SnT 2025
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Leveraging the OSIRIS-REx Sample Return Capsule re-entry for infrasound detection of atmospheric events

Elizabeth A. Silber, Daniel C. Bowman

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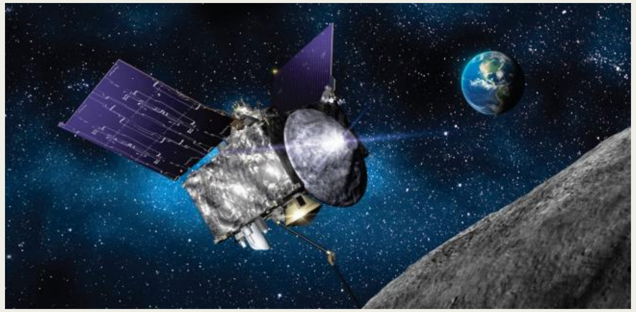
Introduction

The OSIRIS-REx Sample Return Capsule (SRC) reentry on September 24, 2023 was the first interplanetary capsule reentry over the US since Stardust (2006), providing unique infrasound observations during hypersonic descent [1].

Launched from the OSIRIS-REx spacecraft (shown in figure below) that sampled asteroid Bennu [2], the SRC entered the atmosphere at 14:41:55 UTC above San Francisco at 12.36 km/s and landed at the Utah Test and Training Range (UTTR) [3].



We present the analysis of infrasound signals from the SRC reentry, recorded by a dense network of ground-based single sensor stations spanning NV and UT, as part of the largest geophysical campaign for a hypersonic reentry to date [1].

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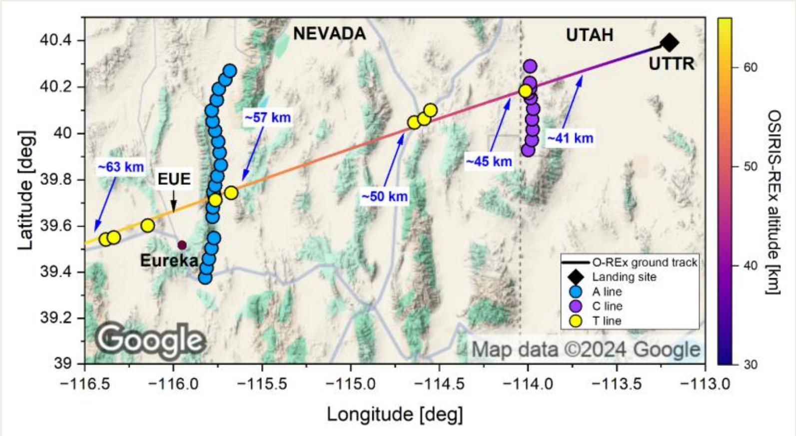
Methods

A total of 39 single sensor ground stations were deployed in NV and UT. All stations used portable, low-power Gem microbarometers sampling at 100 Hz.

The network was arranged into three lines (A, C, and T).

The figure below shows the deployment regions of ground-based single sensor stations. The SRC travelled from SW to NE. The labels with arrows show the approximate SRC altitude.



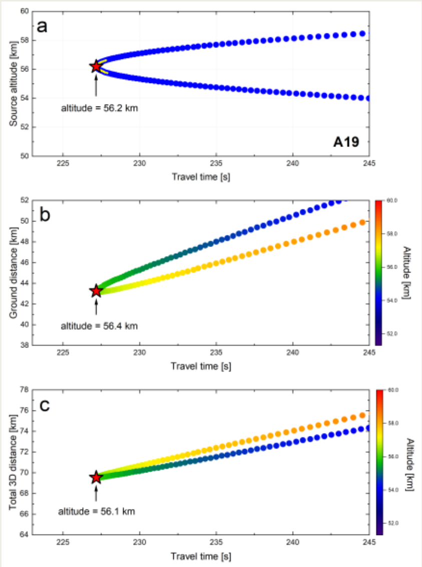
Data were filtered using a Butterworth filter, and propagation was modeled with InfraGA [4] incorporating realistic G2S atmospheric specifications [5].

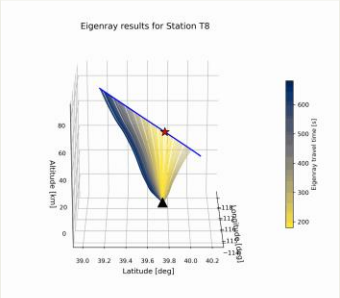
Methods (cont'd)

We traced rays from ~2000 points along the nominal SRC trajectory, with each point treated as an independent source, to systematically identify eigenrays (Fig. 2).

We then collected eigenrays arriving near-perpendicularly, consistent with hypersonic ballistic shock behavior [6].

An illustrative example is shown in the figures below.





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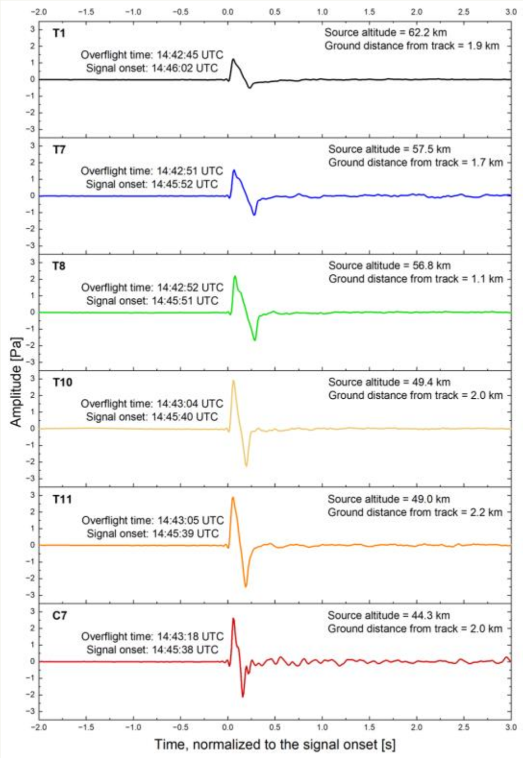
Results

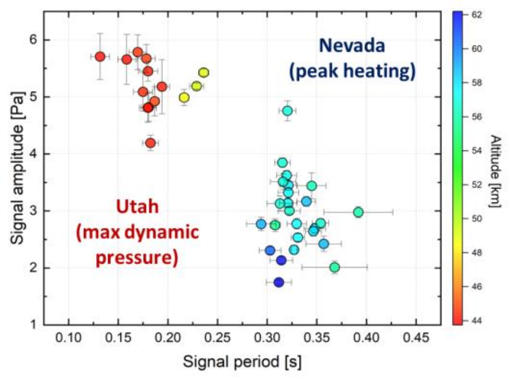
Signals from higher altitudes exhibit lower amplitudes, longer periods, while those from lower altitudes display higher amplitudes and shorter periods.

The figure below shows infrasound signals received on stations beneath the trajectory, from westmost point (T1) to the eastmost point (C7).



Results (cont'd)

The altitude dependence is also seen through signal period and amplitude clustering: high-altitude (~61 km) peak heating regions and lower-altitude (~44 km) dynamic pressure regions. This is shown in the figure below.



Raytracing results agree well with observed arrival times, confirming that hypersonic SRC shocks propagate ballistically and validating our propagation modeling. This is illustrated in the figure below.

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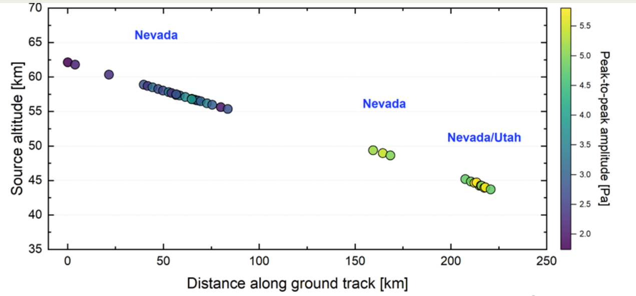

Conclusions

A dense infrasound sensor network can effectively capture altitude-dependent variations, demonstrating its utility in reconstructing reentry trajectories and refining shock wave propagation models.

Infrasound measurements and raytracing analyses confirm that hypersonic SRC reentry produces predictable ballistic shocks, with source altitudes between 44–62 km. Signal properties (amplitude, period, frequency content) strongly depend on source altitude.

The controlled SRC reentry provides unique, well-characterized data to refine shock propagation models, improve planetary defense strategies, and advance our understanding of both space debris and meteoroid atmospheric entries.

References:

[1] Silber et al. (2024) The Planetary Science Journal, 5(9), 213. [2] Lauretta et al. (2017) Space Science Reviews, 212, 925-984. [3] Francis et al. (2024) 46th Annual AAS GN&C Conference, Breckenridge, CO. [4] Blom & Waxler (2017) JASA, 141, 2681-2692. [5] Drob et al. (2003) JGR, 108, 1-12. [6] Silber (2024) Remote Sensing, 16, 3628.

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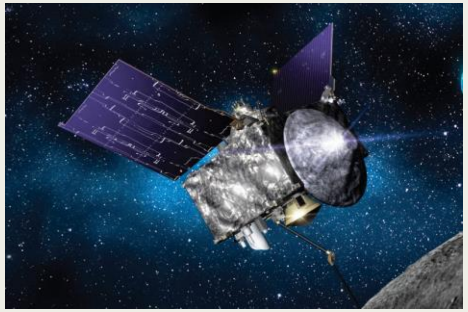
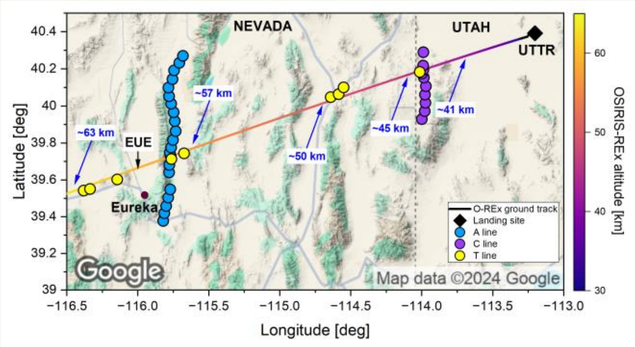
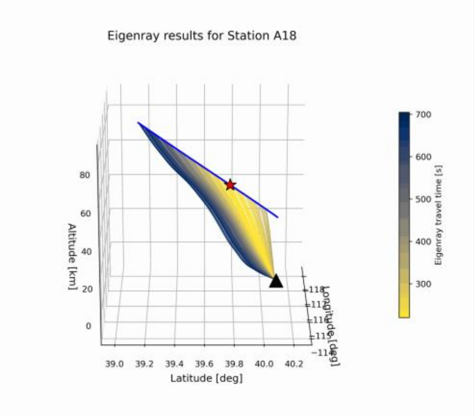
- We present infrasound observations of the OSIRIS-REx capsule's hypersonic re-entry.
- This unique event provided an exceptional opportunity to study atmospheric entry dynamics, imperative for understanding meteoroid interactions and improving planetary defense.
- We deployed a network of 39 infrasound sensors across Nevada and Utah to examine how signal amplitude and period vary with altitude.
- Our results demonstrate a clear correlation between altitude and signal characteristics, contributing directly to the refinement of atmospheric entry models.
- For further discussion, please visit our poster!







*work performed at SNL
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