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Surface-to-space acoustic propagation model validation using chemical explosion sources: The DARPA AIRWaveS Project

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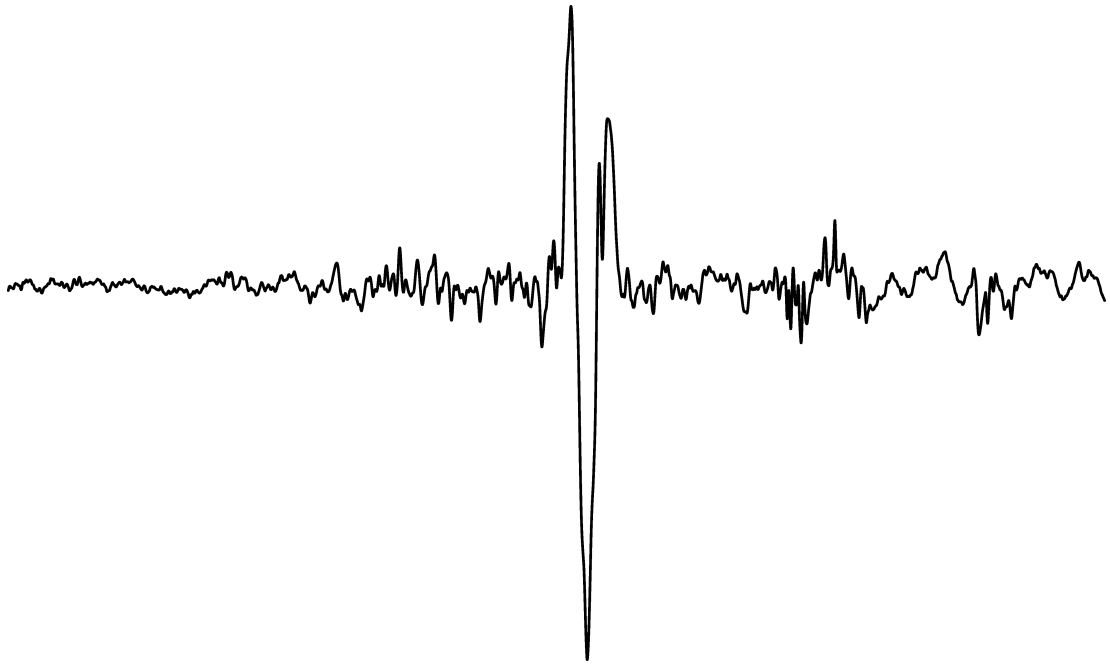
Introduction

Energetic events in Earth's atmosphere can create optical, electromagnetic, and acoustic signatures.

- How can we fuse modalities for detection and geolocation?
- How can we predict the signatures of different events?
- How can we validate them against controlled sources?



Turn the atmosphere into a sensor

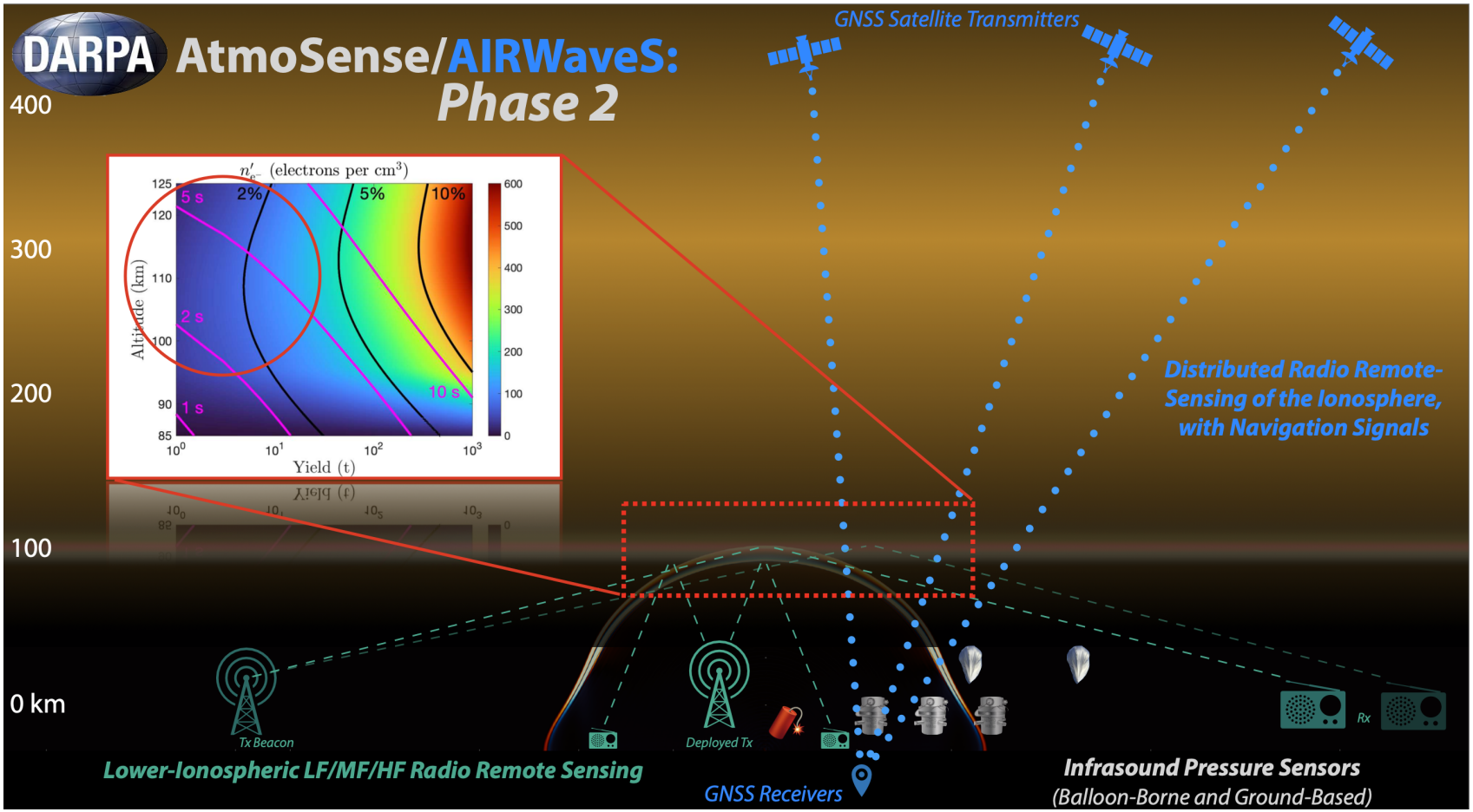
Phase 1 (2021-2023):

- TA1: Modeling & Simulation
- TA2: Characterization of the Background
- TA3: Sensing Modalities

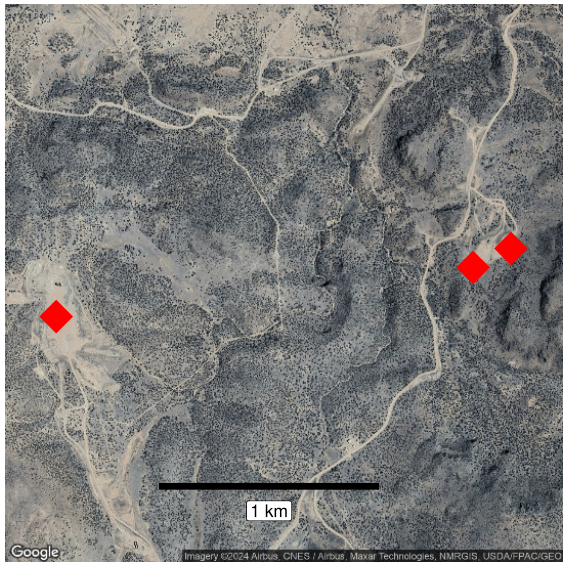
Phase 2 (2023-2024):

- Proof of Principle Field Tests

Atmosphere-Ionosphere Responses to Wave Signals (AIRWaveS)



Field Tests



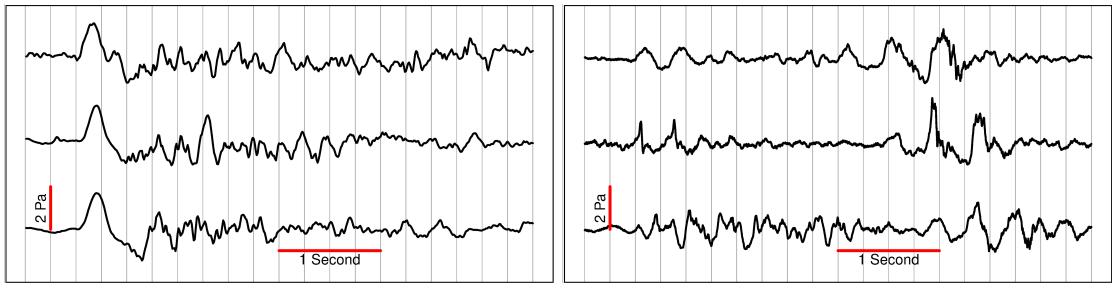
Two campaigns planned

- Campaign 1: Early May 2024
- Campaign 2: Mid October 2024

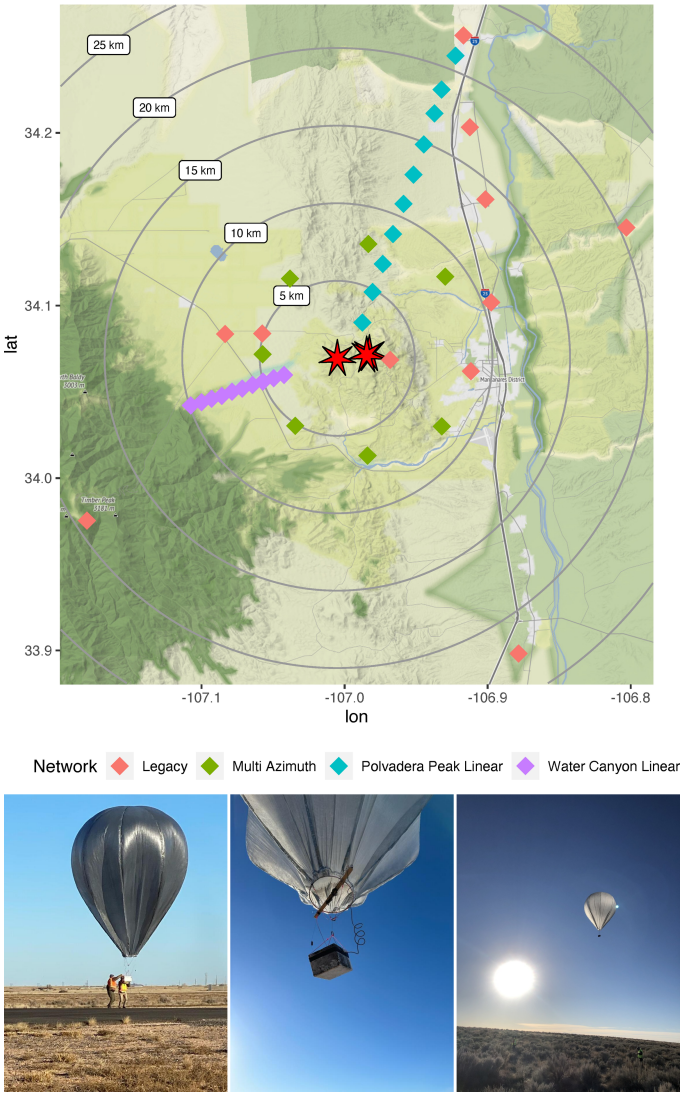
Each campaign consists of:

- Two sets of two smaller events
- One larger event with 10x the yield

Location: Central New Mexico



Ground and Airborne Acoustic Sensors (Sandia)



Local acoustic network

- Two linear networks
- One circular network
- Legacy stations

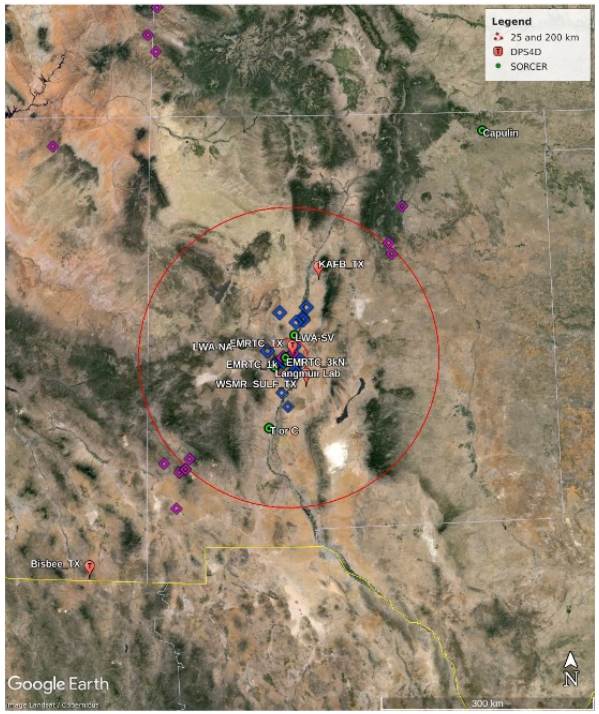
Regional acoustic network

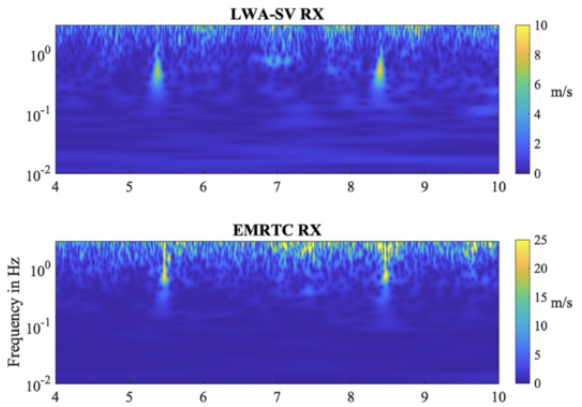
- Three 4-element arrays
- One at 200 km west
- Others at 170 and 250 km east

Balloons

- Up to 6 infrasound balloons
- Lightweight microbarometers
- Aeroseismometers

Ionospheric Microphone (AFRL)



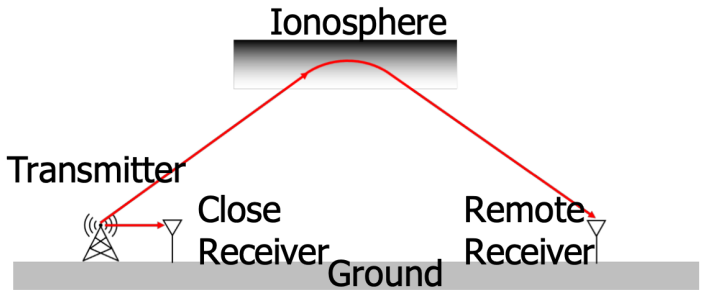


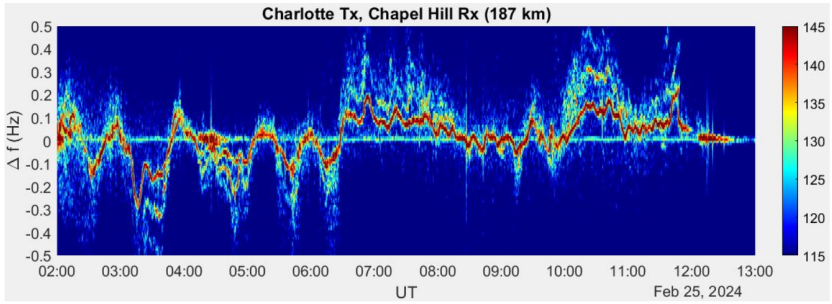
Capture the displacement of ionosphere plasma isodensity regions using pulsed Doppler radar.

- One set of reflection points nearly directly above the test site
- Other sets at oblique incidence

Determine the detection threshold and spatiotemporal variability of this technique.

Ionosphere Sounding using AM Radio (Duke)

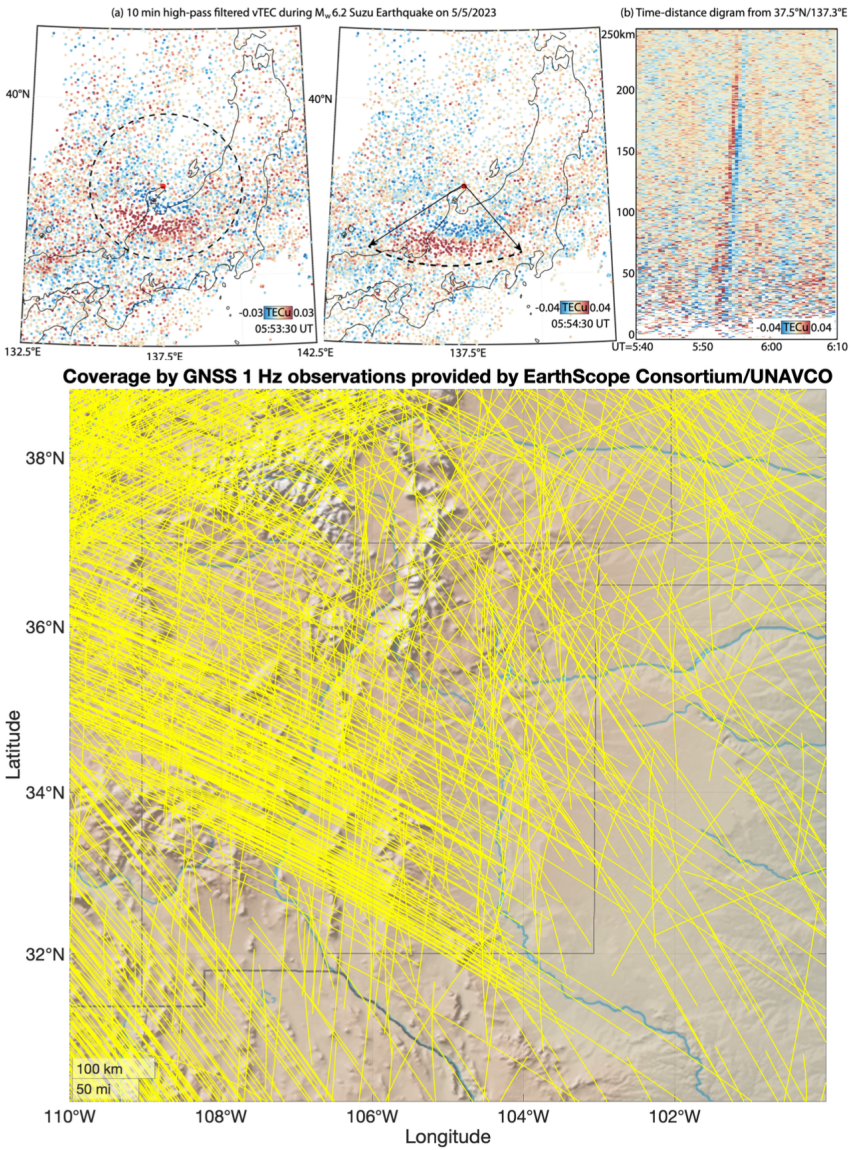




Record ionospheric fluctuations using AM radio stations as transmitters.

- Transmitter: AM radio station in Roswell, NM
- Receiver: Portable antenna in St. Johns, AZ
- Reflection point very close to test site

TEC measurement using GNSS (Embry-Riddle)

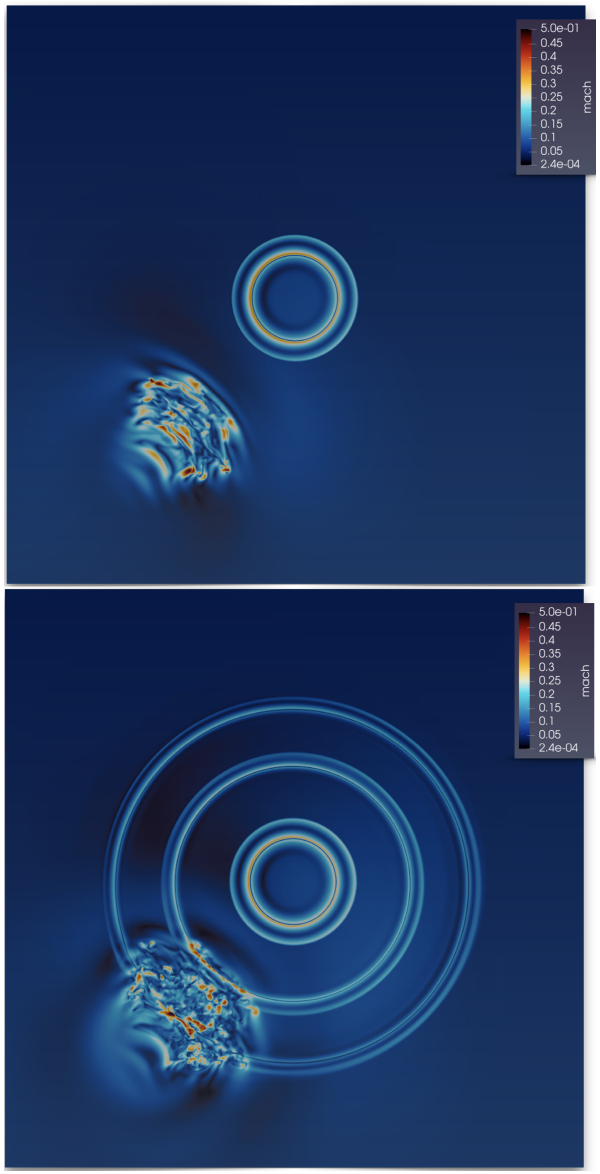


Capture total electron content (TEC) variations caused by infrasound waves

- 9 GNSS receivers running at 50 Hz
- 50 GNSS receivers running at 5 Hz requested from EarthScope

Determine GNSS detectability threshold.

Wave Propagation Modeling (Embry-Riddle and Partners)



- MAGIC Forest: Nonlinear, compressible Navier-Stokes equation model
- Forest GEMINI: Self-consistent multi-fluid ionosphere model
- ForestClaw & p4est: Adaptive mesh refinement library

Compare field observations with model results.

Conclusions

Verify simulations and evaluate sensing modalities using a series of powerful infrasound-generating events.

Interested in recording the fall campaign on a non-interference basis? Contact me at dbowma@sandia.gov.

Acknowledgments

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