



Elizabeth A. Silber

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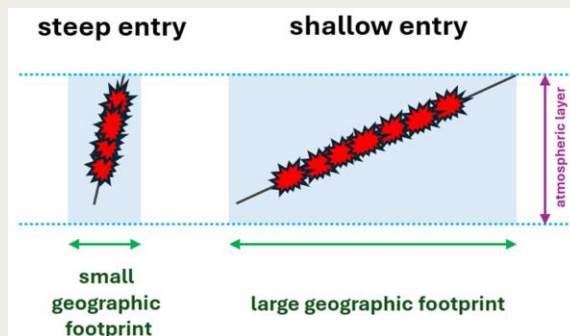
Introduction

Infrasound sensing is critical for detecting and geolocating bolides and other high-energy, extended trajectory events [1].

Infrasound monitoring has traditionally assumed that bolides can be approximated as point sources at sufficiently large distances [2].

Bolides and reentry events can generate shock wave along extended paths as shown below, often resulting in non-negligible discrepancies between observed infrasound back azimuths and theoretical predictions derived from the object's peak brightness location, notably during shallow-angle atmospheric entries [3-5].

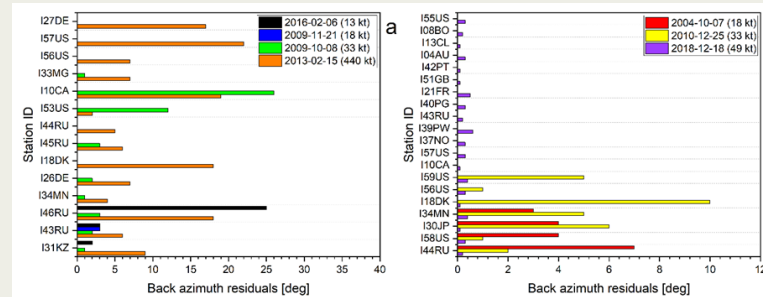
This study aims to quantify the geometric effects on infrasound signal arrival directions and improve bolide geolocation accuracy.



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Observations

Seven most energetic bolides detected by both US government sensors and infrasound were examined to determine variability in observed back azimuths (plotted below).



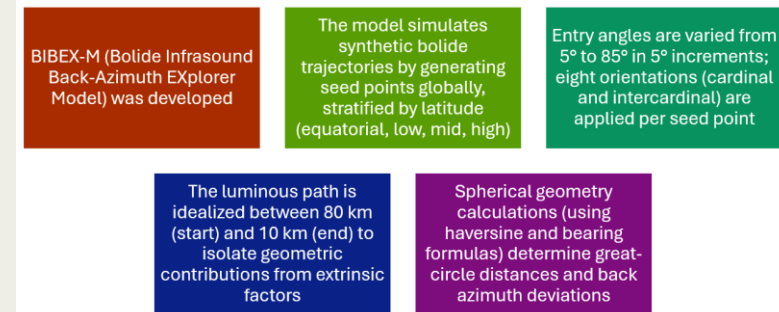
Shallow entry angle events tend to exhibit higher back azimuth residuals.

This motivated the development of a modeling framework to determine maximum possible back azimuth deviations that would arise due to the trajectory geometry alone.

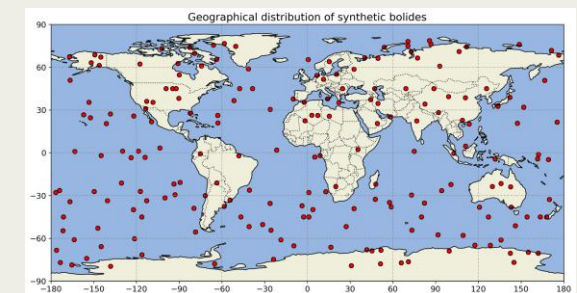
Quantifying the contribution of trajectory geometry alone is essential to isolate it from other influences such as atmospheric propagation and station-specific effects.

Model Development

A theoretical framework, the Bolide Infrasound Back-Azimuth EXplorer Model (BIBEX-M), was developed to compute predicted back azimuths solely from geometric considerations.



Simulations using synthetic bolides explore back azimuth deviations as a function of entry angle and station distance up to 15,000 km.





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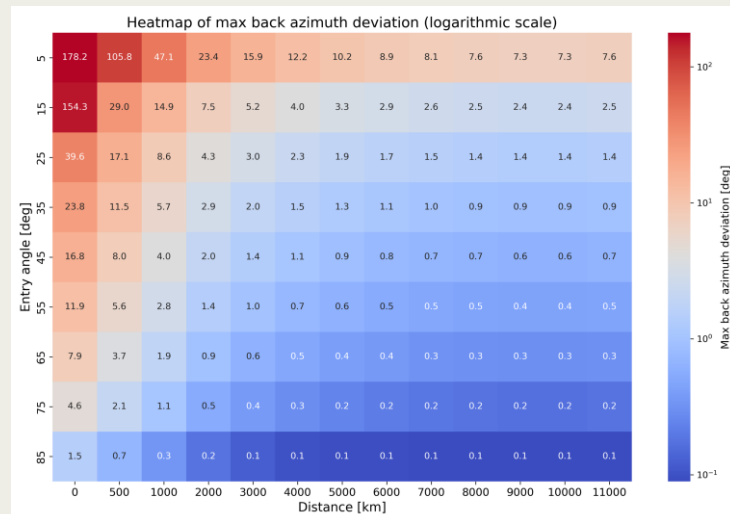
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Results

Simulations reveal that shallow-entry bolides ($\leq 10^\circ$) produce large back azimuth deviations, up to $\sim 46^\circ$ within 1000 km.

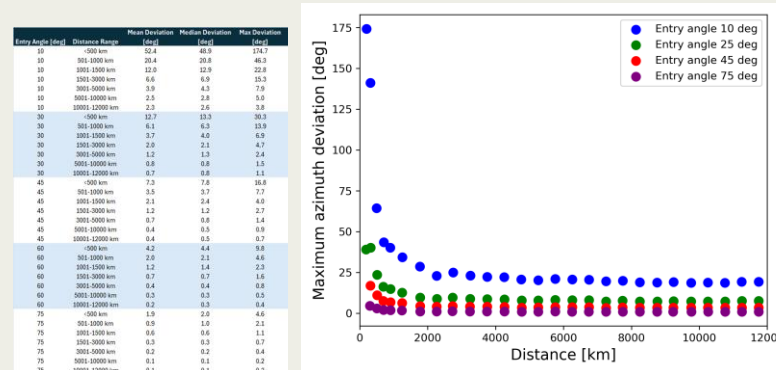
Steeper trajectories ($\geq 60^\circ$) consistently result in deviations below $\sim 5^\circ$ at 1000 km and less than $\sim 1^\circ$ beyond 5000 km.

A global heatmap visualization systematically quantifies maximum geometric deviations in back azimuth across entry angles and source-to-station distances, providing a practical global reference table for interpreting observed infrasound signals.



Results

A scatter plot of maximum azimuth deviations versus distance for representative entry angles (10° , 25° , 45° , and 75°) illustrates the dependence of azimuth residuals on entry angle and source-to-receiver distance, confirming variability especially evident in shallow angle scenarios.



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- Infrasound sensing is critical for detecting and geolocating high-energy, extended trajectory events, but has traditionally approximated emitters as stationary point sources at large distances
- However, moving elevated sources can generate shock wave along extended paths, thereby causing significant deviations in observed back azimuths
- This study focuses on the geometric contribution to quantify how event trajectory affects infrasound signal arrival directions
- To learn more about this work, visit my poster!

