R.T.

Spectral analysis of Lamb wave signals from the 2022 Hunga Tonga Eruption

Goals and Objectives

 Analyzed the pressure waves from the 2022 Tonga eruption. Used the continuous wavelet transform and Stockwell transform to evaluate spectral information and entropy signal-to-noise ratio (snr).

Introduction

• The Hunga Tonga submarine volcano erupted on January 15 2022, producing the largest explosion ever recorded digitally. • Atmospheric Lamb waves propagated around the earth multiple times.

 Figures show open-access Fiji barometer signals, 754 km away. Analysis of the propagating pressure waves from the primary Lamb wave returned an equivalent TNT yield of ~200 megatons. There is a second Lamb wave.

Methods

 Spectral information snr (isnr) and entropy snr (esnr) are evaluated for selected time series with the continuous wavelet transform (cwt), the Stockwell transform (stx).

Shirin Wyckoff¹, Milton Garces¹ ¹University of Hawaii, Manoa shirinm@hawaii.edu ETI Annual Workshop, February 8 - 9, 2023

Results





Figure 3: Scaled input signal (lower panel), information snr ($isnr_{T}$ middle panel) and entropy snr ($esnr_{T}$ upper panel) per time step.

Figure 6: Scaled input signal (lower panel), information snr ($isnr_{T}$, middle panel) and entropy snr ($esnr_{T}$ upper panel) per time step.

Conclusions Both methods clearly show the primary Lamb wave. Convolution smoothening has a greater effect on the cwt and we can only see the second Lamb wave in the stx (Fig 4). In Figs 2 and 5 we see the second smaller, shorter period Lamb wave, because for both cases the $esnr_{F}$ acts as a highpass filter. Fig 3 mostly shows the distribution of ambient noise energy. Although the primary and secondary Lamb wave are seen as small transients in the ambient noise. Fig 6 we can see clearly both the primary and secondary Lamb wave because the stx esnr_T distribution can enhance the distribution of energy of the ambient noise.

Next Steps Explore alternate transforms to provide further enhancement on the information snr and entropy snr scaling to use in machine learning. • Garces M. A. (2023, in review). Quantized Spectral Information, Submitted to MDPI Entropy.

National Nuclear Security Administration