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WEAK-SHOCK ANALYSIS OF THE ACOUSTIC SIGNALS GENERATED BY THE OSIRIS-REX RE-ENTRY

Elizabeth. A. Silber¹

EGU General Assembly 2026

Vienna, Austria, 3–8 May 2026 (presentation: Tue, 5 May 2026, 11:20 CET)

EGU26-2618

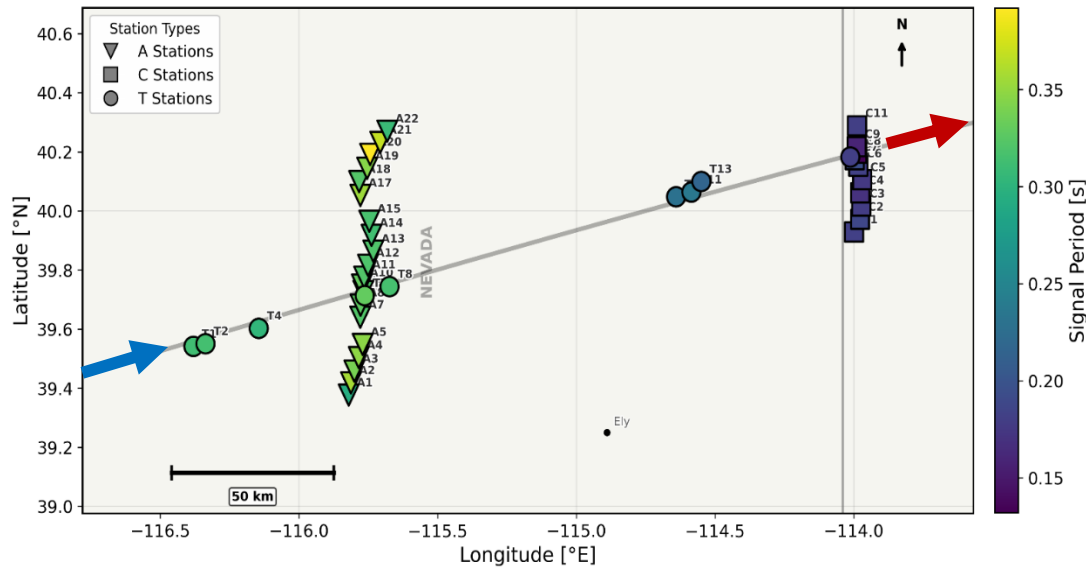
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¹Sandia National Laboratories, Albuquerque, NM, 87144, USA (esilber [at] sandia.gov)

WEAK-SHOCK ANALYSIS OF THE ACOUSTIC SIGNALS GENERATED BY THE OSIRIS-REX RE-ENTRY



Infrasound Signal Period Distribution
OSIRIS-Rex Sample Return Capsule Entry

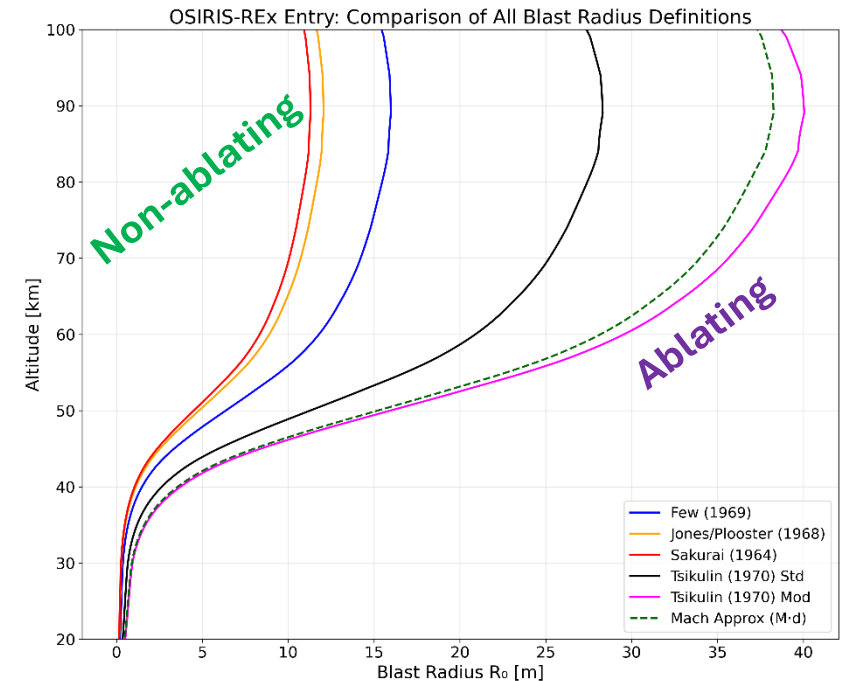


Benchmarking weak-shock theory

- Meteor and stochastic re-entry infrasound models rely on cylindrical blast-wave theory, but source parameters are usually unknown
- OSIRIS-REx Sample Return Capsule provides a rare controlled test (known geometry, trajectory, velocity)
- 39 infrasound stations used to evaluate 6 blast-radius formulations and 3 weak-shock transition coefficients

Key Results: *What works and what doesn't*

- Sakurai (1965) and Jones/Plooster reproduce observed signal periods best (10–15% error) for non-ablating objects
- Mach-diameter and Tsikulin formulations overestimate blast radius by $\sim 3\times$ (appropriate for ablating objects)
- Signal period is robust, amplitude is not \rightarrow period provides reliable constraints on blast radius



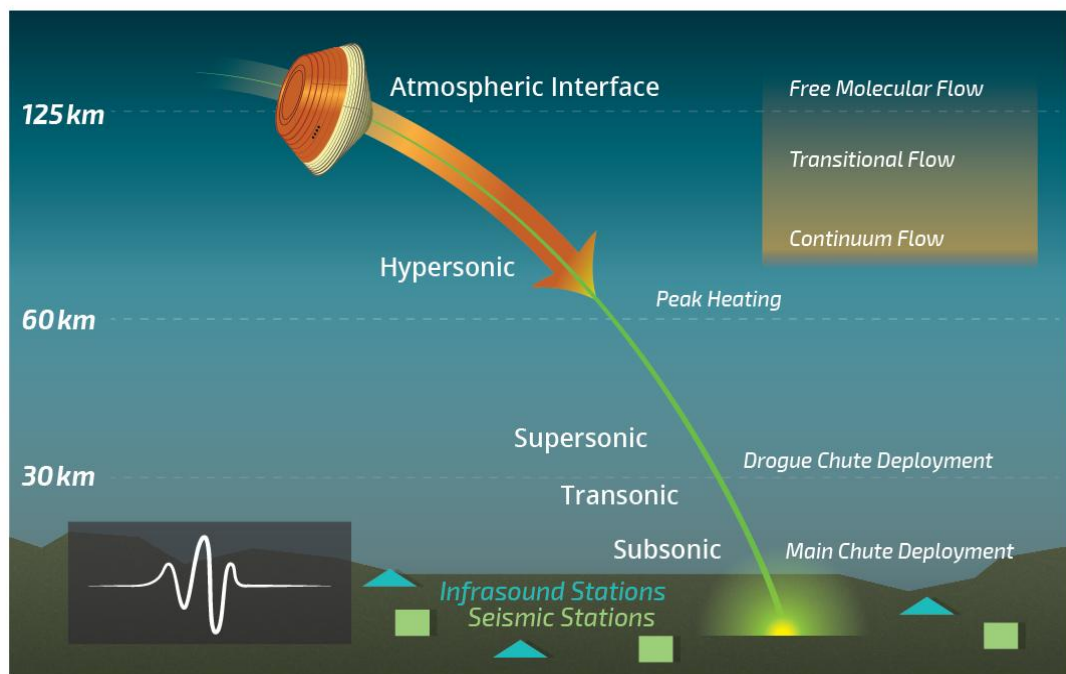


EXTRA SLIDES

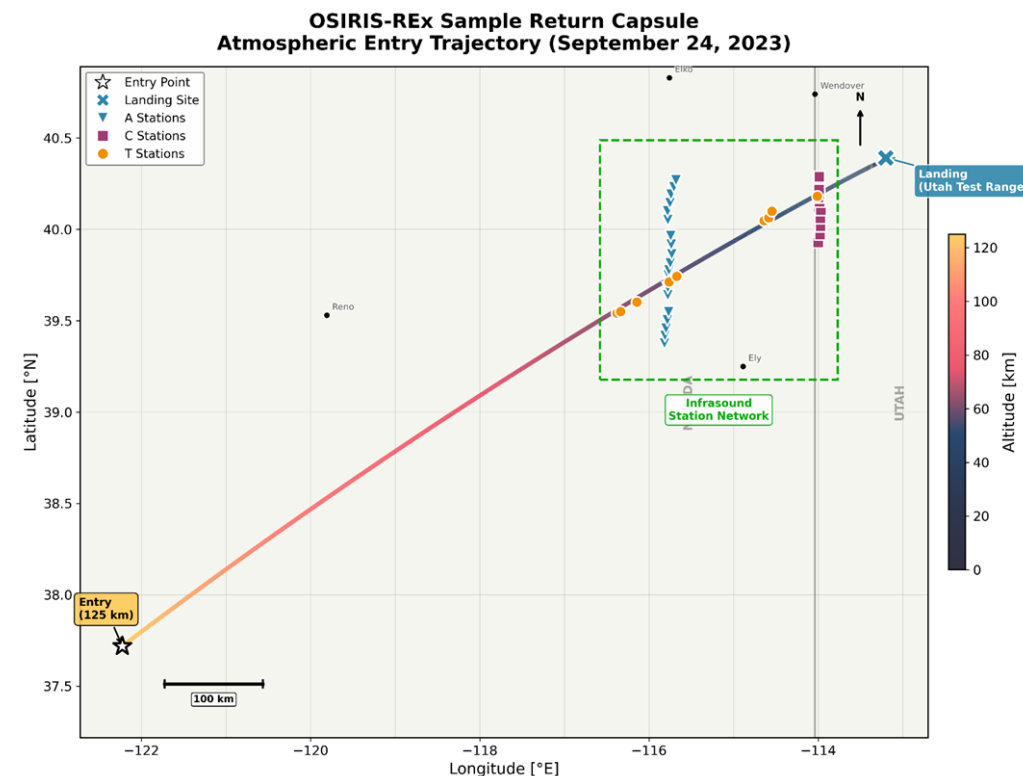


WHY OSIRIS-REX IS AN IDEAL BENCHMARK

- In most meteor studies, source parameters are uncertain (size, density, energy deposition must be inferred from optical data)
- The OSIRIS-REx Sample Return Capsule provides a rare controlled case: known diameter, mass, trajectory, and velocity from mission telemetry
- This allows the first direct benchmarking of cylindrical blast-wave formulations independent of ablation or fragmentation effects



- Entered the atmosphere at 14:41:55 UTC above San Francisco, CA at 12.36 km/s
- Landed at the Utah Test and Training Range (UTTR)

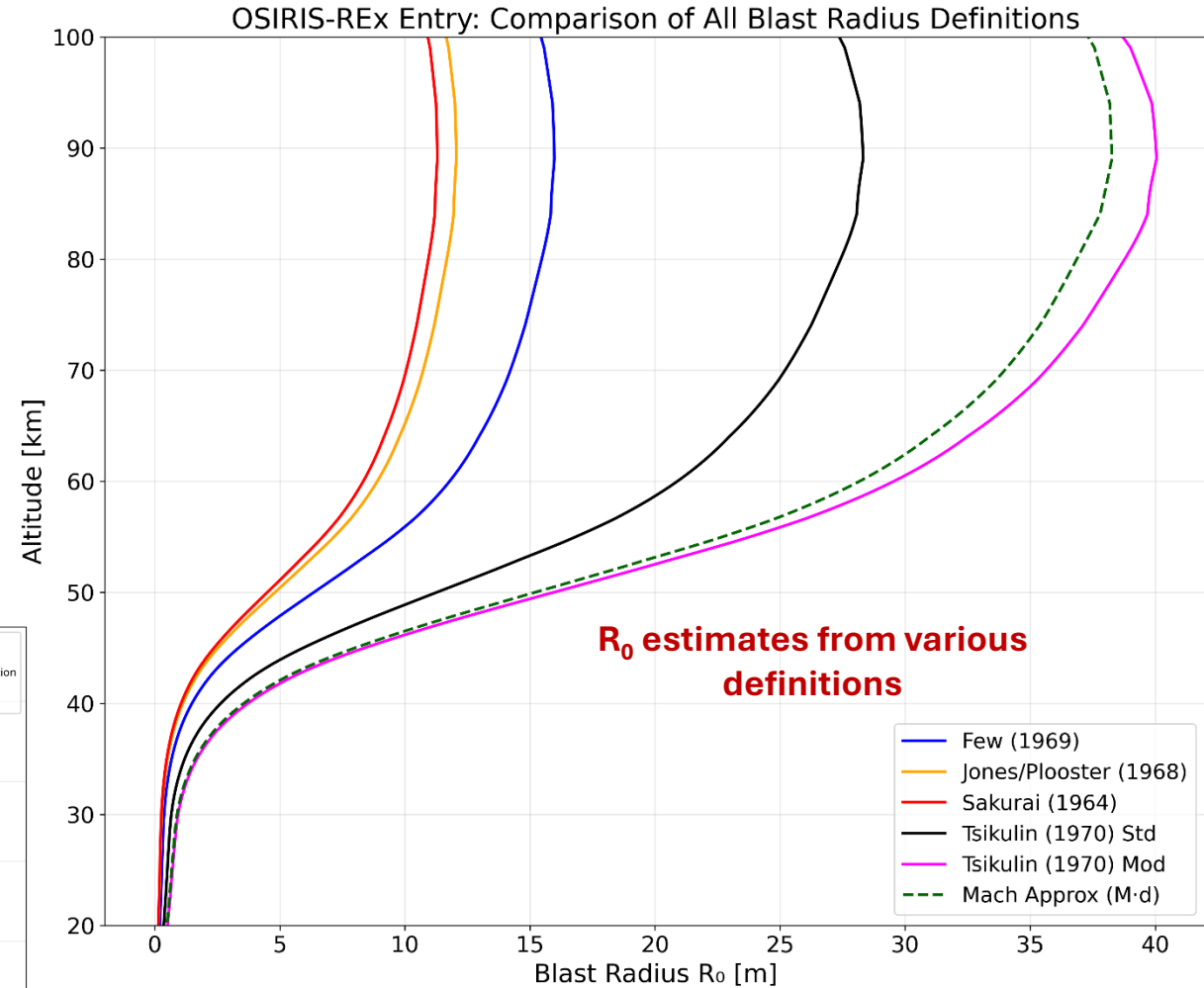
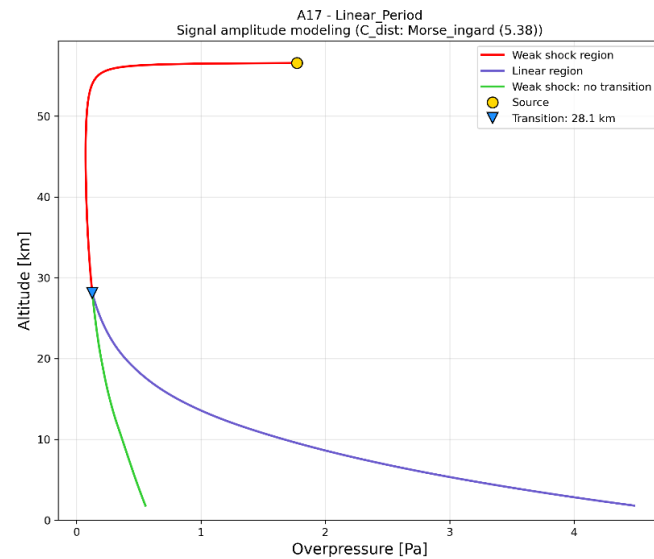
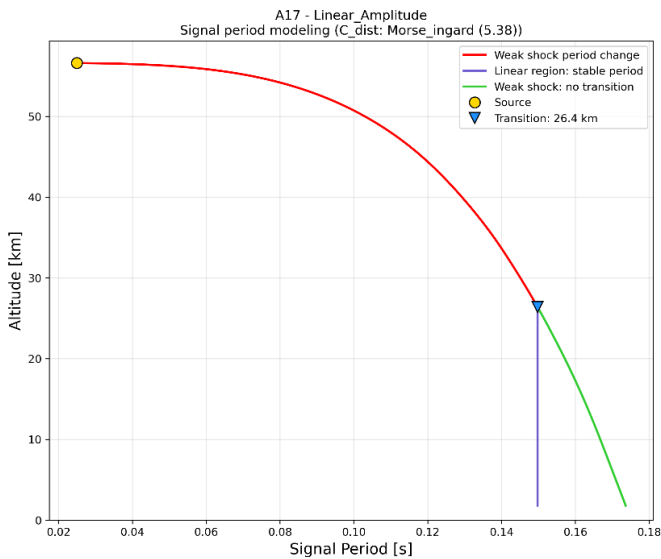


- Reentry detected by 39 infrasound stations across Nevada and Utah
- Stations sample multiple emission points along the trajectory with source heights between ~44 and 62 km
- Direct acoustic arrivals recorded at ~43–76 km propagation distances, enabling comparison between modeled and observed signals



WEAK-SHOCK MODELING FRAMEWORK

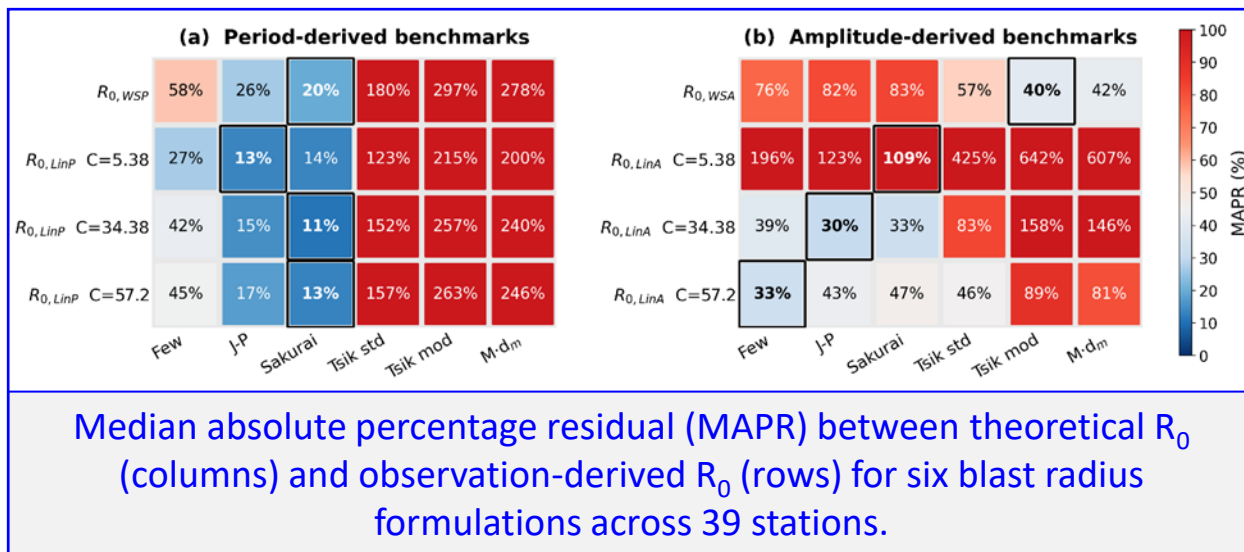
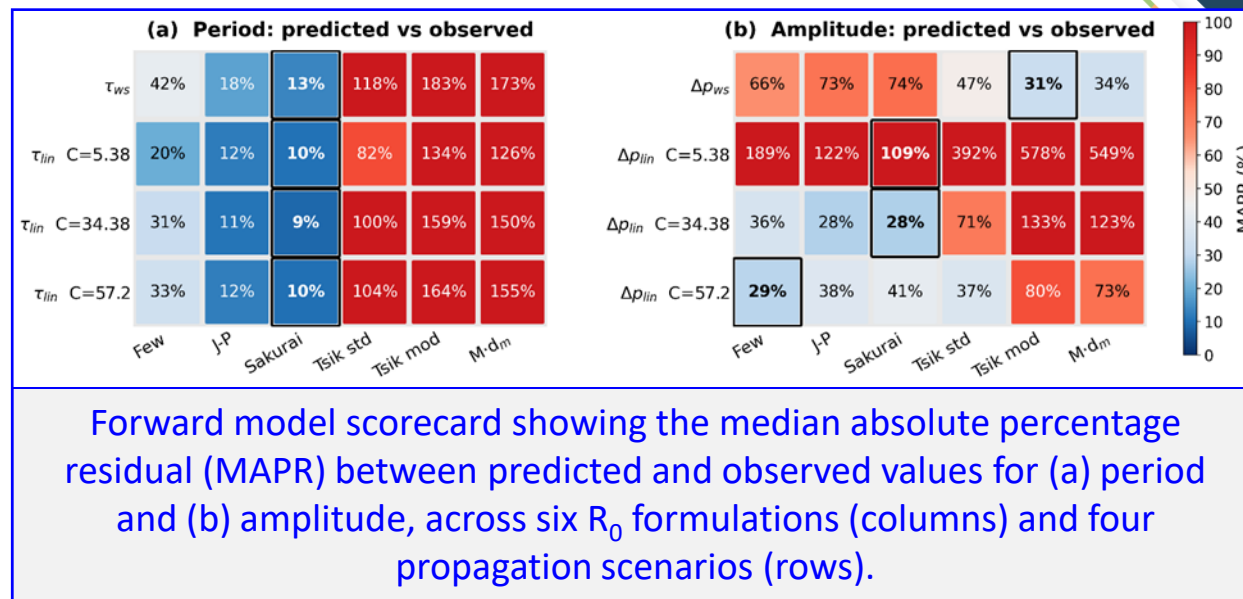
- Implemented a weak-shock propagation model including atmospheric stratification, wind effects, and frequency-dependent absorption
- Evaluated six blast radius (R_0) formulations from the literature
- Tested three weak-shock transition coefficients and compared predictions with observed signal period and amplitude





PERFORMANCE OF BLAST-RADIUS FORMULATIONS

- Energy-normalized formulations reproduce observations best: Sakurai (1965), and Jones et al. / Plooster (1970)
- Scaling formulations systematically overestimate blast radius: Mach-diameter approximation and Tsikulin formulations
- For this non-ablating body, these formulations overpredict R_0 by roughly a factor of 3



- At slant ranges of ~46-72 km weak-shock and linear period predictions converge
- As a result, the infrasound period becomes only weakly sensitive to the transition coefficient
- Signal period provides a stable observable, while amplitude remains strongly affected by propagation effects



ACKNOWLEDGEMENTS

This work was supported by the Nuclear Arms Control Technology (NACT) program at the Defense Threat Reduction Agency (DTRA). Cleared for release.

Sandia National Laboratories is a multimission laboratory operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.