Seismoacoustic Signals from Hunga Tonga

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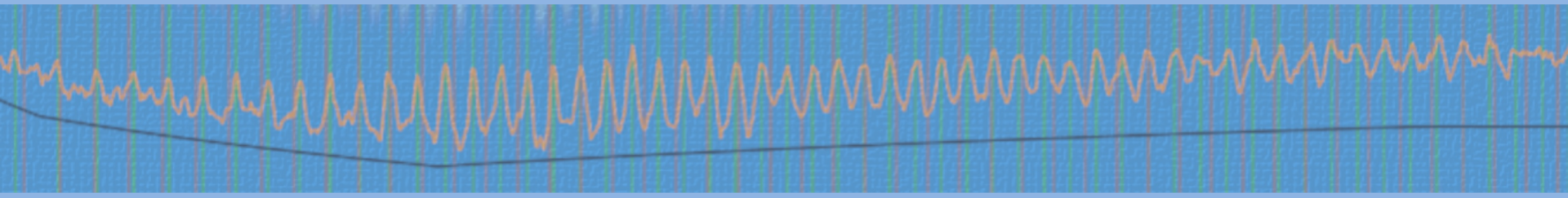
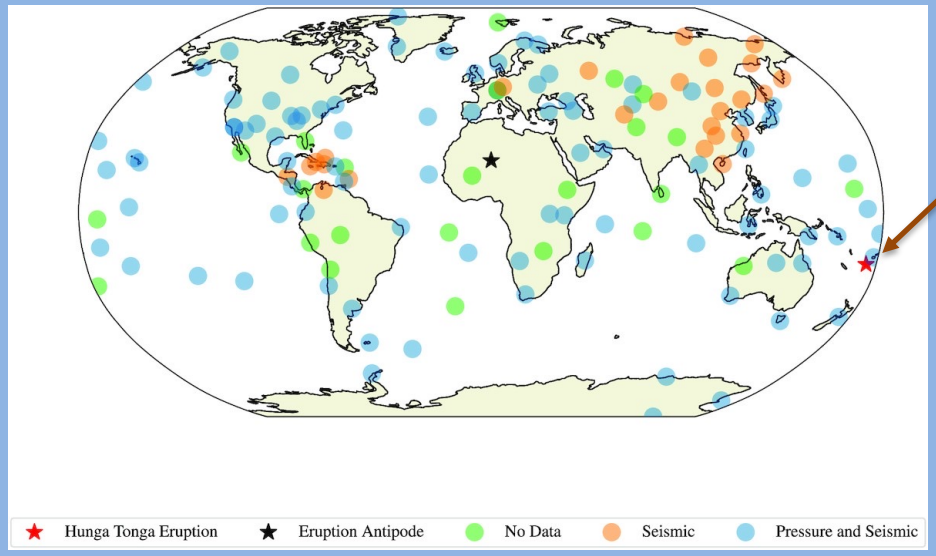


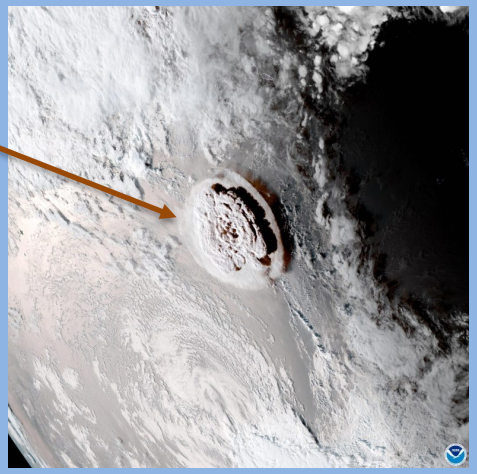
Part 1: Atmospherically Coupled Modes

Part 2: Seismoacoustic amplitude ratios

USGS/IDA Stations



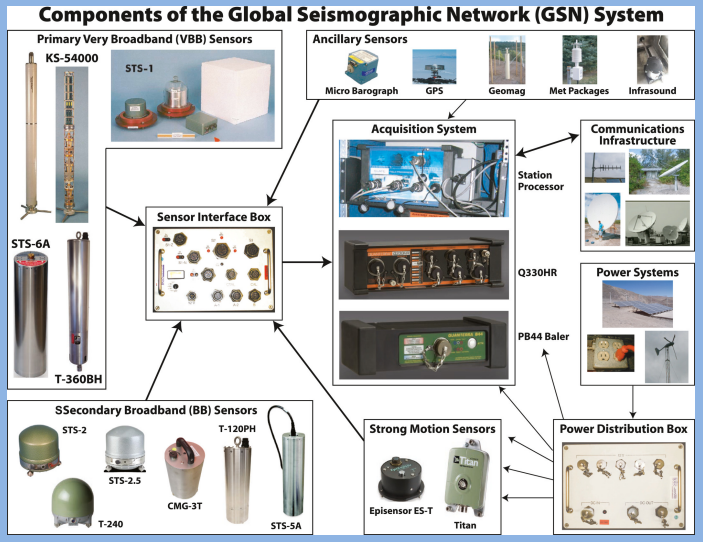
Eruption



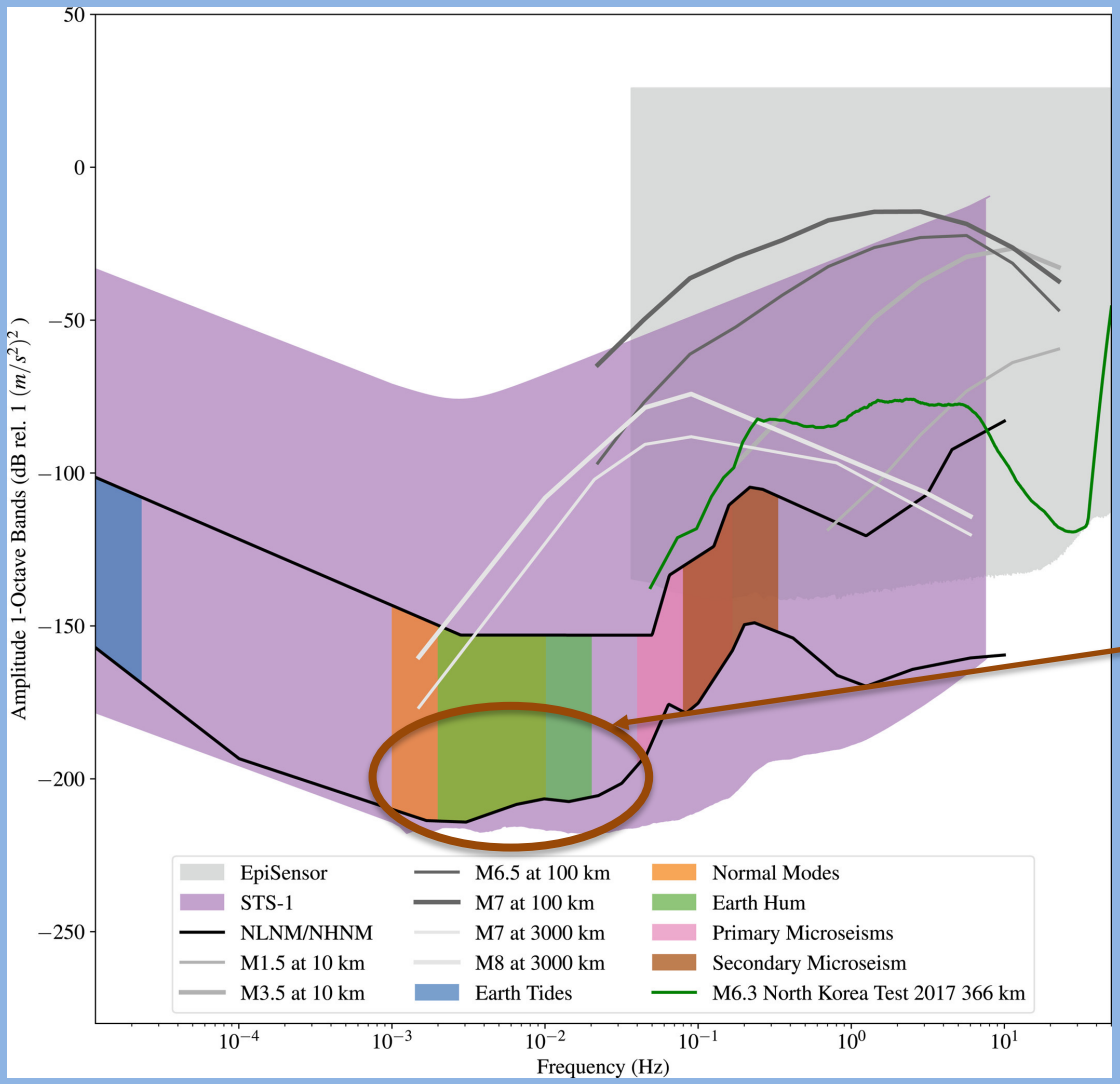
From NOAA

Multiuse network aimed at recording the entire seismic wavefield

Most GSN stations have pressure + VBB seismic + other sensors 114 stations with data



USGS Stations

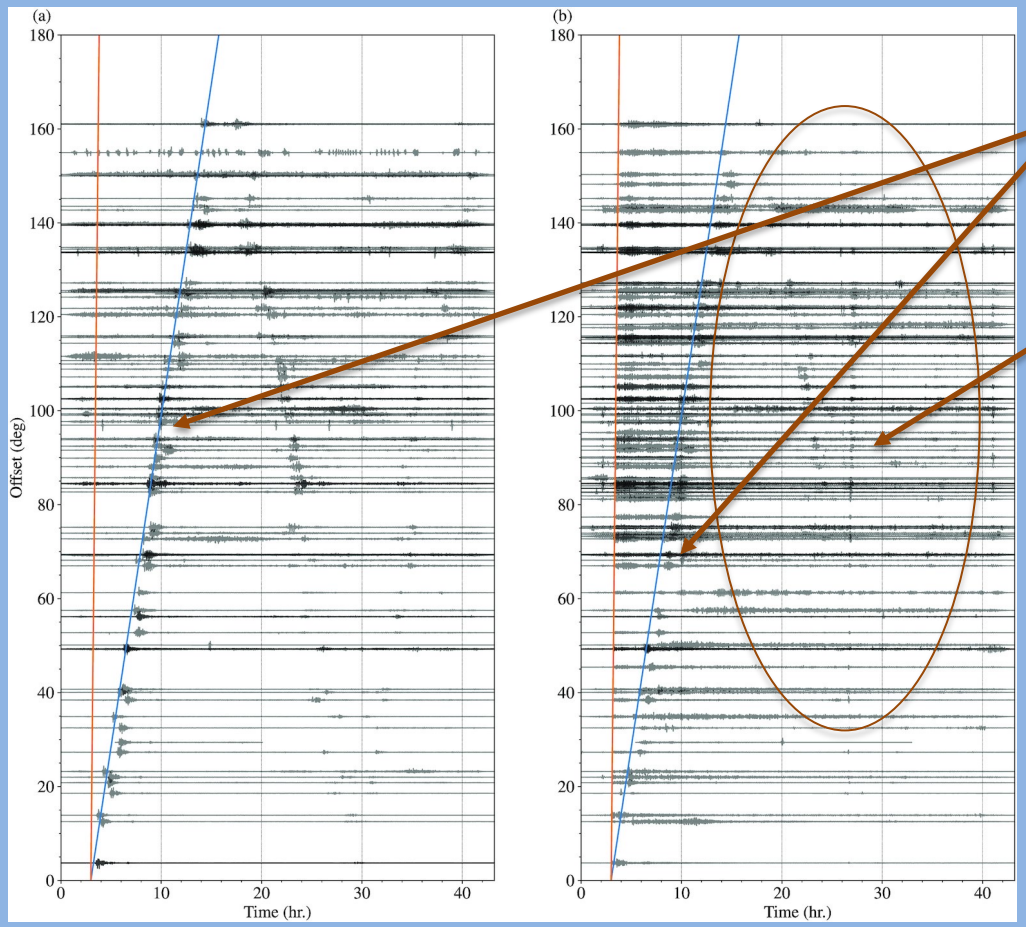


Our aim is to record the *ENTIRE* seismic wavefield with high-fidelity!

The GSN is *INTERESTED* in 6C seismology!

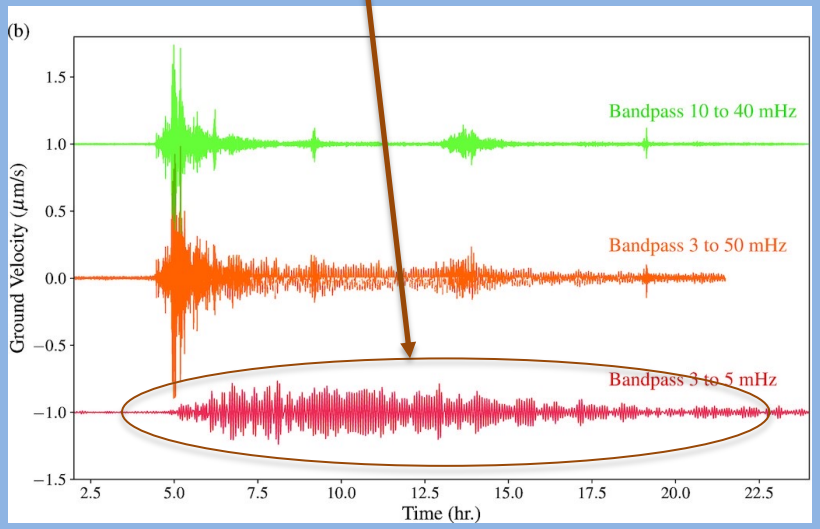
Area of focus today

Seismic Fuzz



Have 310 m/s acoustic + Rayleigh wave arrival

Some ”seismic fuzz” going on afterwards



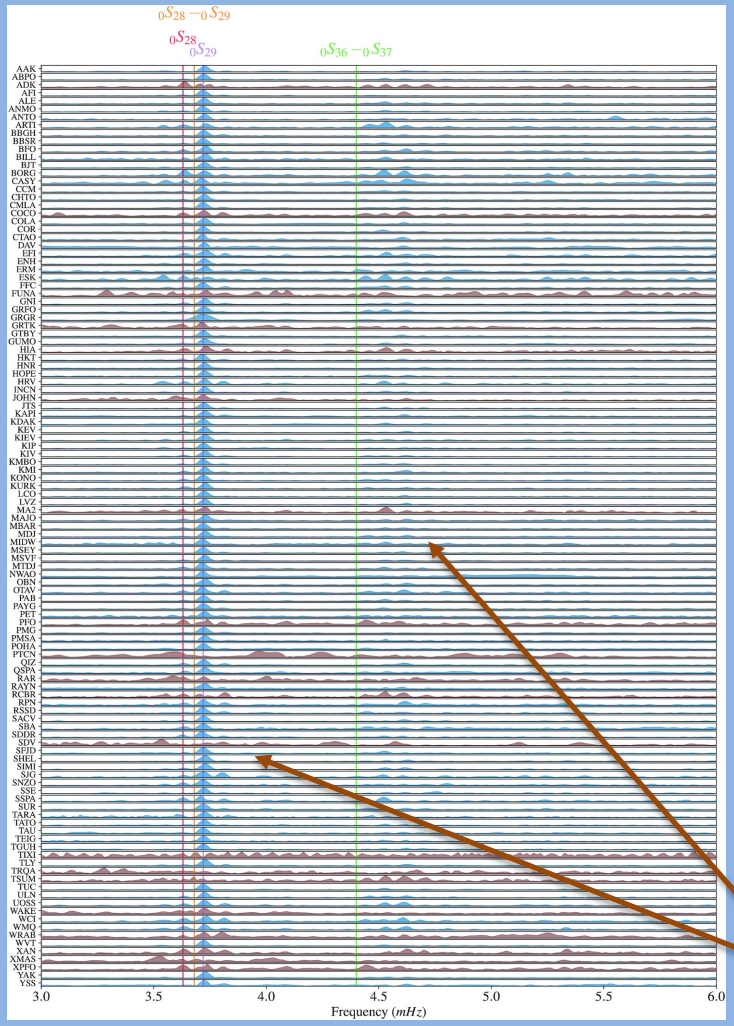
Pressure

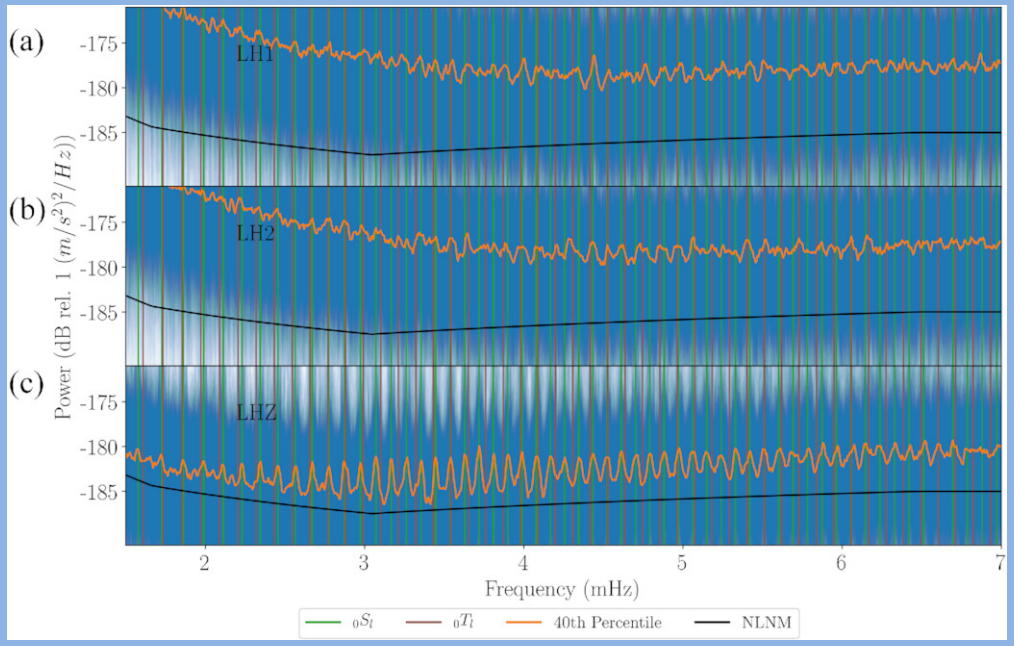
Seismic

Limited to 3 to 5 mHz (Earthhum band)

Filtered 10 to 1000 s

A Few Spectra





Background seismic hum (broadband across 3 to 7 mHz)

Eruption produced only 3.7 and 4.4 mHz excitation ($_0S_{29}$ and $_0S_{37}$)

Solid+Atmosphere

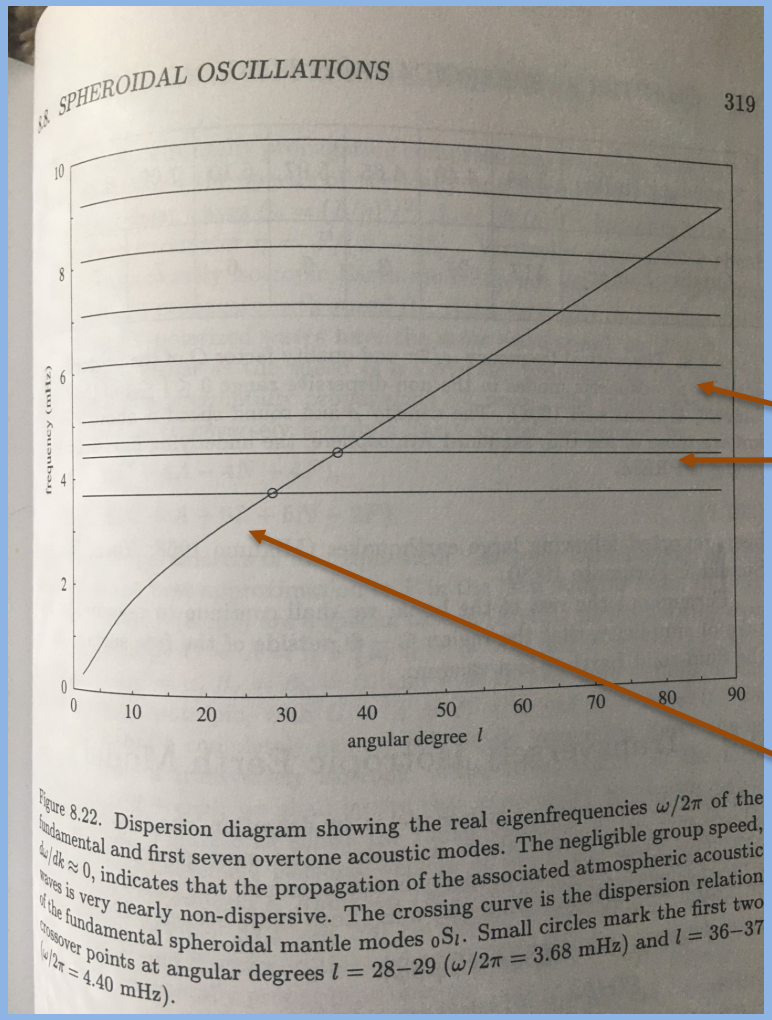


Figure 8.22. Dispersion diagram showing the real eigenfrequencies $\omega/2\pi$ of the fundamental and first seven overtone acoustic modes. The negligible group speed, $d\omega/dk \approx 0$, indicates that the propagation of the associated atmospheric acoustic waves is very nearly non-dispersive. The crossing curve is the dispersion relation of the fundamental spheroidal mantle modes ${}_0S_l$. Small circles mark the first two crossover points at angular degrees $l = 28$–29 ($\omega/2\pi = 3.68$ mHz) and $l = 36$–37 ($\omega/2\pi = 4.40$ mHz).

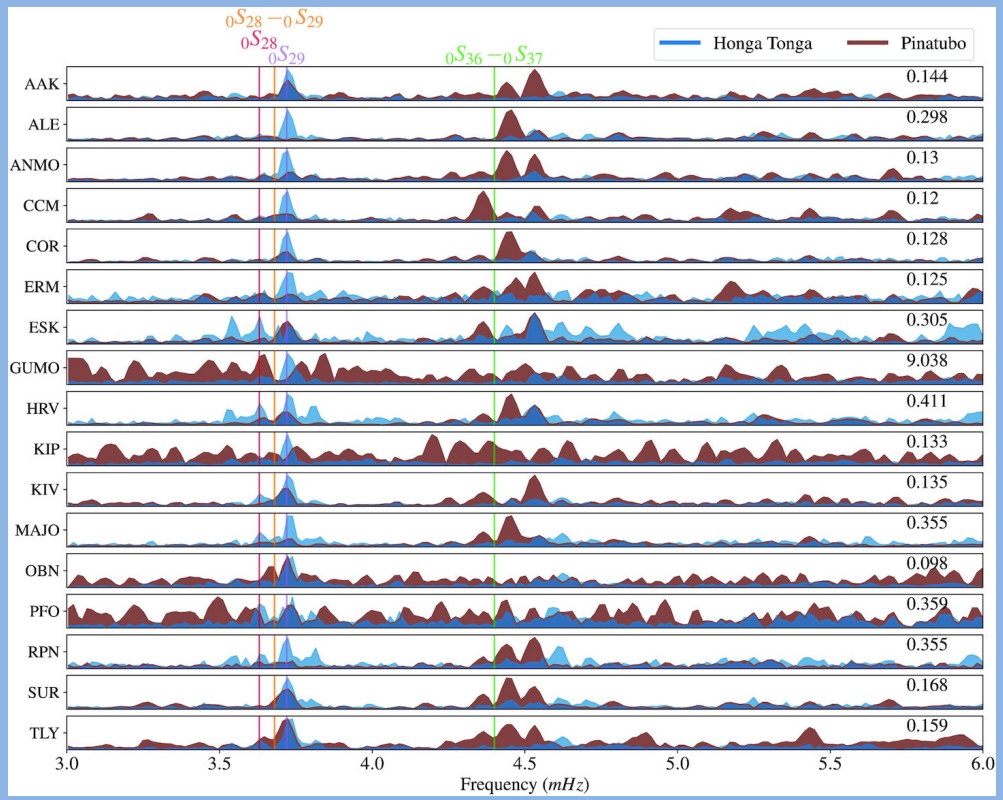
Acoustic eigenfrequencies cross-over the fundamental spheroidal mode ${}_0S_l$

Acoustic modes

${}_0S_l$ dispersion relation

Dahlen and Tromp (p. 319) need to consider solid Earth + atmosphere

Pinatubo



Oddly, the Pinatubo event was “larger” and excited the 4.4 mHz mode while Hunga Tonga excited 3.7 mHz

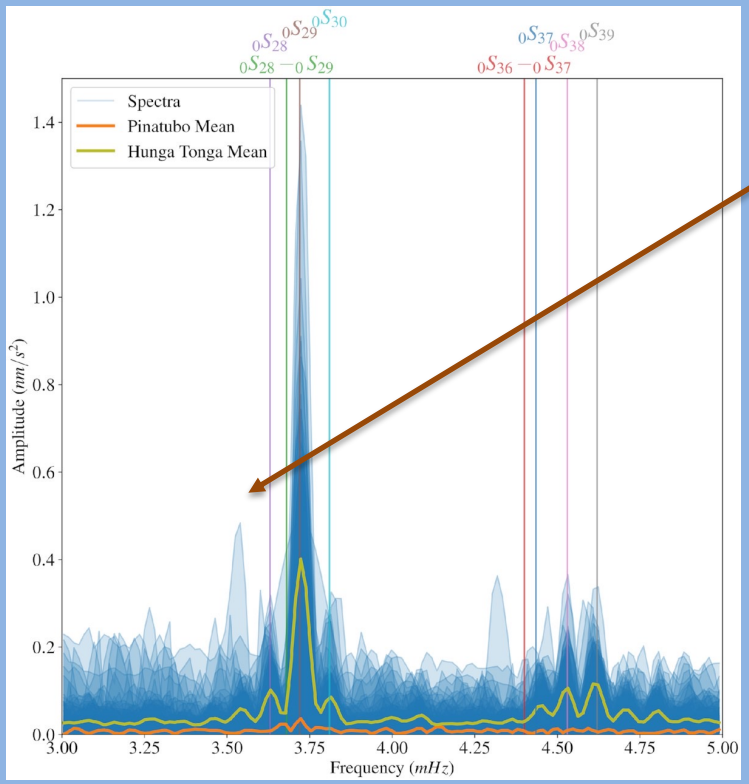
Magnitude was larger?

Peak frequency amplitude is 70% bigger

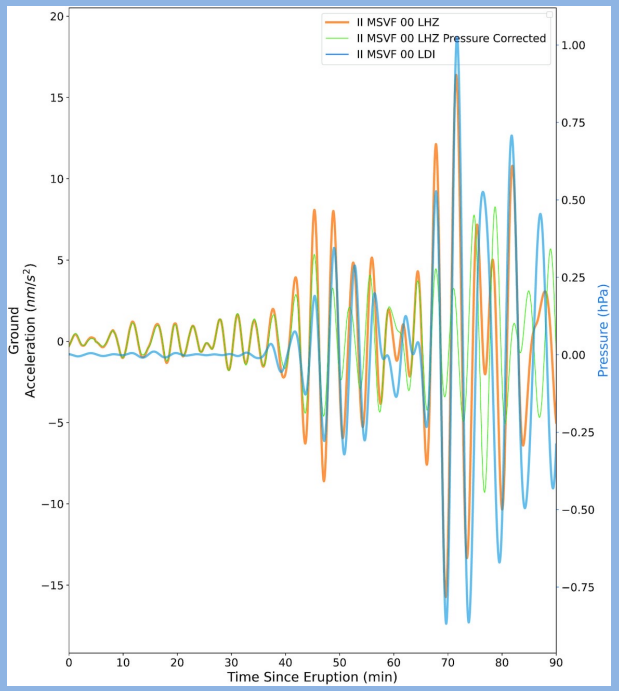
Why did Pinatubo excite 4.4 mHz but Honga Tonga 3.7 mHz?

Oddly, Pinatubo has a higher VEI and larger seismic magnitude…

Nearfield



Variations in the frequency are likely caused by different atmospheric conditions above the station



Seismic and pressure at MSVF (Fiji)
Direct correlation only present within 1000 km

Hypothesis by Widmer and Zuern and Kanamori and Watada:
Pressure excitation is only near the eruption

More Questions

Do the amplitudes of the 3.7 and 4.4 mHz excitations give information about the eruption?

Kanamori et al. (1994) pressure/seismic amplitude modeling needs to be revisited as it is only within 1000 km of the station. It doesn't work in phase.

What do shifts in the frequency say about the atmosphere above the station?

Large events with good instrumentations are rare. How much variability is there and what can we say with a sample set of only a few of these eruptions?

Read more Here:

Geophysical Journal International

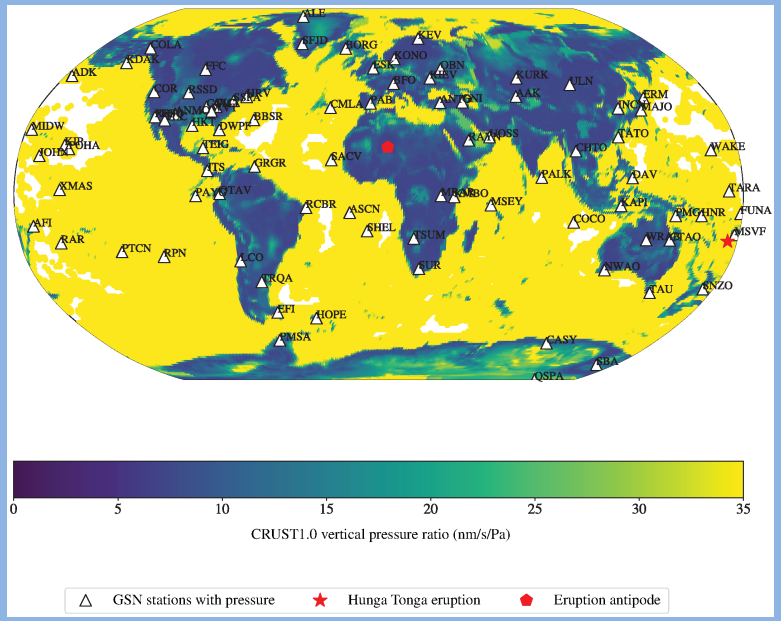
Geophys. J. Int. (2023) **232,** 2160–2174
Advance Access publication 2022 July 26
GJI Seismology

https://doi.org/10.1093/gji/ggac284

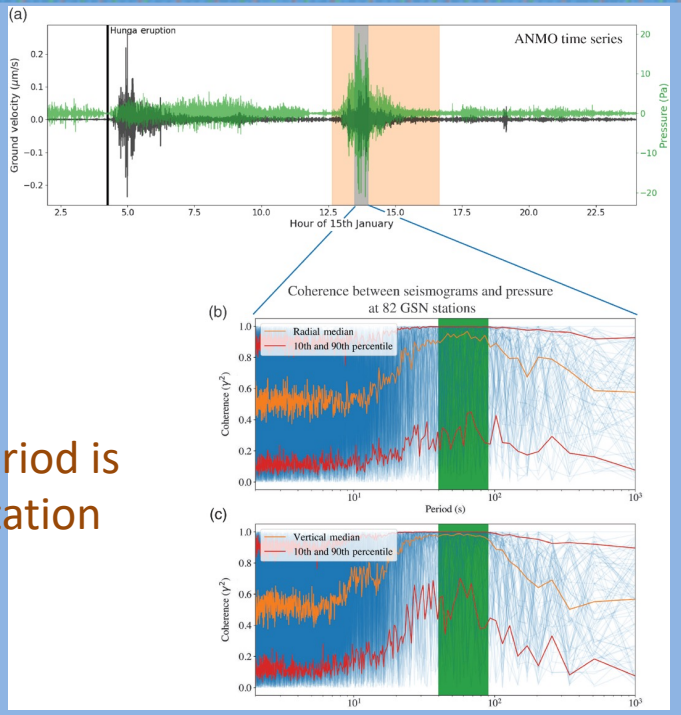
The global seismographic network reveals atmospherically coupled normal modes excited by the 2022 Hunga Tonga eruption

A. T. Ringler,[1,4] R. E. Anthony,[1,4] R. C. Aster,[2] T. Taira,[3] B. R. Shiro,[4] D. C. Wilson,[1,4] S. De Angelis,[5] C. Ebeling,[6] M. Haney,[7] R. S. Matoza[8] and H. D. Ortiz[8]

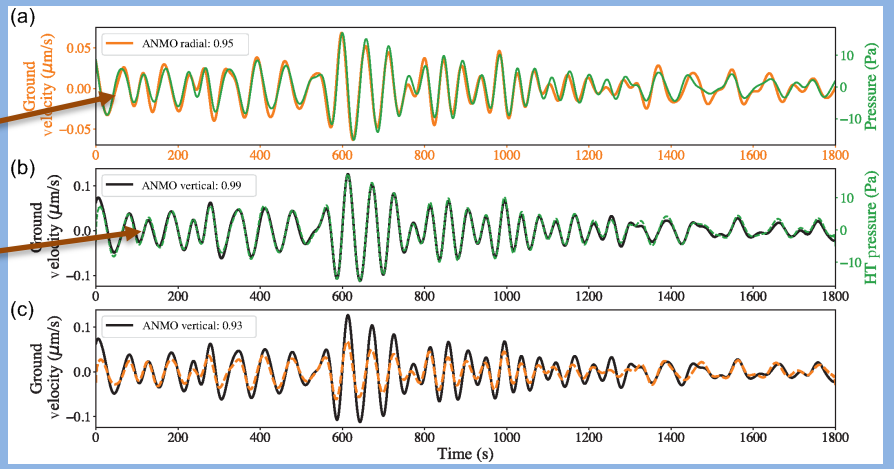
Seismoacoustic



CRUST1.0 predicts the seismic to acoustic ratio



40 to 80 s period is band of excitation



Vertical

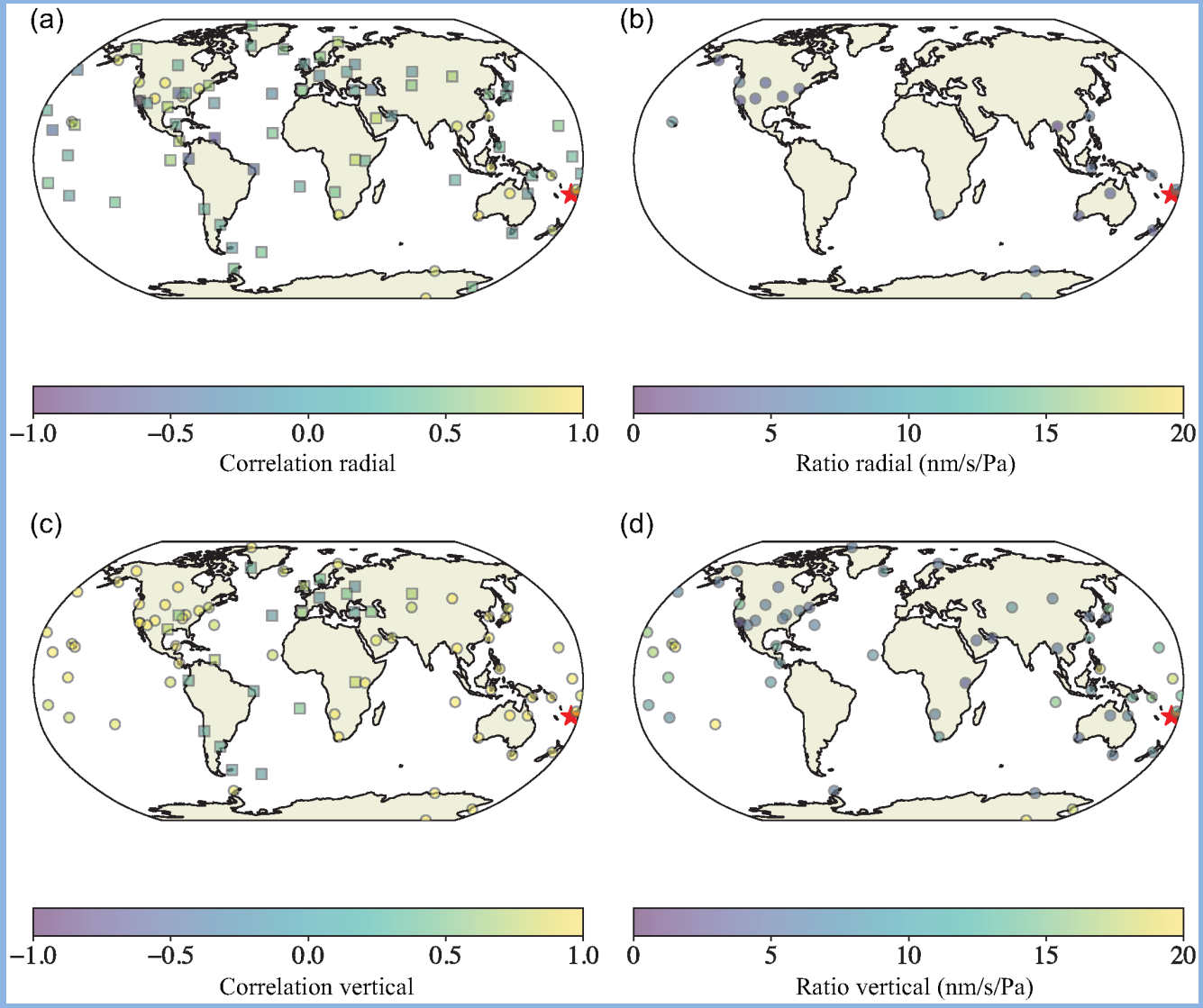
Radial

Pressure phase shifted to compare with seismic

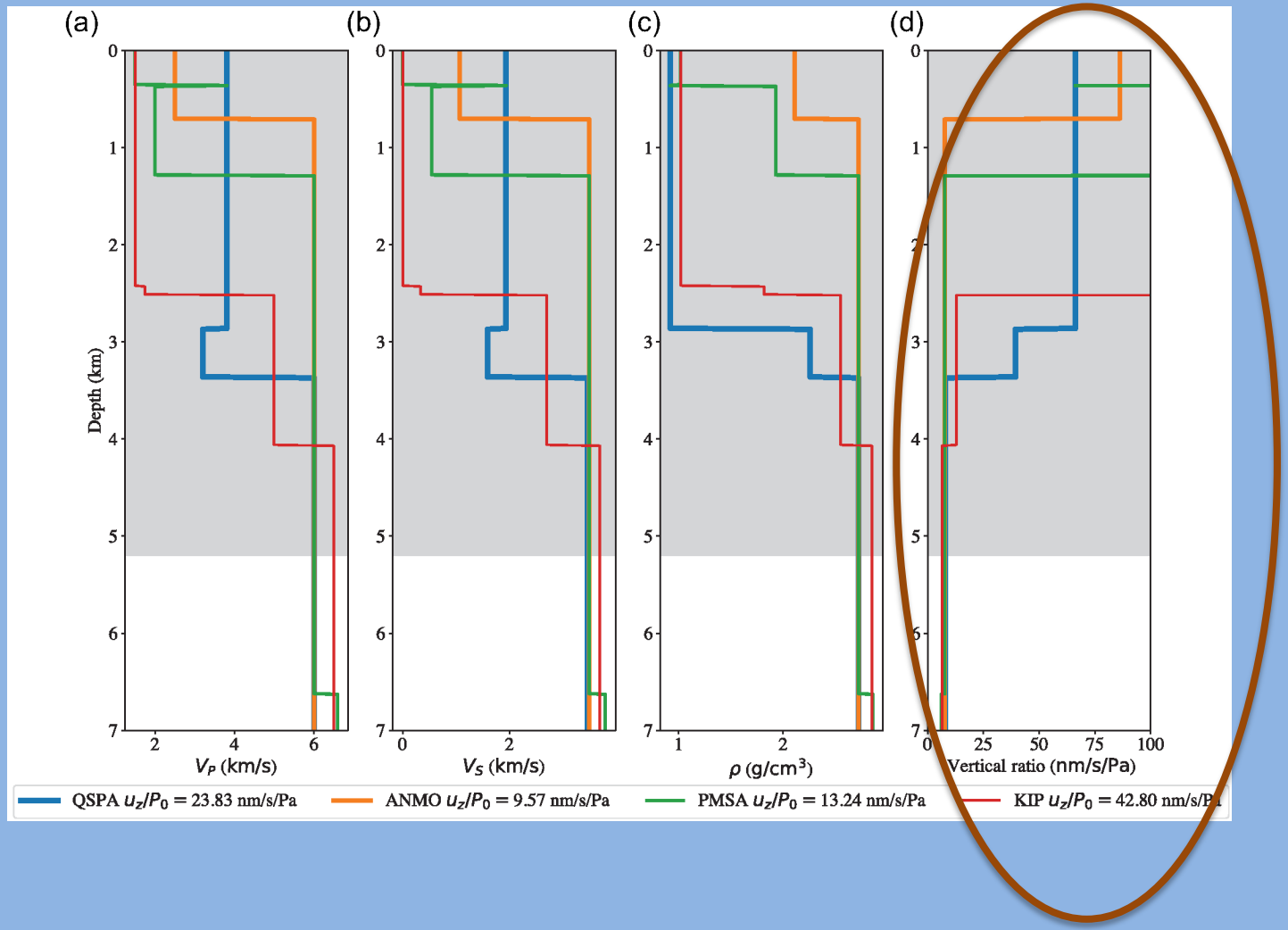
The Data

Radial component usually low correlation (cavity effects)

Vertical has great correlation with pressure



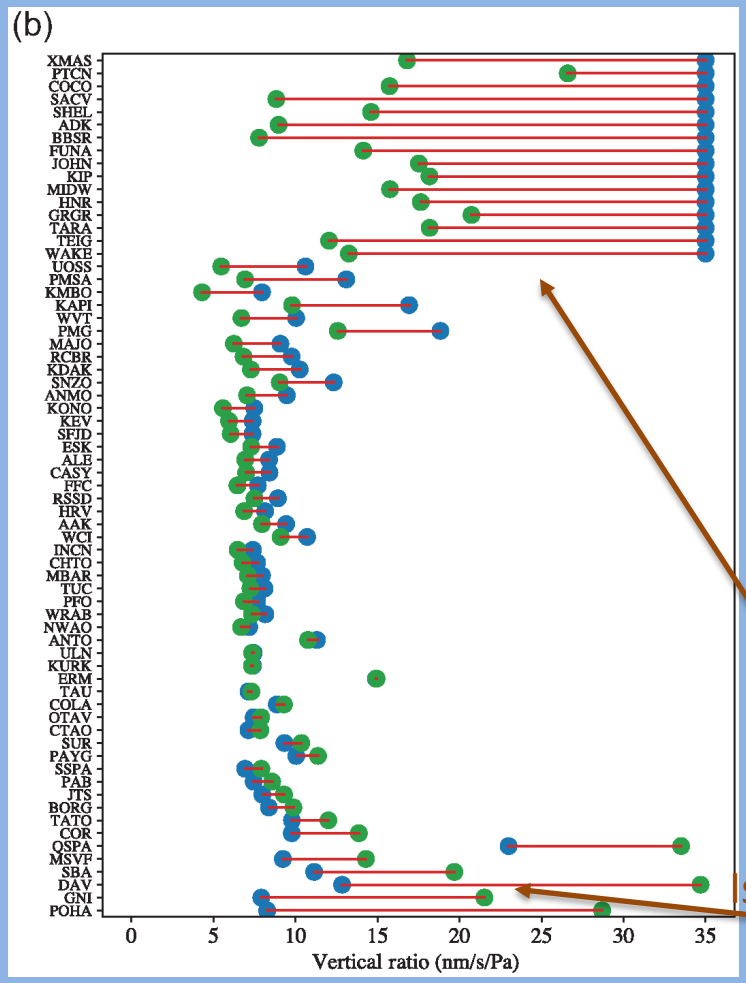
What the model says



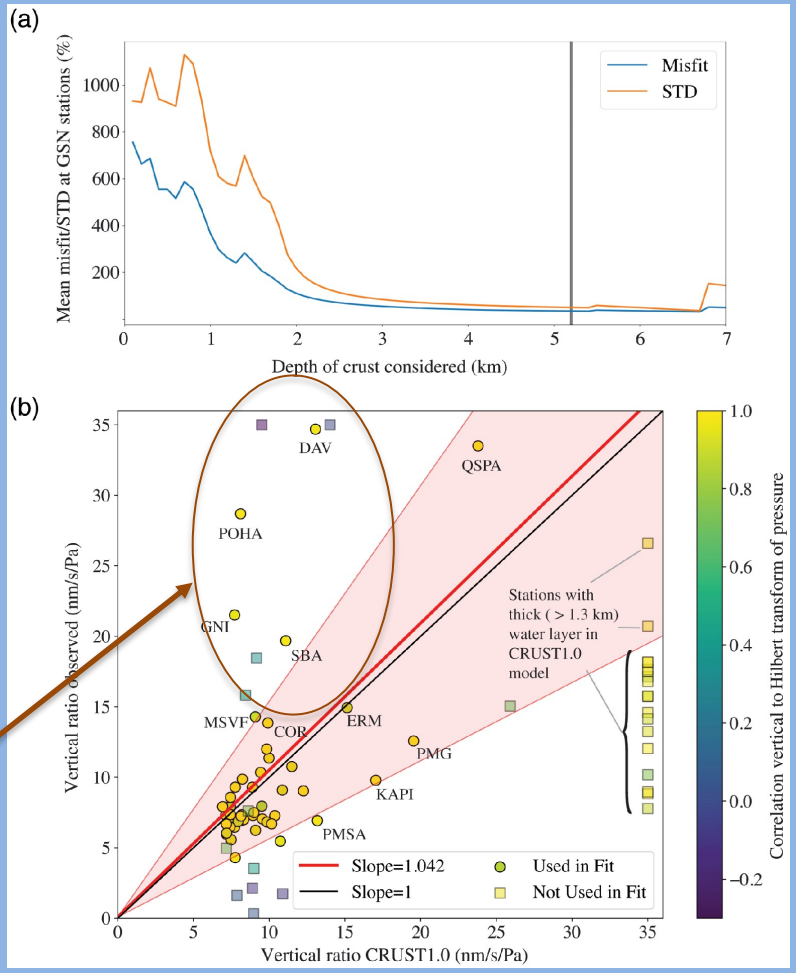
Seismic to acoustic ratio from Crust1.0

Crust1.0 V_p V_s density and seismic to acoustic

What the data says

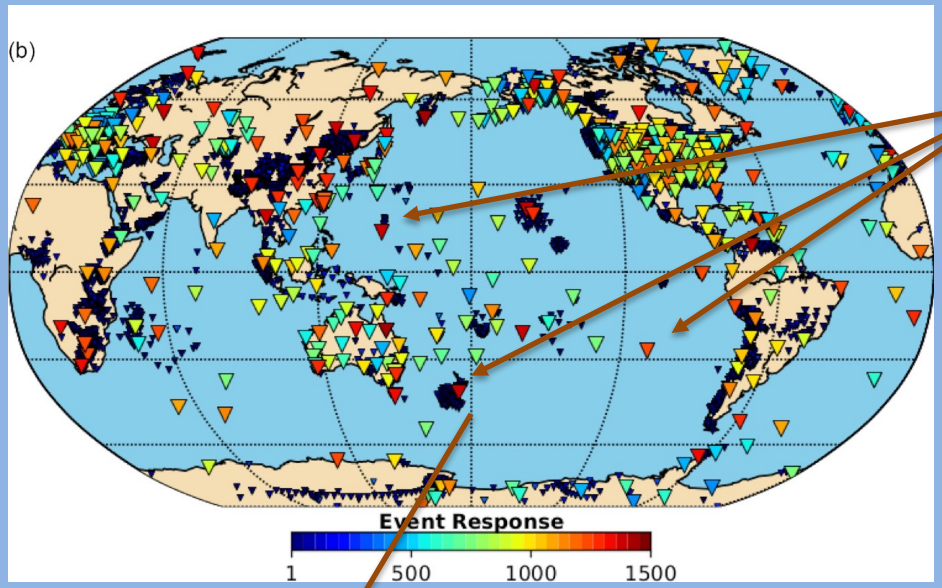


Island stations



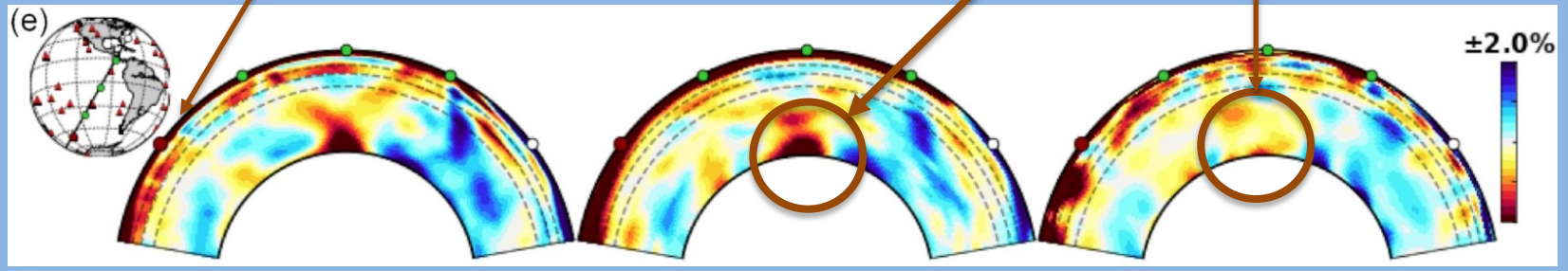
Comparison of S/A from Hunga Tonga compared to S/A of CRUST1.0

So What?



Remote stations (islands provide the most data in inversions)

LLFVP? Inversion issue? Bad starting model?



GLAD25 Lei et al. (2020)

That is all!

Can use S/A to estimate crustal structure

Island stations deviate from CRUST1.0 –could have implications for full-waveform tomography (bad starting model)

Read More:

Focus Section: 15 Jan 2022 Hunga Tonga-Hunga Ha-apai Eruption and Tsunami

Earth's Upper Crust Seismically Excited by Infrasound from the 2022 Hunga Tonga–Hunga Ha'apai Eruption, Tonga

Robert E. Anthony[*1], Adam T. Ringler[1], Toshiro Tanimoto[2], Robin S. Matoza[2], Silvio De Angelis[3], and David C. Wilson[1]

In the spirit of Skience all figures can be reproduced:
https://github.com/aringler-usgs/Tonga_SA

https://github.com/aringler-usgs/tonga_paper