Enhancing Shear Wave Velocity (Vs) Mapping using Elitist Genetic Algorithm through the HVSRInv Program

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INTRODUCTION

- **Average shear wave velocity for the upper 30 meters (Vs30)** of the horizontally stratified soil layers is a **crucial factor** in assessing **earthquake hazards** due to its correlation with the **amplification factor**.
- Borehole logging and geophysical surveys, such as the **Refraction Microtremor (ReMi)** are some of the methods for determining Vs30, but they can be time-consuming and limit the number of sites to be surveyed
- To create a site amplification map, the use of **three-component microtremor (3CMT) data** obtained using **McSEIS-MT NEO** and **Raspberry Shake 3D** was implemented.
- **Elitist genetic algorithm** using a MATLAB-based graphical interface for **inversion of horizontal-to-vertical spectral ratio (HVSR)** was applied in this study to come up with a more convenient and time-efficient way of generating a Vs30 map and obtaining shear-wave velocity profiles from geophysical data.

McSEIS-MT NEO

Raspberry Shake 3D

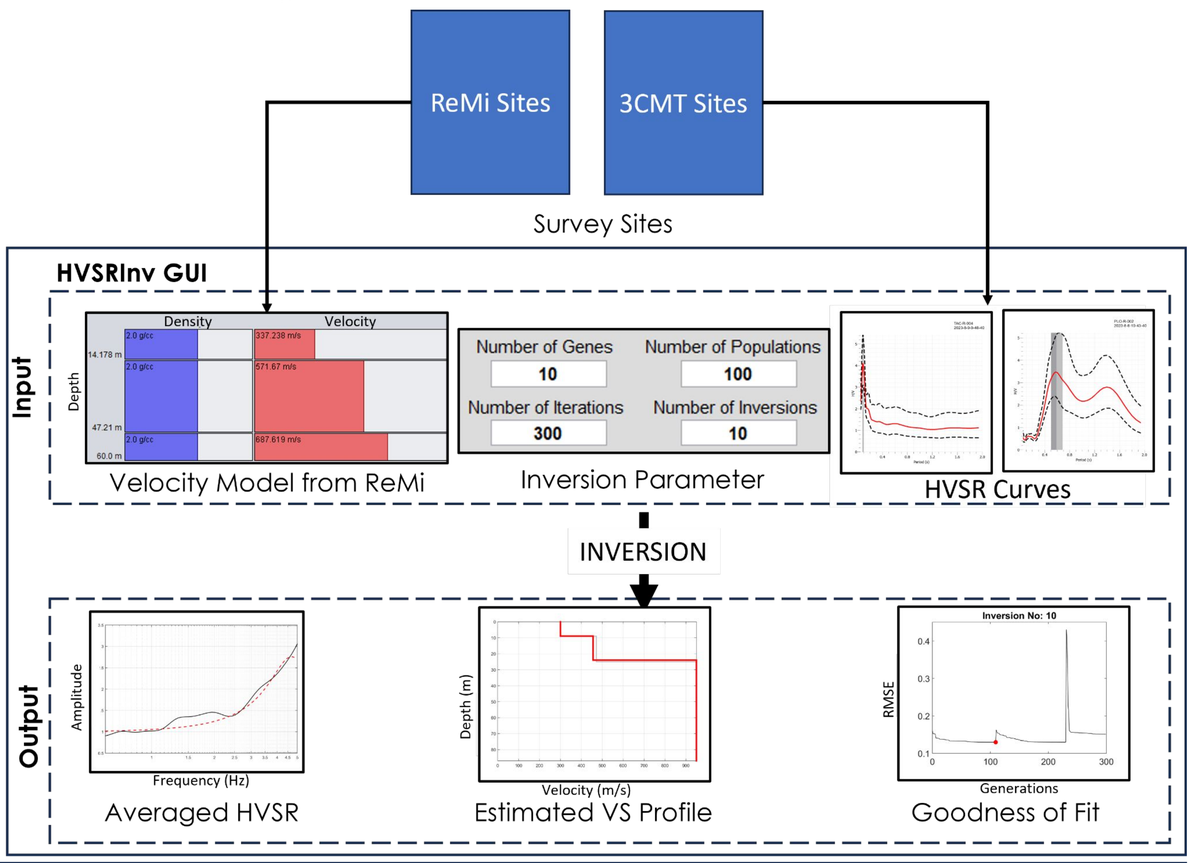
METHODOLOGY

- This study adapted a MATLAB-based graphical user interface (GUI) for **inversion** and **forward calculation** of horizontal-to-vertical spectral ratio (HVSR), **HVSRInv**, developed by Kafadar and İmamoğlu (2022).
- HVSRInv requires model parameters, HVSR data, and inversion parameters to estimate the shear wave velocity of a site
- **Model parameters** used were obtained from **ReMi data** and were applied to 3CMT site models having the **same site period ranges**
- The output of the GUI are averaged HVSR, estimated VS profile, and goodness of fit
- Average VS30 of a site can then be computed from the inferred VS profile using:

$$Vs_{30} = 30 / \sum(d_n/Vs_n)$$

where,

d_n = thickness of the n-th layer
Vs_n = shear-wave velocity of the n-th layer



RESULTS

- A total of **59 3CMT site models** were initially processed. Each model was given **simulation parameters** such as the number of layers, thickness of each layer, velocity, density, and damping ratio
- The sample model shown below, whose parameters are given by Table 1, comprises of three-layered subsurface with velocities increasing with depth.

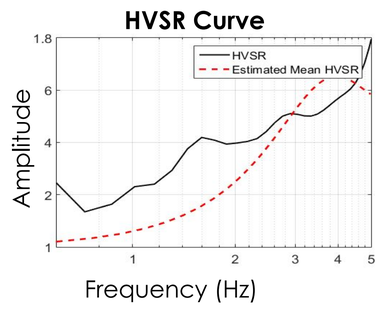
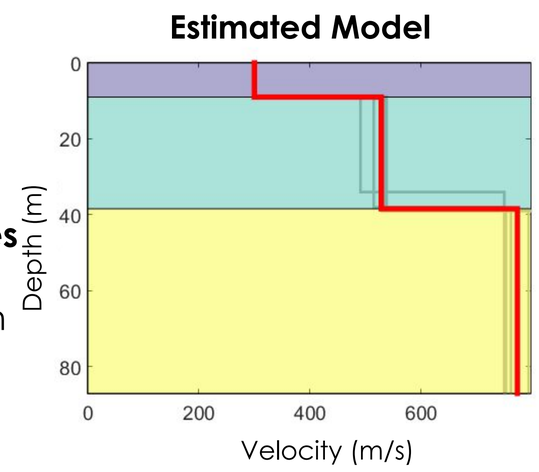


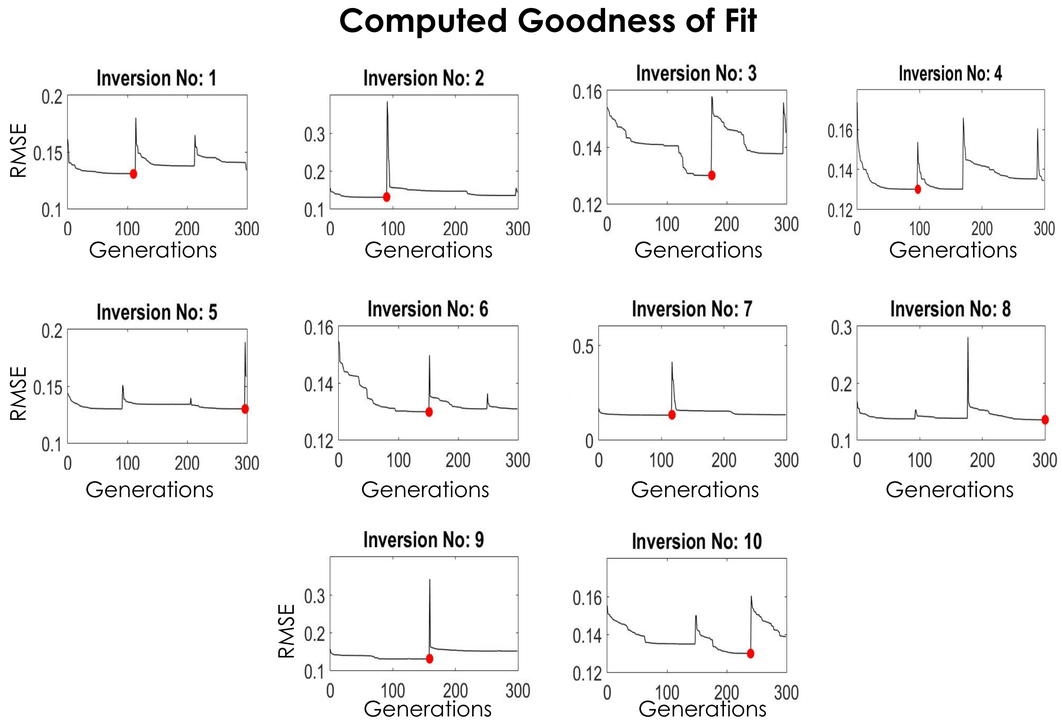
Table 1. Model Parameter

Layer Number	Thickness (m)	Shear Wave Velocity (m/s)	Density (g/cm^3)	Damping Ratio
1	1-10	300-550	1.9-2.1	0.0152 - 0.0278
2	1-30	450-800	2.0-2.2	0.0104 - 0.0185
3	30-40	550-950	2.1-2.2	0.0088 - 0.0152

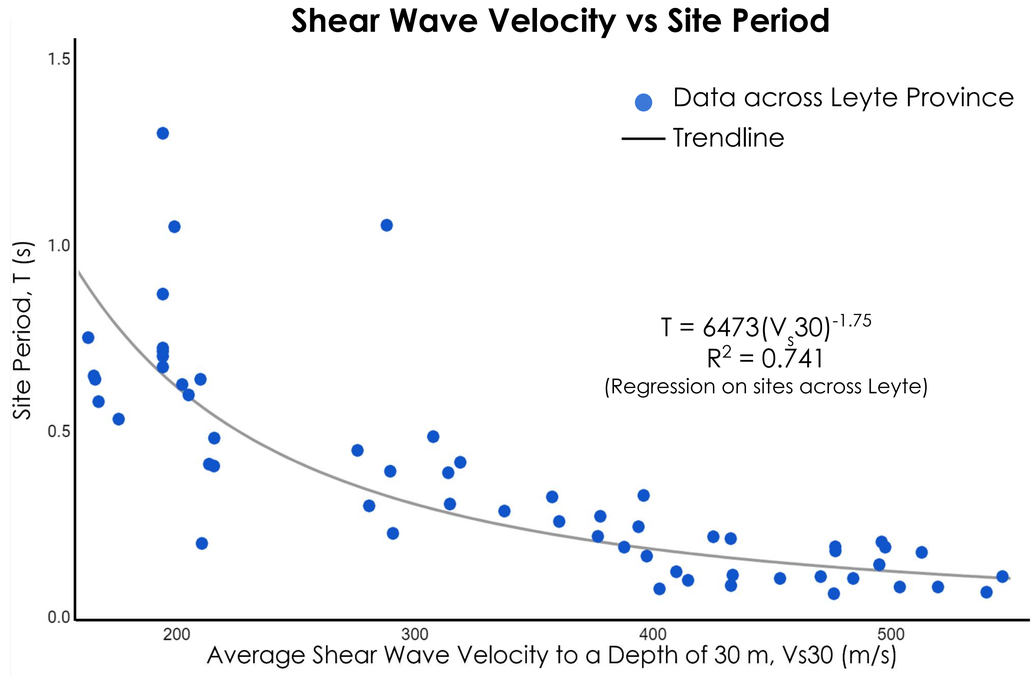
- For the inversion process, the **minimum and maximum frequency** utilized were 0.6 Hz and 5 Hz.
- Figure on the right displays the **estimated shear wave velocities** (gray-colored lines) resulting from **each inversion**, along with the **averaged shear velocity profile** (red-colored thick line).



- The **calculated goodness of fits** for each inversion is illustrated. Peaks and red points on the graph correspond to **high-order mutations** and the **best generations**, respectively.



- Empirical correlation was developed using **power function**. This relation has a regression $R^2 = 0.741$ indicative of a **strong correlation** between the initial datasets of the study



REFERENCES

Kafadar, Ö., & İmamoğlu, Ç. (2022). Estimation of the amplification properties of soil through HVSR inversion based on an elitist genetic algorithm. Earth Science Informatics, 15(4), 2319-2334.

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