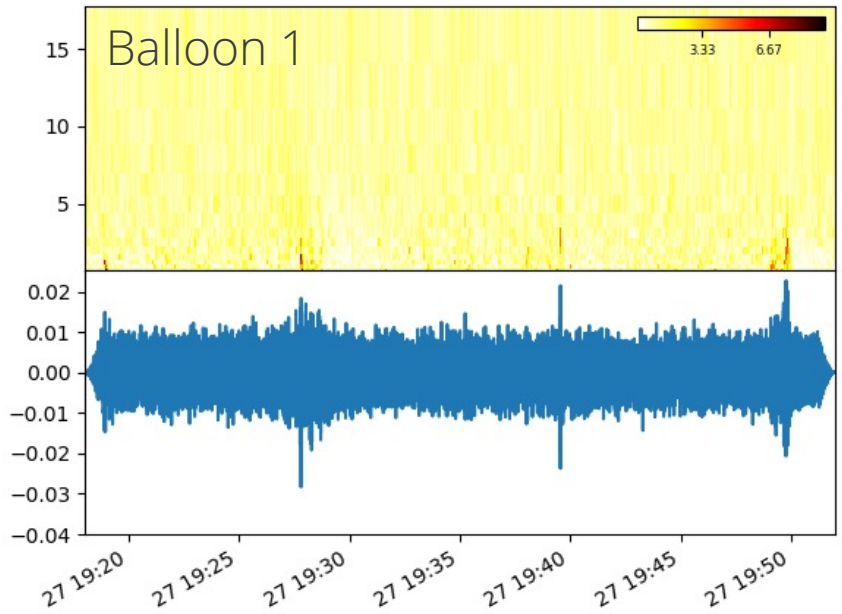
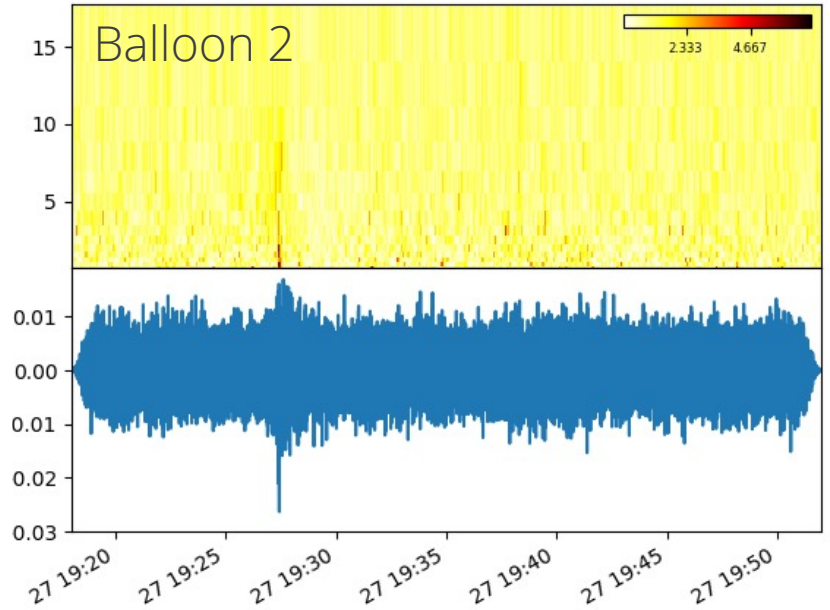
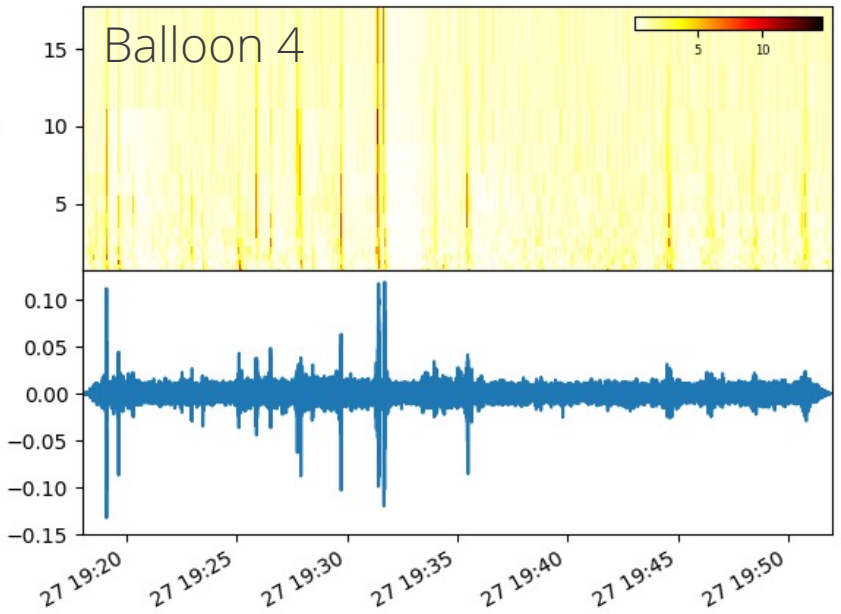
ULA Landsat 9

Time Series Analysis



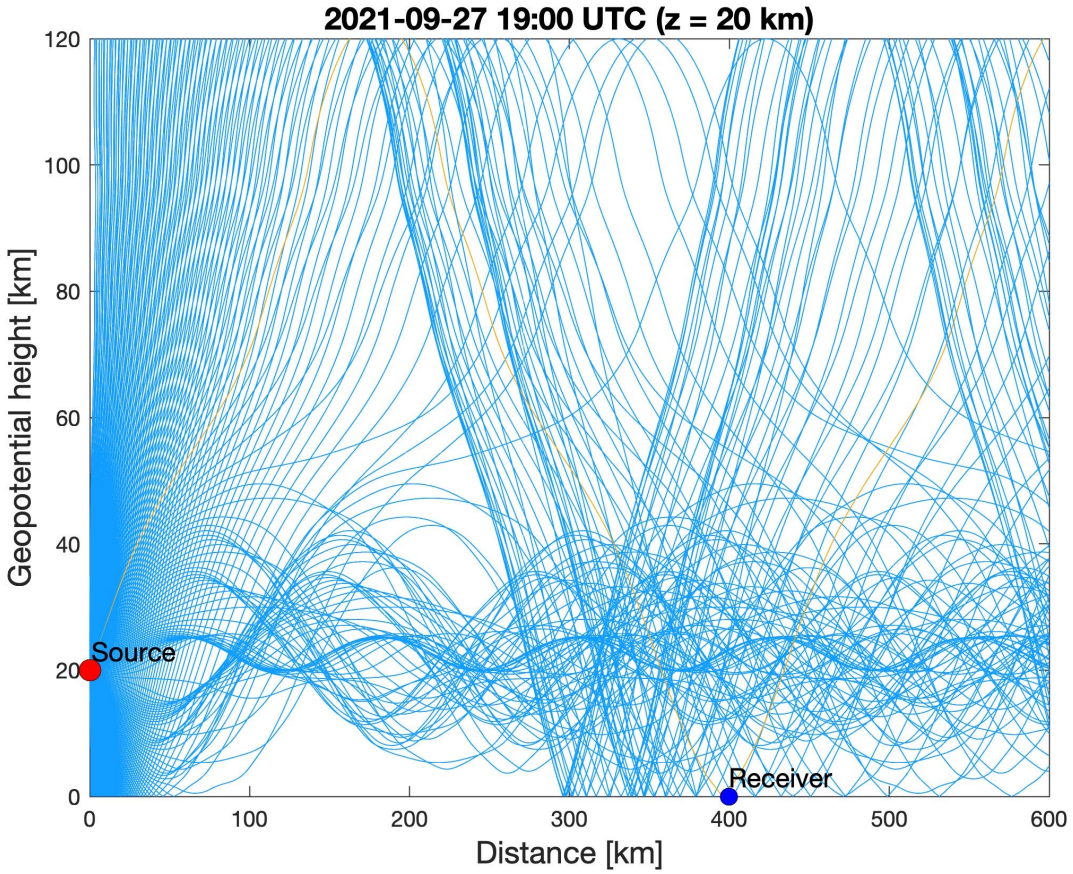


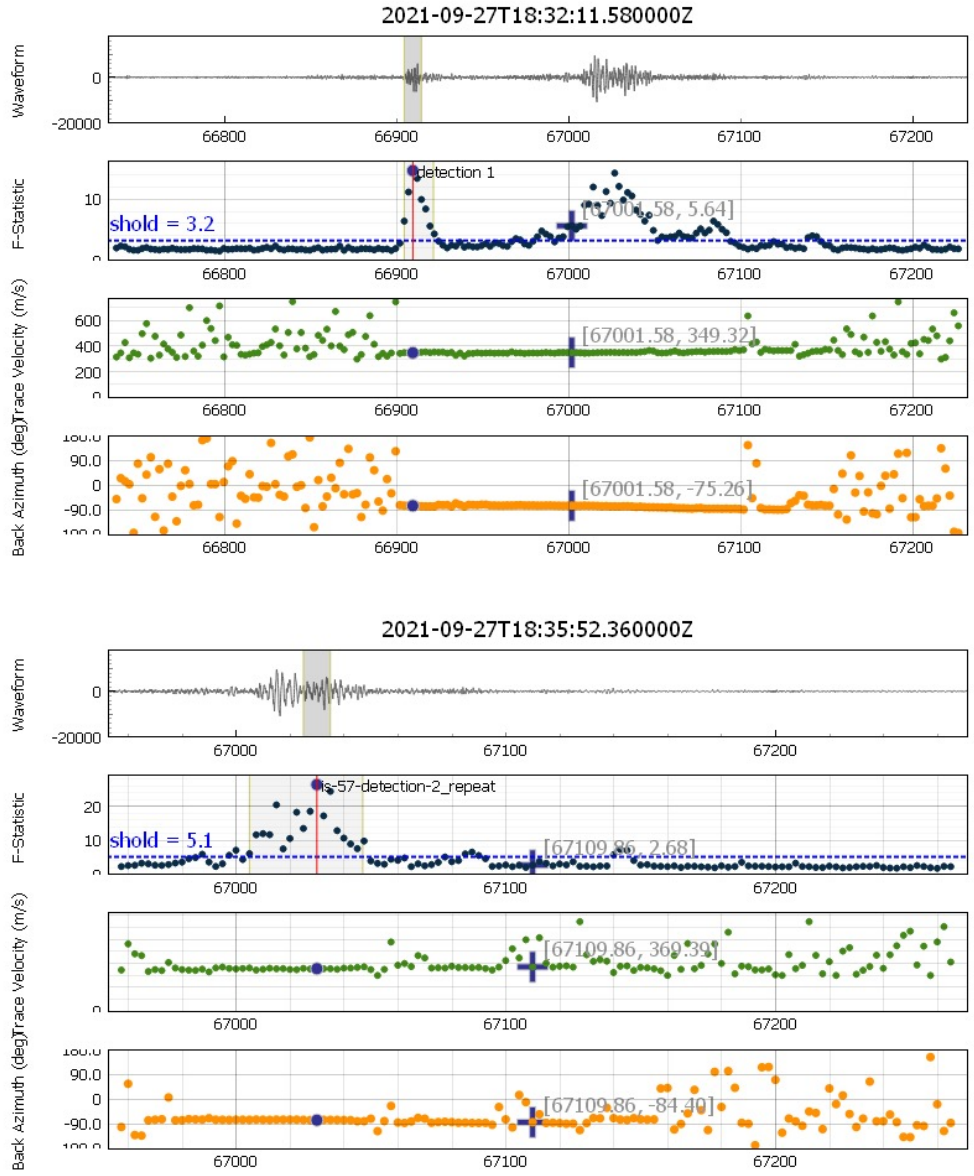


Blue Origin NS-15

ULA Landsat 9

IMS Network Detections

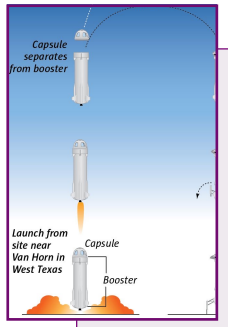




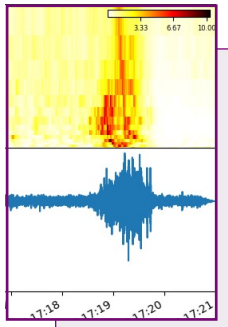
Blue Origin NS-15

ULA Landsat 9

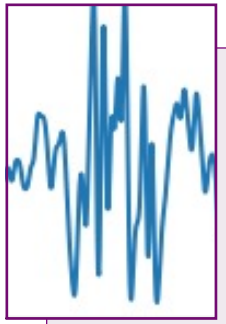
Conclusions



Able to detect events in the AtmoSOFAR channel under certain conditions

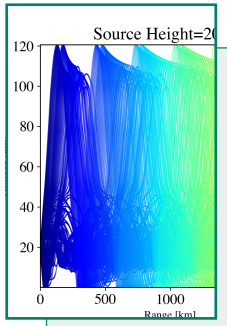


Rocket re-entry signal seems to be stronger



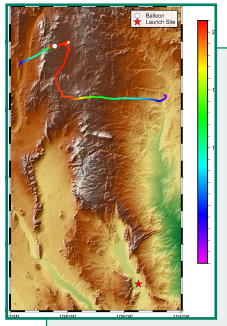
Acoustic background is much more complex than previously thought

Future Work

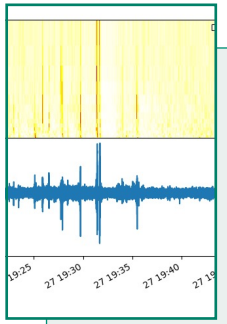


Target two more launches

- At least one Blue Origin



Determine detection range



Investigate acoustic background noise