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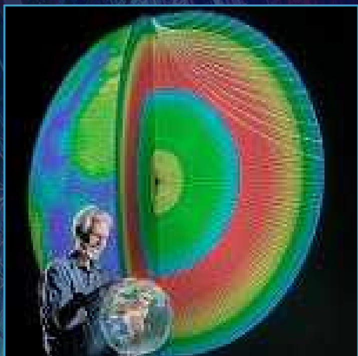

Infrasound Monitoring of Natural Hazards

Stephen J. Arrowsmith

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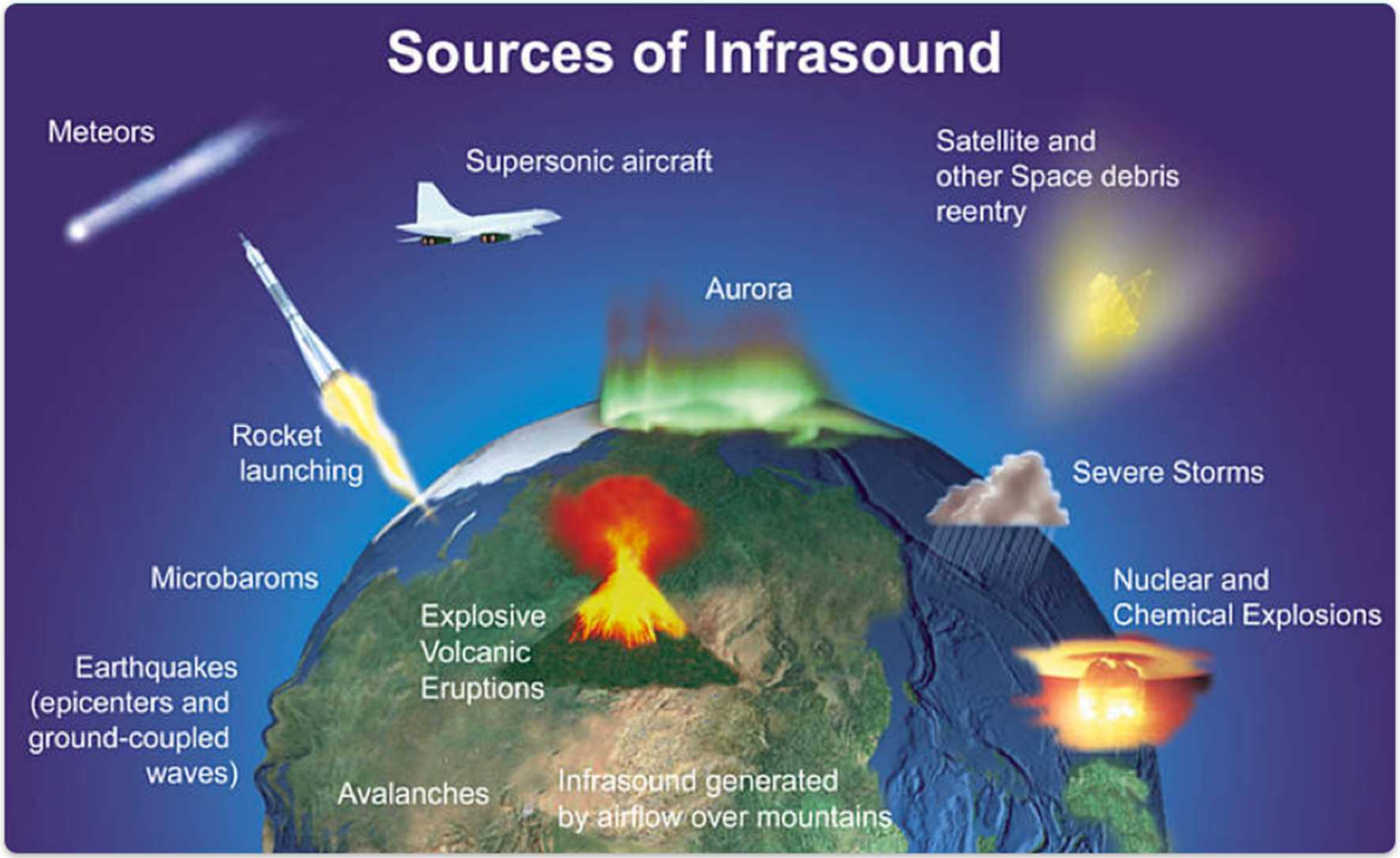
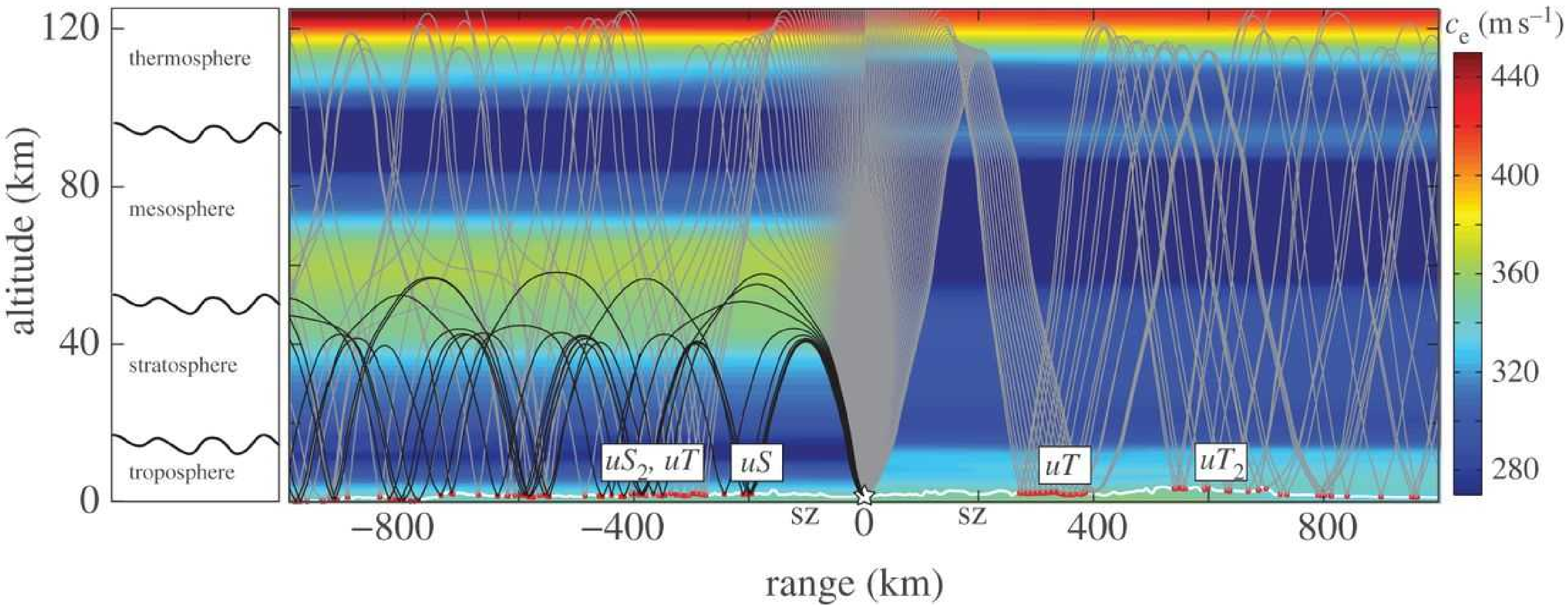
Infrasound as a tool to study natural hazards



A wide-variety of natural hazards in the solid earth, oceans, and atmosphere generate infrasound

Infrasound Propagation

Figure from Hedlin and Walker, 2012



Infrasound propagates long distances in waveguides in the troposphere, stratosphere, and thermosphere.

Infrasound Propagation

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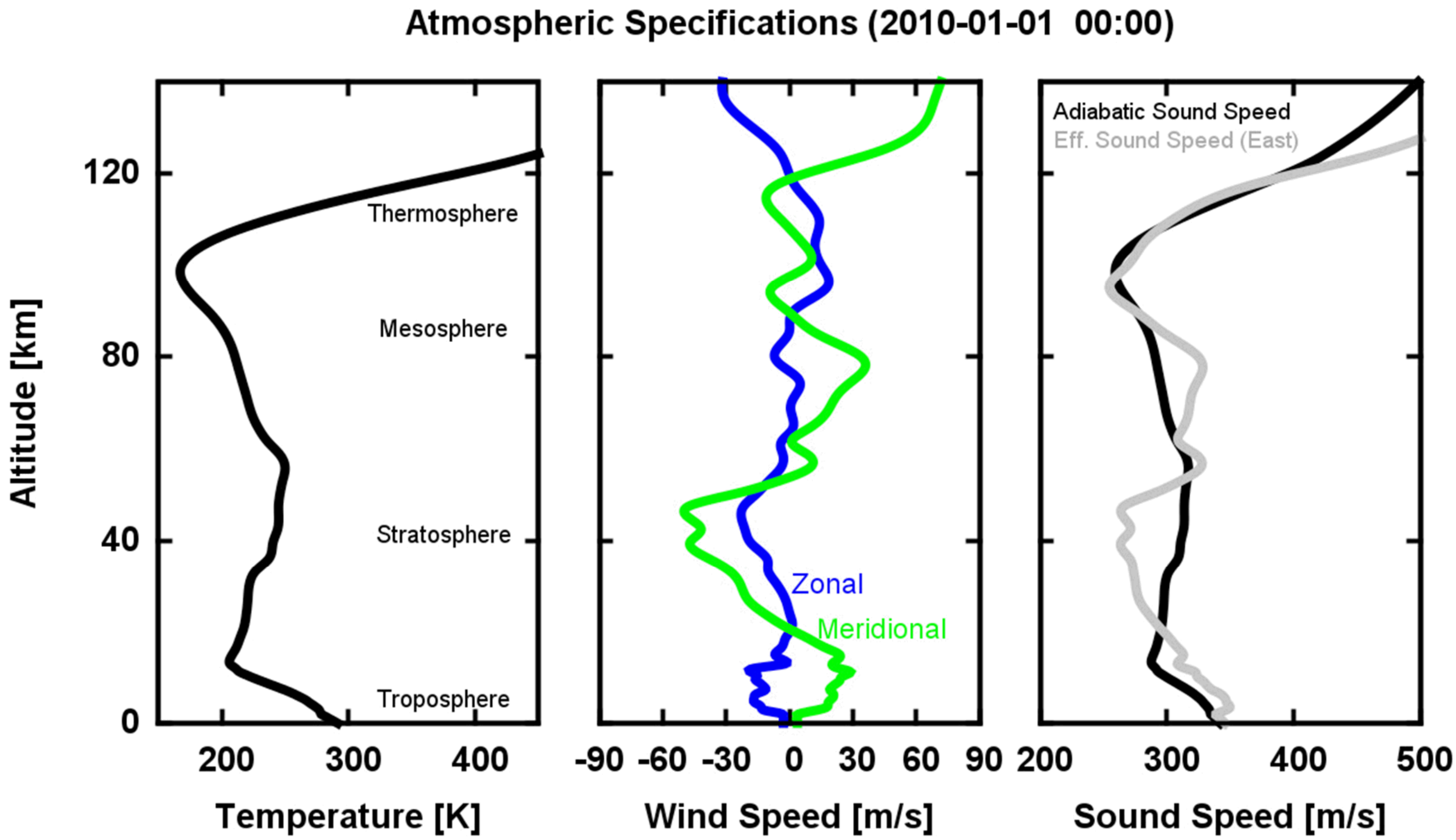
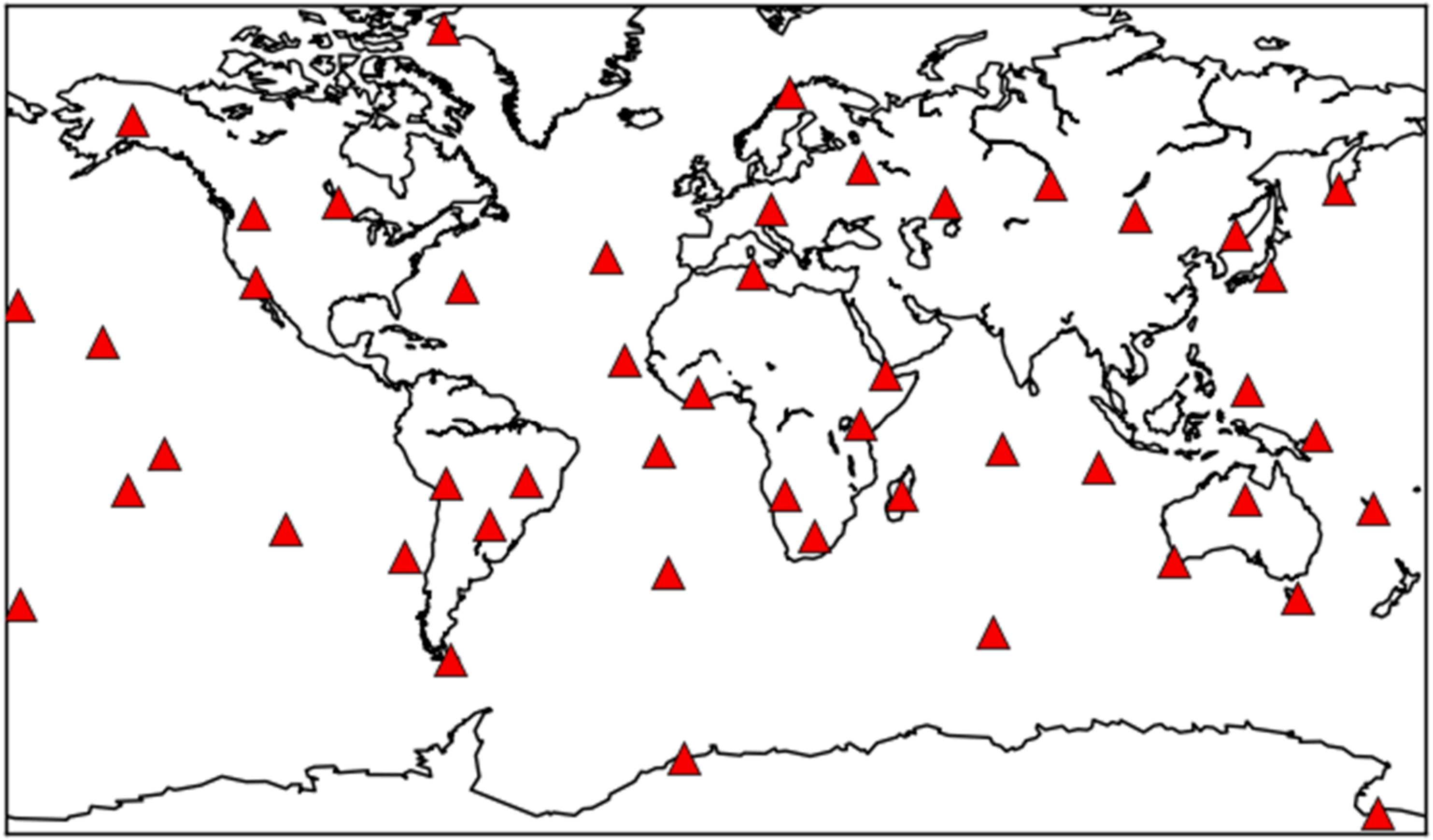


Waveguides are formed by the combination of increasing temperature and wind jets. Their characteristics are transient and affected by sub grid-scale phenomena.

A Global Infrasound Network



The International Monitoring System infrasound network has grown from inception to 47 arrays in ~15 years. The full network will comprise 60 arrays.

What can we detect?

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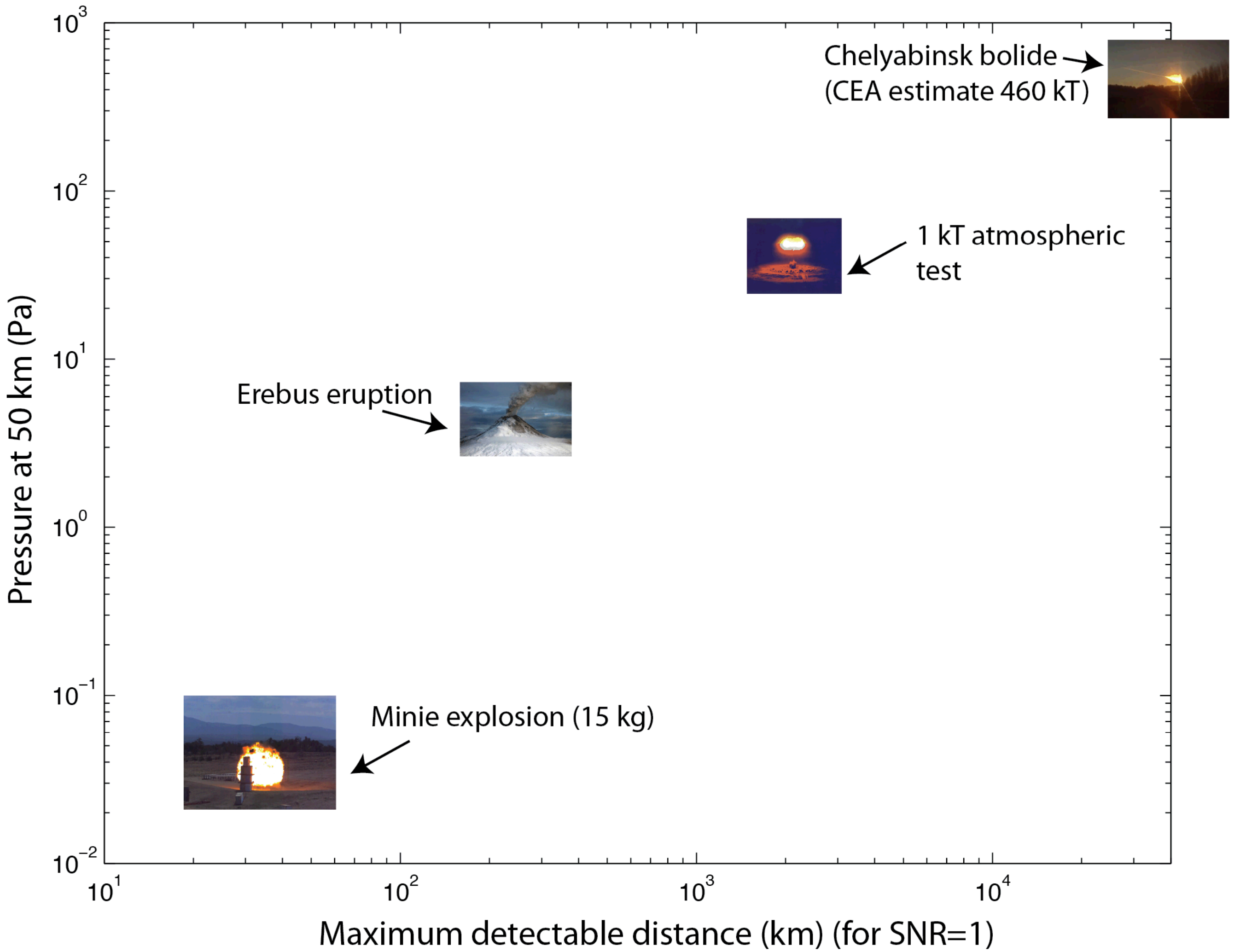
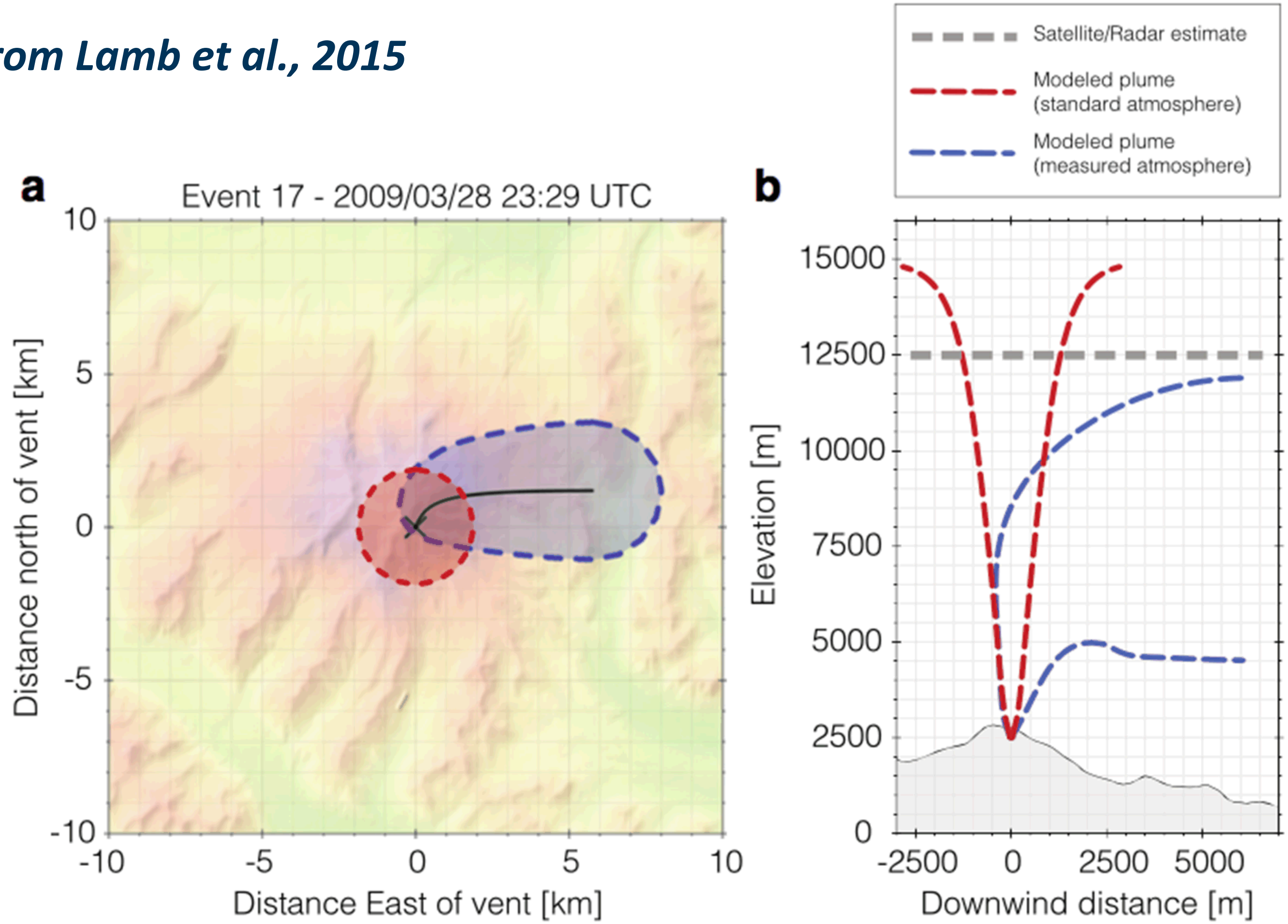


Detection range depends on the source size. Some large events, such as the Chelyabinsk bolide, can be detected twice around the world.

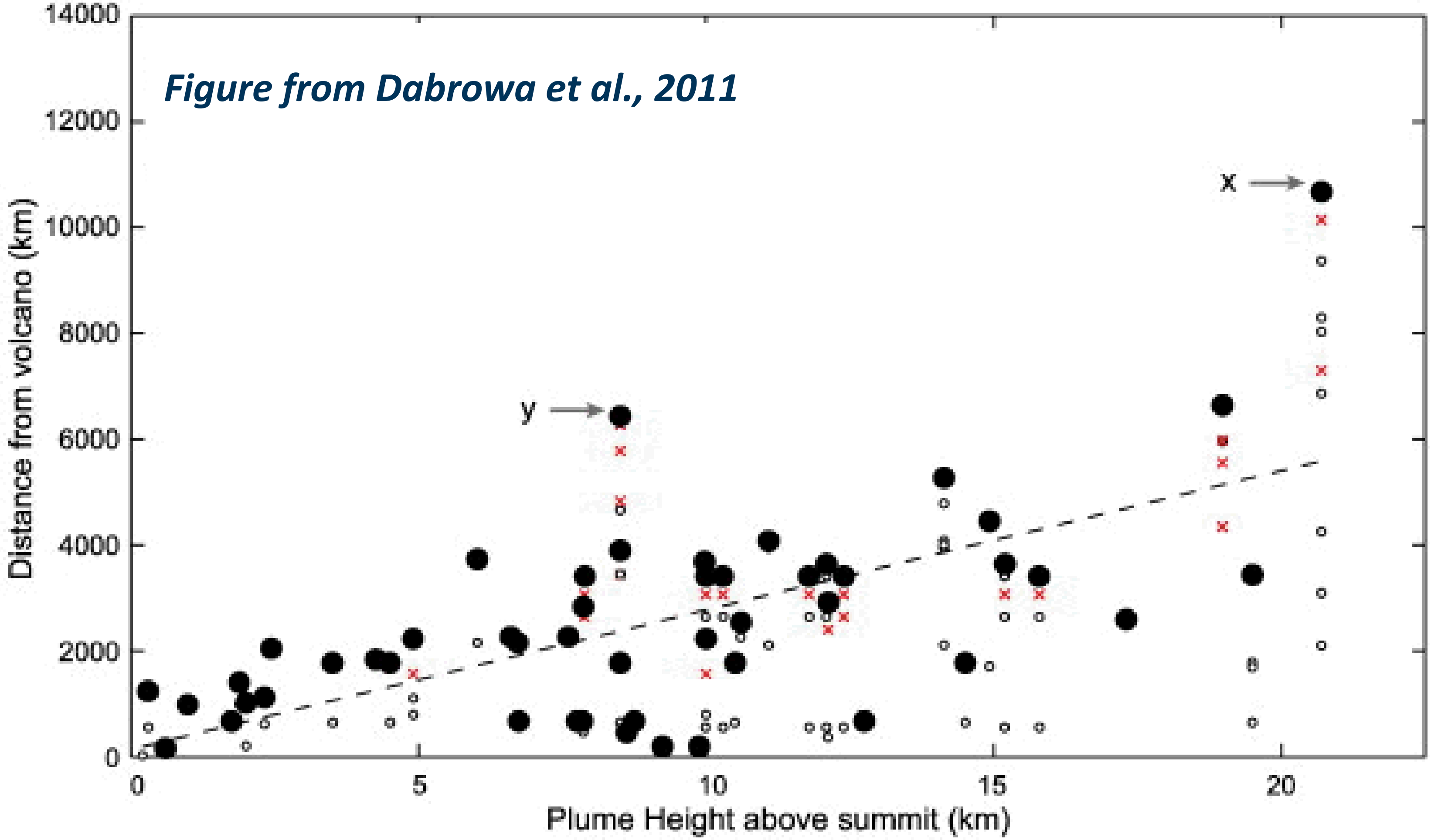
Volcanoes: Local Recordings

Figure from Lamb et al., 2015



Local infrasound signals can be used to estimate source parameters: acceleration of the atmosphere, volume flux, mass flux. Such recordings constrain numerical models of plume dispersion.

Volcanoes: Long-range Recordings



Long-range recordings of volcanoes can be used to detect eruptions in remote regions, providing needed information for the aviation industry.

Meteoroids

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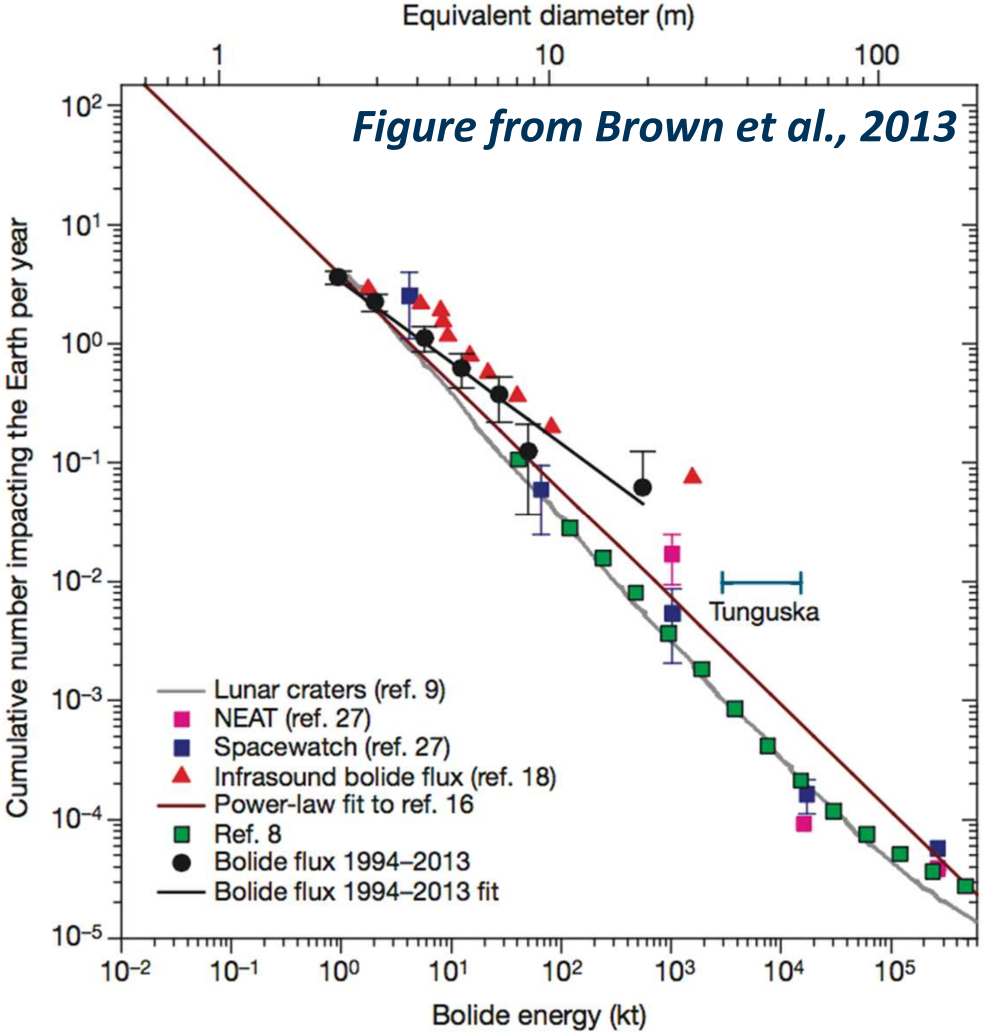
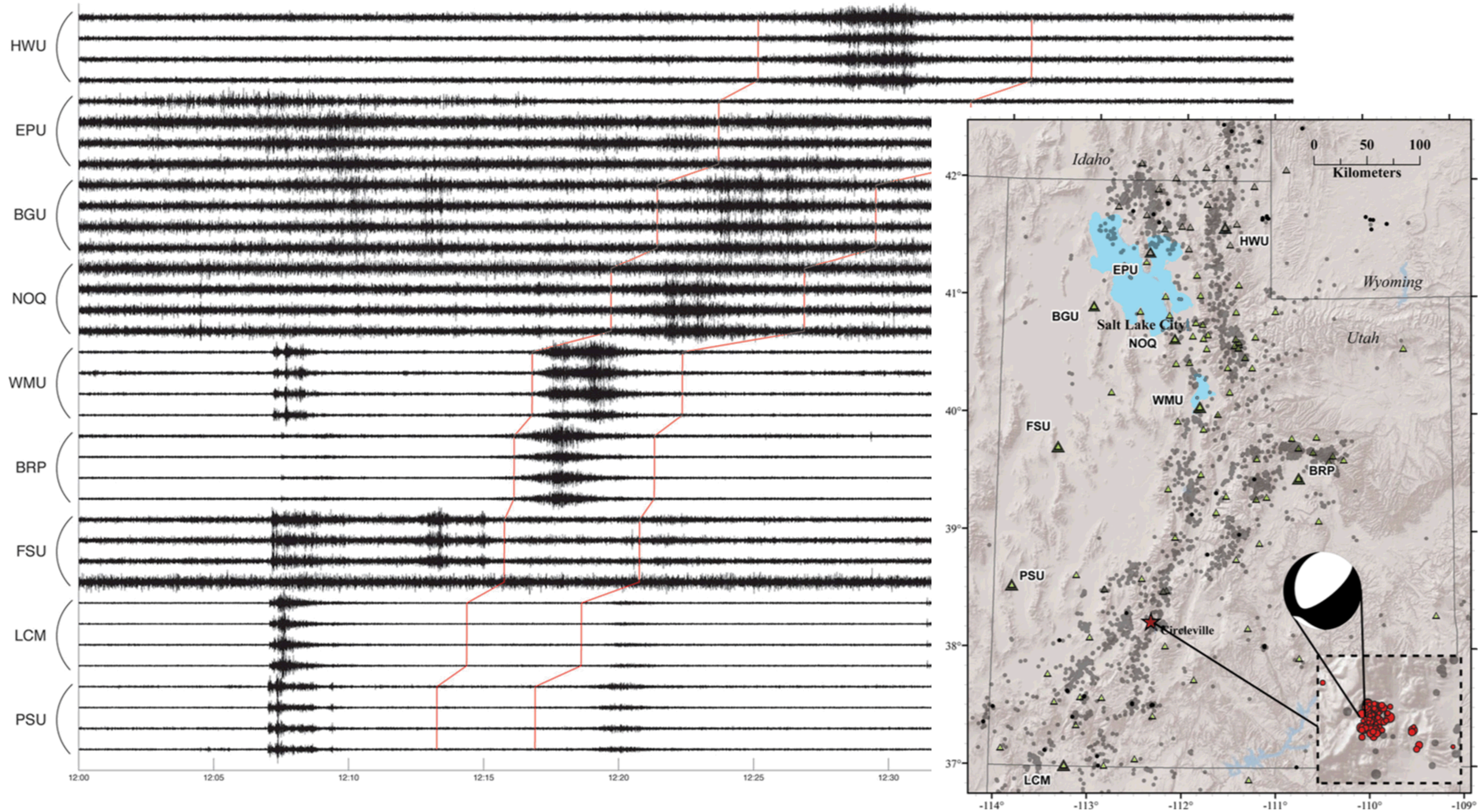


Infrasound can be used to quantify the flux of Near-Earth Objects. Recent work suggests the flux may be higher than expected over certain size ranges.

Earthquakes



Infrasound measurements are sensitive to ground shaking over a broad area following large earthquakes.

Tsunamis

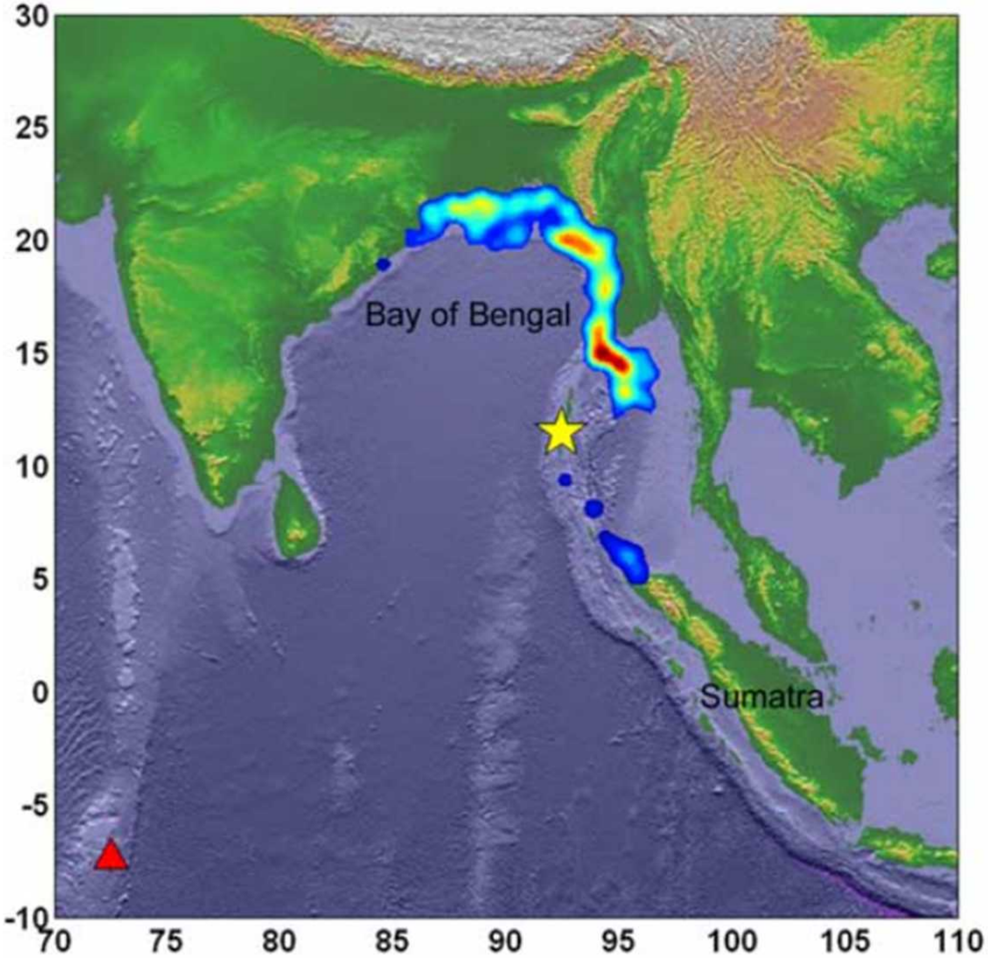
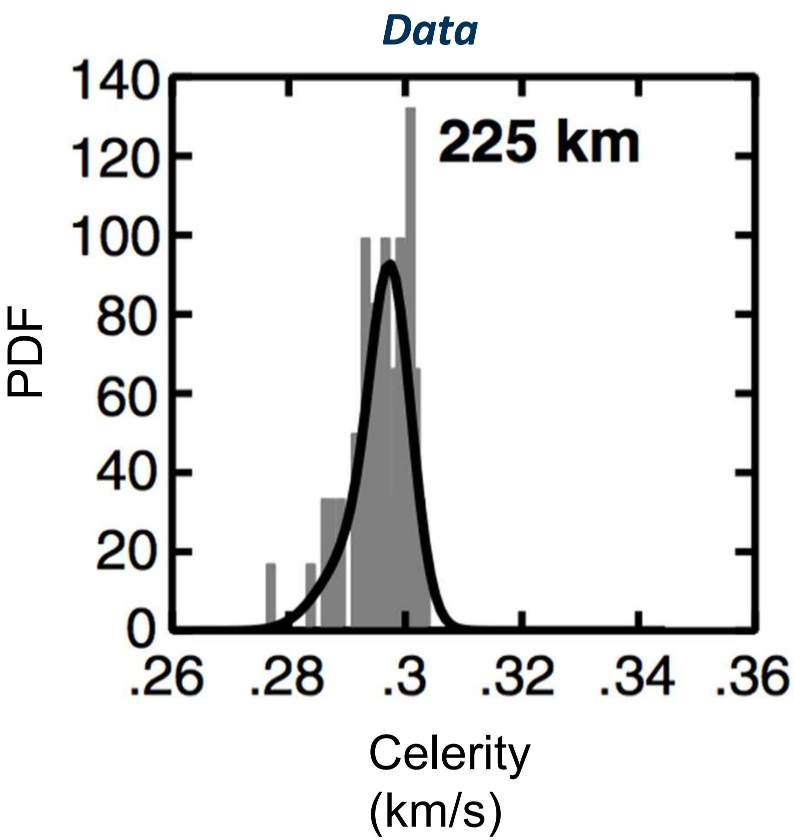
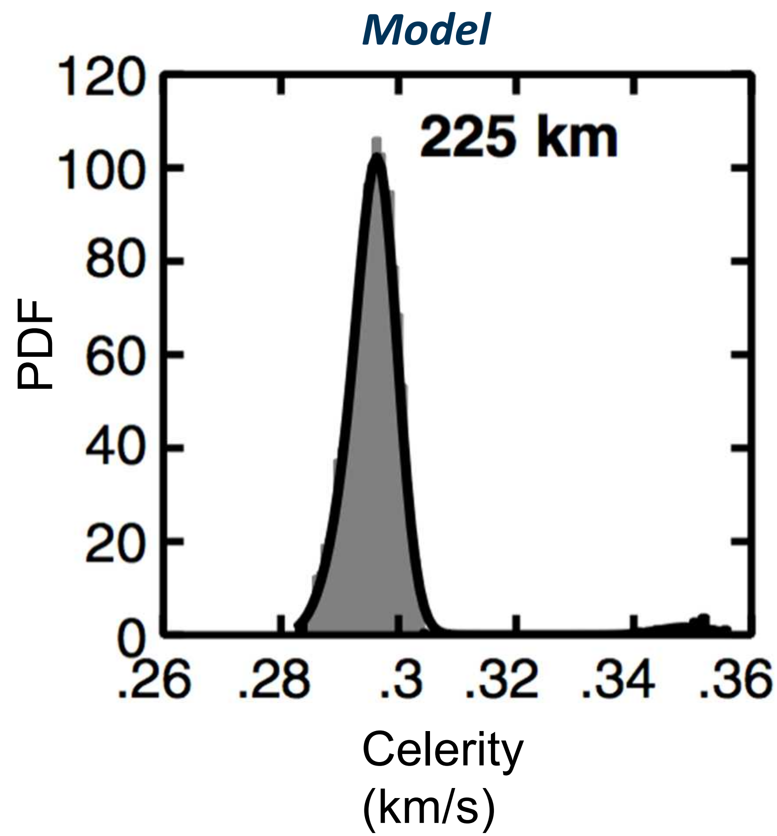


Figure from Le Pichon et al., 2005

Tsunami-generated infrasound was observed from the 2004 Sumatra earthquake along the Bay of Bengal.

A Stochastic Treatment of the Atmosphere

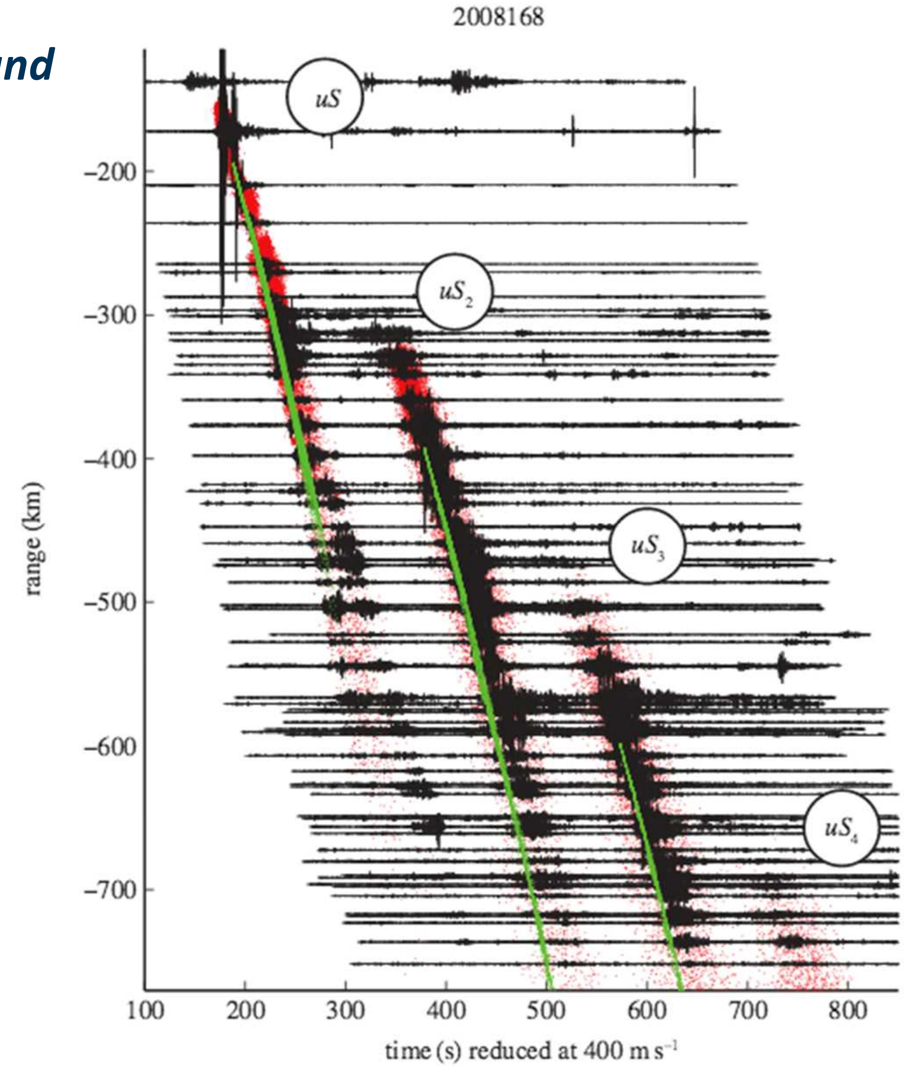




At long ranges, propagation models for signal parameters (e.g., arrival-time, amplitude) can be treated as distributions through modeling ensembles of possible atmospheric states.

Beating down spatial aliasing

Figure from Hedlin and Walker, 2012



Recordings on infrasound signals from an explosion in Utah recorded on USArray seismic sensors.

Summary

- A wide variety of natural events generate infrasound signals that can be detected at long range.
- However, using these signals to better understand hazards, particularly at long range, is extremely challenging.
- Local measurements are much more useful for constraining source models, as has been demonstrated with local deployments at volcanoes.
- At long ranges, infrasound offers the opportunity to detect events that may be otherwise missed (e.g., volcanic eruptions under aviation routes, large meteoroids), particularly in remote areas.
- The use of low-cost, low-power, portable sensors may ultimately revolutionize the capability of infrasound measurements for hazards monitoring (beyond detecting events, towards better characterizing them)