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Infrasound detections of the OSIRIS-REx Sample Return Capsule re-entry

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1. Motivation

- Sample Return Capsules (SRCs) enter Earth's atmosphere with energies equivalent to decimeter-scale meteoroids and can serve as 'artificial' meteors [1].
- Upon entering dense regions of the atmosphere, these objects generate shockwaves, which decay to low frequency sound.
- Since SRCs are well-characterized objects with known parameters (speed, mass, size, etc.), their re-entries can be leveraged towards studying meteor phenomena, characterizing high-altitude shockwave dynamics, improving entry and propagation models, and advancing global monitoring efforts.

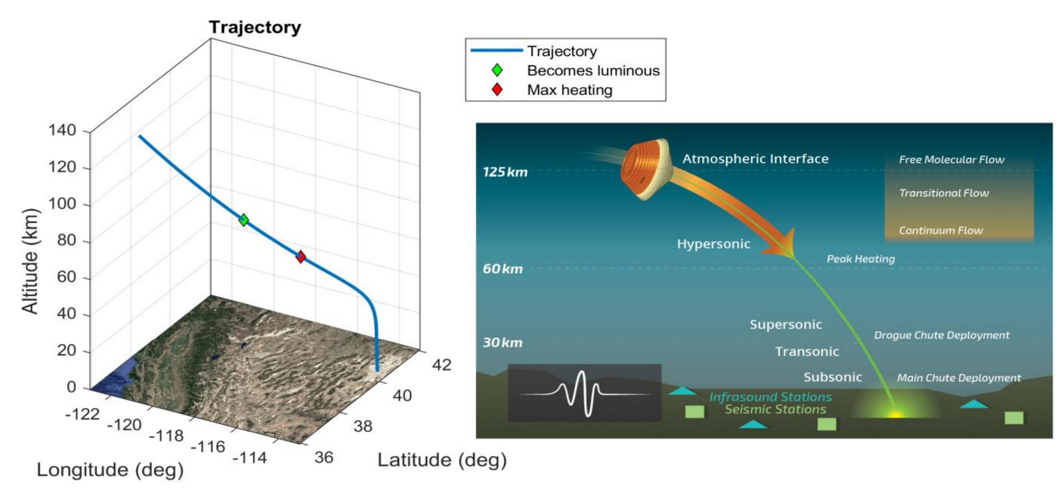

Figure 1: Left: OSIRIS-REx re-entry trajectory. Right: Diagram showing the various stages of SRC flight. Diagram not to scale.

2. OSIRIS-REx re-entry: Deployment and data collection

- On September 24, 2023, NASA's OSIRIS-REx SRC successfully brought particles of the nearby asteroid Bennu to Earth.
- The sample return capsule generated shockwaves as it entered the atmosphere, traversing California, Nevada and Utah before landing.
- We deployed infrasound and seismic sensors in Nevada and Utah (Fig. 2) to capture the signals as a function of distance from the trajectory and from different parts of the trail.
- 47 single sensor stations (30 in West Region, and 17 in East Region), three 4-element arrays, and 19 seismic nodes were installed in total. Fig. 3 shows the map with deployment areas.

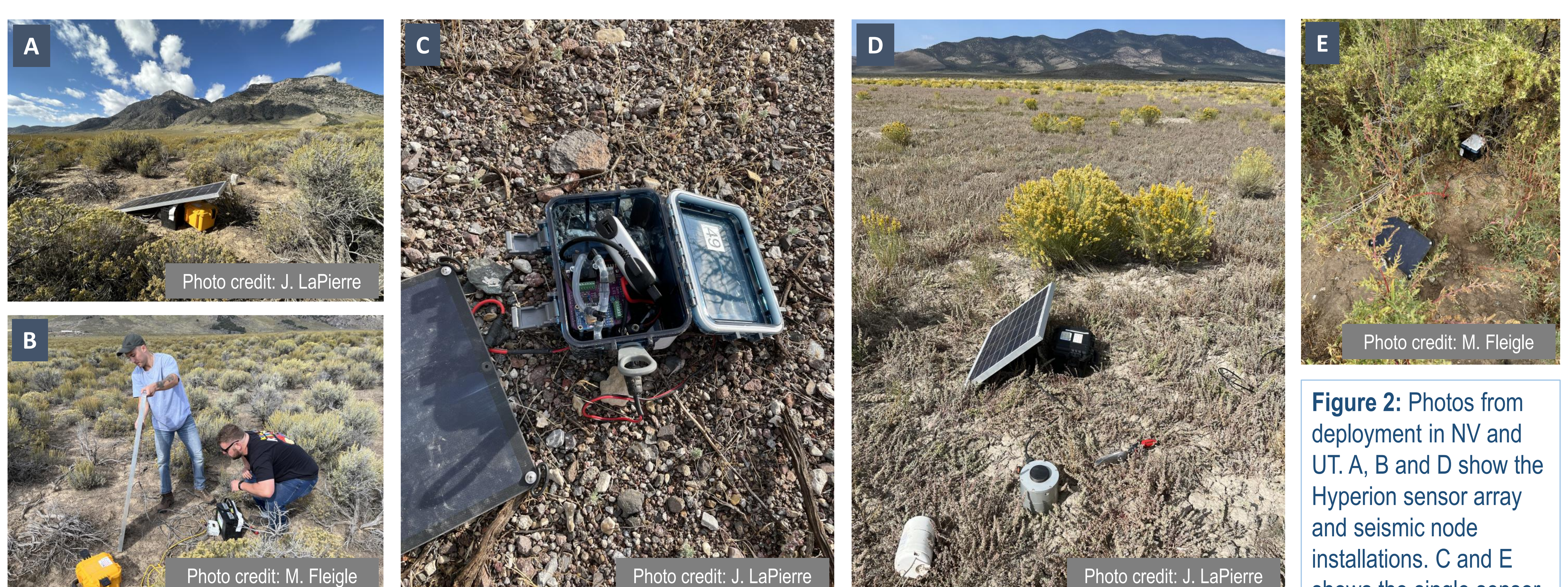

Figure 2: Photos from deployment in NV and UT. A, B and D show the Hyperion sensor array and seismic node installations. C and E shows the single sensor Gem.

3. Signal detections

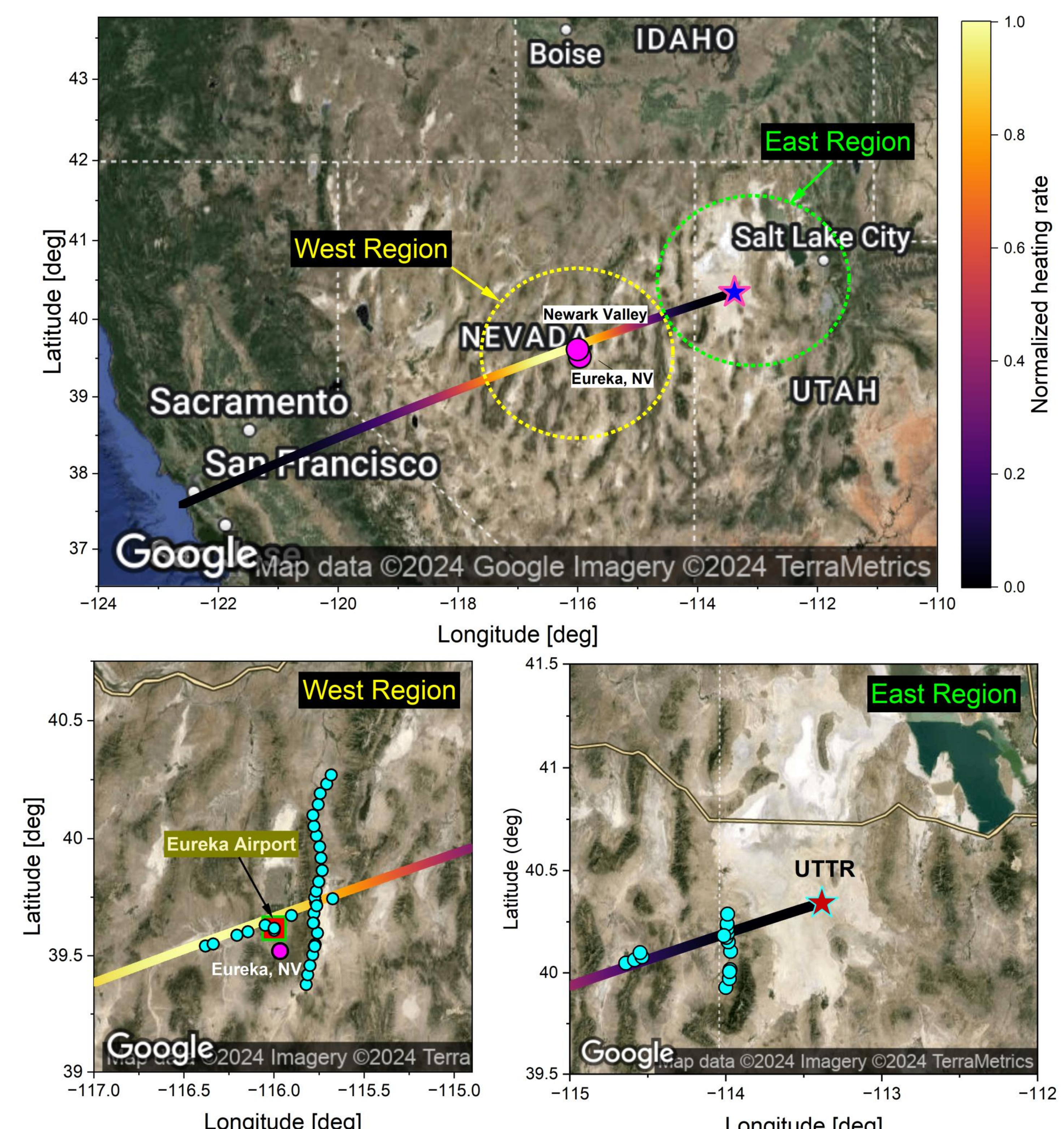

Figure 3: Map showing various deployment regions. Circles in the lower two panels are single sensor stations and arrays.

- We detected strong infrasound signals generated by the OSIRIS-REx SRC at nearly all sensors in NV and UT.
- Preliminary analysis indicate that some signals come from a common point and some from different points along the trail.
- The results have implications for future observational efforts on Earth as well as capturing shockwave signatures on other planetary bodies with atmospheres (e.g., Mars, Titan, Venus).

- An N-wave with some coda was detected at all operational single sensor stations. Fig. 4 shows the signals from the south end of the transect in the West Region. Fig. 5 shows orientation of the transect relative to predicted rays propagating ballistically.

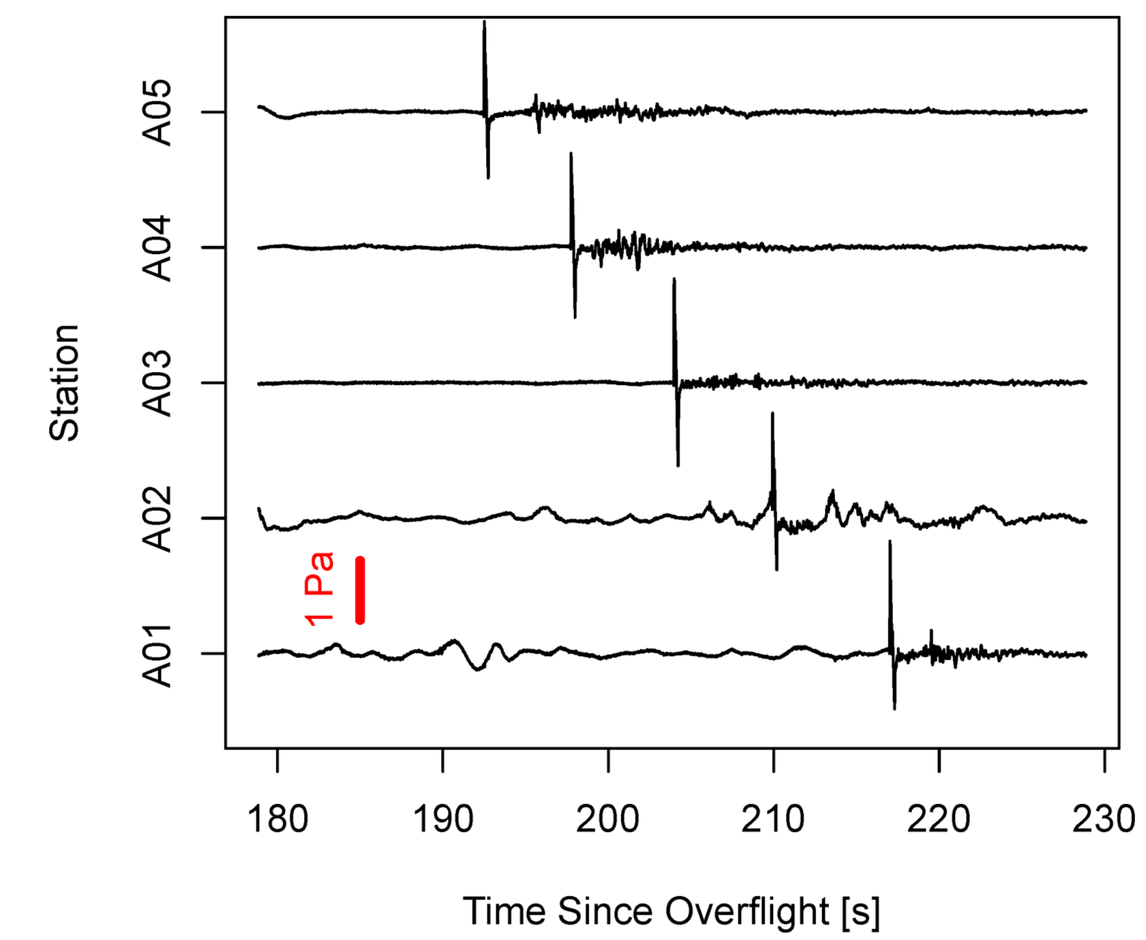

Figure 4: Signals detected by single sensor stations situated along the south end of the transect in West Region.

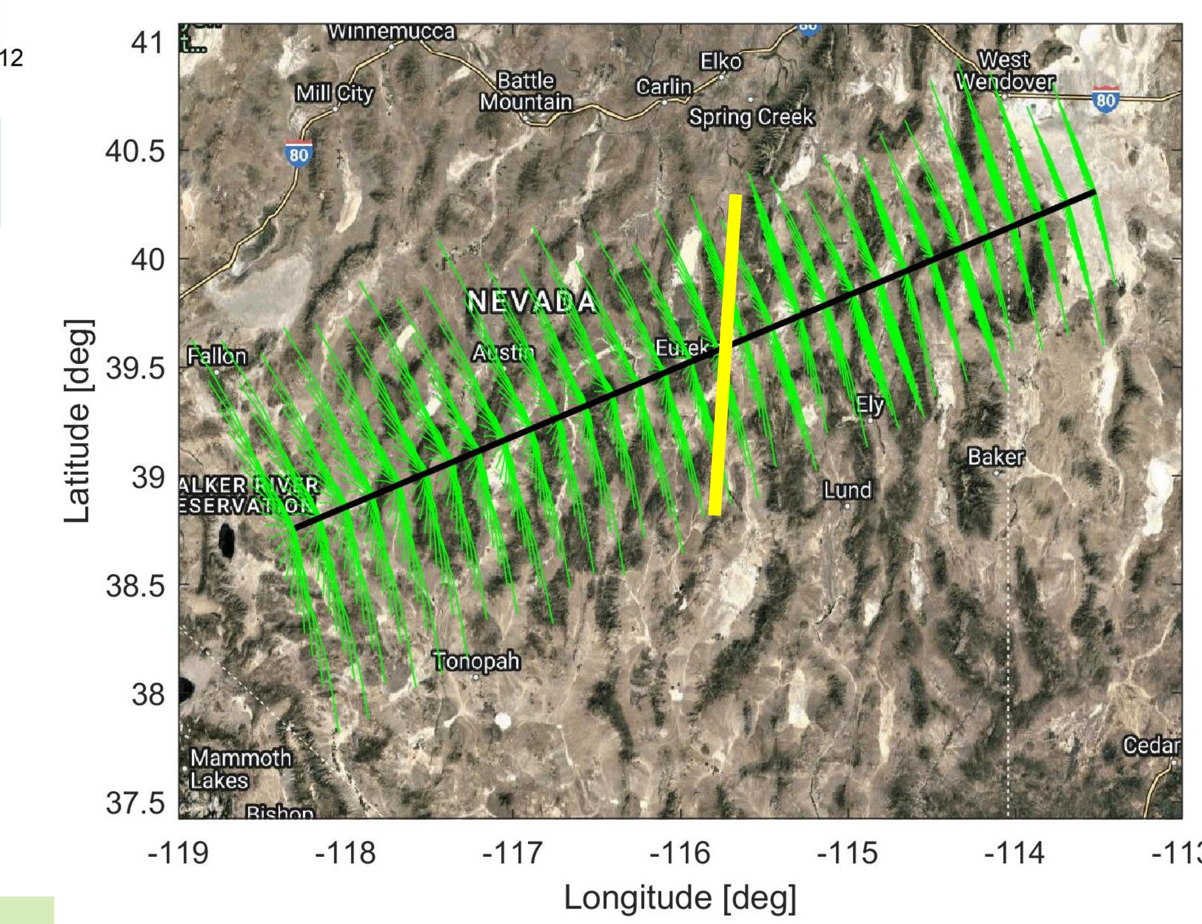

Figure 5: Map showing the predicted hypersonic carpet. Rays are generated far apart to visualize the map below. The yellow line represents the direction of the transect in the West Region (see Fig. 3).

References

[1] Silber, E.A., Bowman, D.C., & Albert, S. (2023). *Atmosphere*, *14*(10), 1473, doi: 10.3390/atmos14101473. [2] Silber, E.A. et al. (2024) PSJ, doi: 10.3847/PSJ/ad5b5e

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