Investigation of anomalously fast infrasound phases from global bolide events

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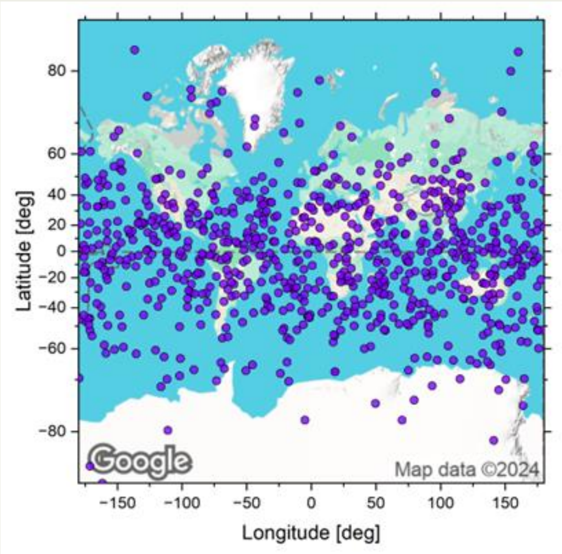
Background and Motivation

Bolides can generate infrasound signals detectable globally; understanding their propagation patterns aids global monitoring and event characterization [1,2].

While typical infrasound signals follow predicted arrival times, some bolide events produce anomalously early arrivals, challenging current models and interpretations.

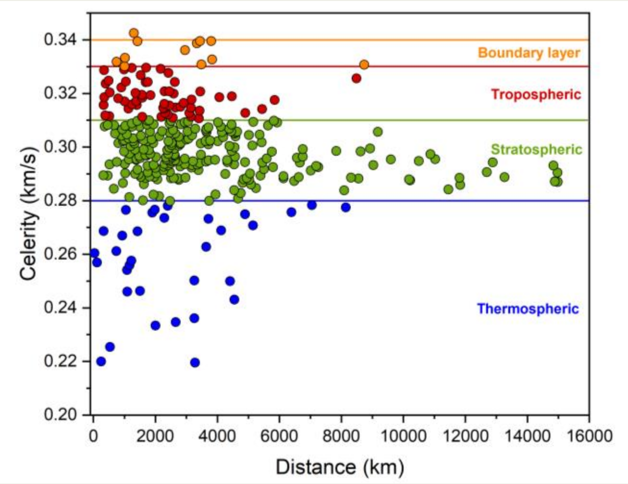
Examining a global dataset of bolide detections (shown below) helps identify and investigate causes of these unexpected early arrivals, improving our understanding of infrasound signal propagation.



Data Set and Preliminary Results

We analyze a dataset of 172 globally distributed bolide detections, combining data from US government sensors and published global infrasound detections [2].

Observed signal celerities, defined as the ratio of source-to-station distance to measured travel time, were calculated and compared to theoretical values for standard atmospheric waveguides (boundary layer, tropospheric, stratospheric, and thermospheric).



Preliminary results (above) indicate most signals align with expected stratospheric arrivals. However, a notable subset exhibits anomalously fast arrivals, even at distances exceeding several thousand kilometers.

Summary

Early-arriving signals suggest influences from atmospheric propagation conditions or source characteristics, warranting further investigation.

Identifying underlying causes, such as wind-driven stratospheric ducts, waveguide characteristics, or specific source properties, is critical for refining signal interpretation accuracy.

Understanding anomalously fast infrasound arrivals advances event characterization, contributing directly to improvements in global infrasound monitoring capabilities, including verification efforts for the Comprehensive Nuclear-Test-Ban Treaty (CTBT).

Improved interpretation of early-arriving signals can strengthen the reliability of global monitoring networks by distinguishing between natural energetic events (bolides) and anthropogenic sources, thereby supporting international monitoring and verification objectives.

References:

[1] Pilger et al. (2020) doi: 10.3390/atmos11010083.
[2] Silber, et al. (2025) doi: 10.3847/1538-3881/add47d

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CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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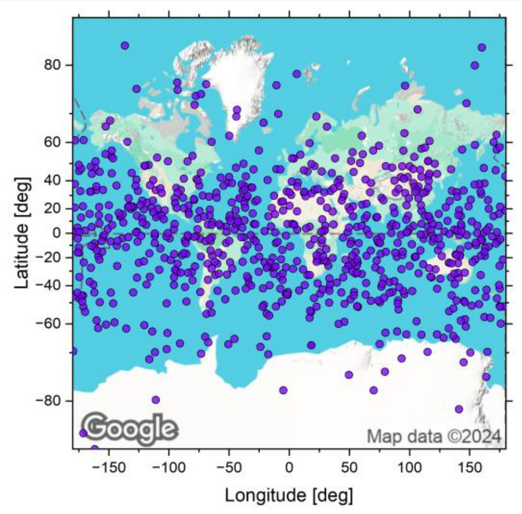
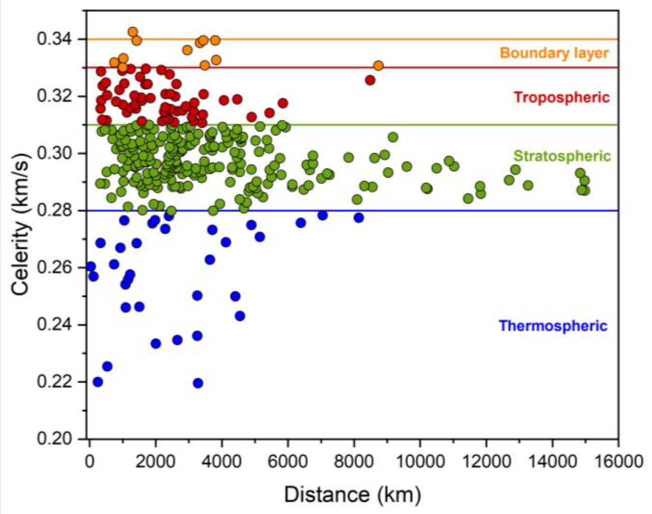
- At long ranges, infrasound predominantly propagates through the stratospheric waveguide.
- However, some infrasound signals arrive at stations earlier than anticipated.
- We investigate the causes for fast infrasound phases to determine if earlier than anticipated arrivals are caused by source or propagation effects, or both.
- For more details, visit our poster!





*work performed during summer internship at Sandia

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