
# Calibrating a new attenuation curve for the Dead Sea region using surface wave dispersion surveys in sites damaged by the 1927 Jericho earthquake


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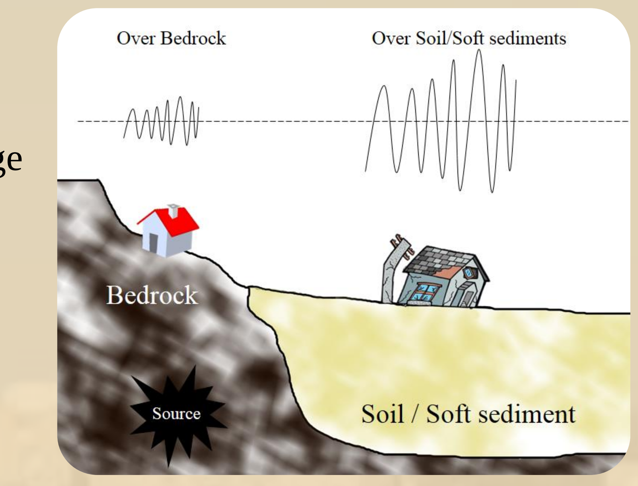
## 1. Introduction

On 11 July 1927 a crustal rupture generated a moderate 6.2 earthquake in the northern part of the Dead Sea. Up to five hundred people were killed and extensive destruction was recorded, even in places as far as 150 kilometers from the focus. We consider local near-surface properties, in particular the shear wave velocity as an amplification factor. Where the shear wave velocity is low, the seismic intensity at places far from the focus might be greater than expected from a standard attenuation curve.

### 1.1 Shear Wave Velocity

In seismic hazard analysis the shear wave velocity at a site is of interest because it is an index for evaluating dynamic behavior of soil. Most seismic codes adopt as a key quantitative variable the average shear wave velocity in the top 30 meters of subsurface (Vs30), as does the Standards Institute of Israel (SII).




### 1.2 Attenuation Equation

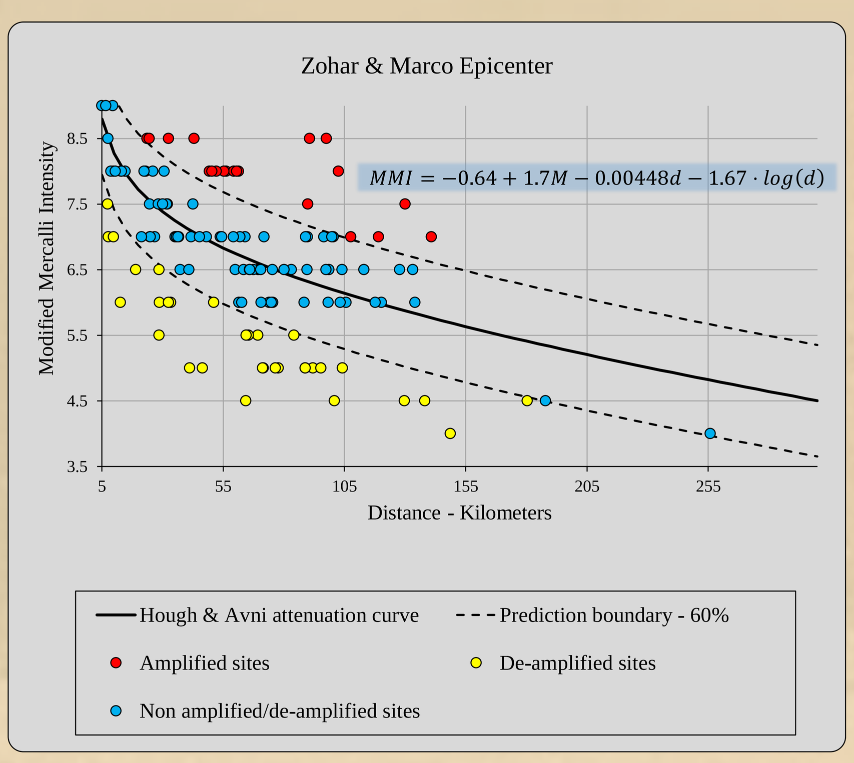
An attenuation equation shows how large the ground motions are expected to be for a certain earthquake magnitude and a certain distance from the earthquake. Given a magnitude, a distance, and a Geologic site condition, a ground motion prediction equation gives the value of the ground motion expected.

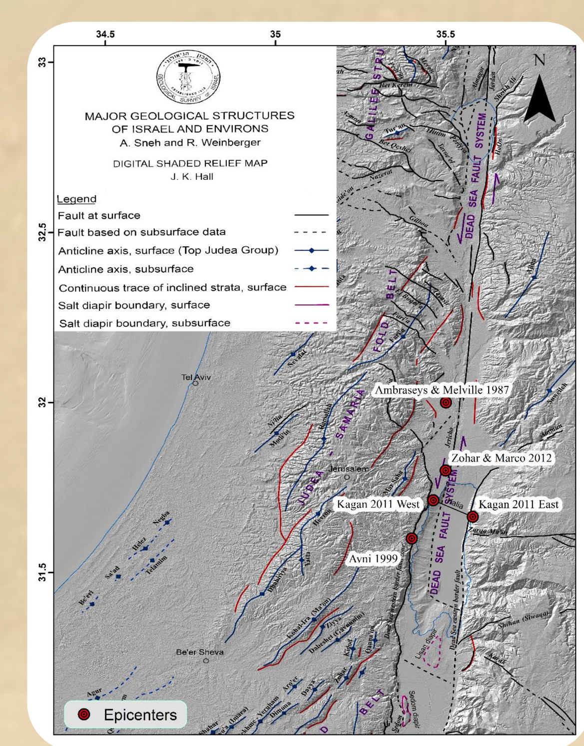
## 2. Motivation

We expect that the anomalous amplification and de-amplification in certain sites of the 1927 Jericho earthquake are direct results of low and high shear velocity, respectively. Those, better attenuation equation can achieved.

## 3. Data Analysis & Methods

From 133 sites that Avni (1999) investigated and estimated seismic intensities, we measured those which are out of 60% prediction boundary and are accessible. We chose Zohar & Marco epicenter (2012) as the accurate one from all other optional epicenters.




## 4.1 Multi Analysis of Surface Waves –MASW

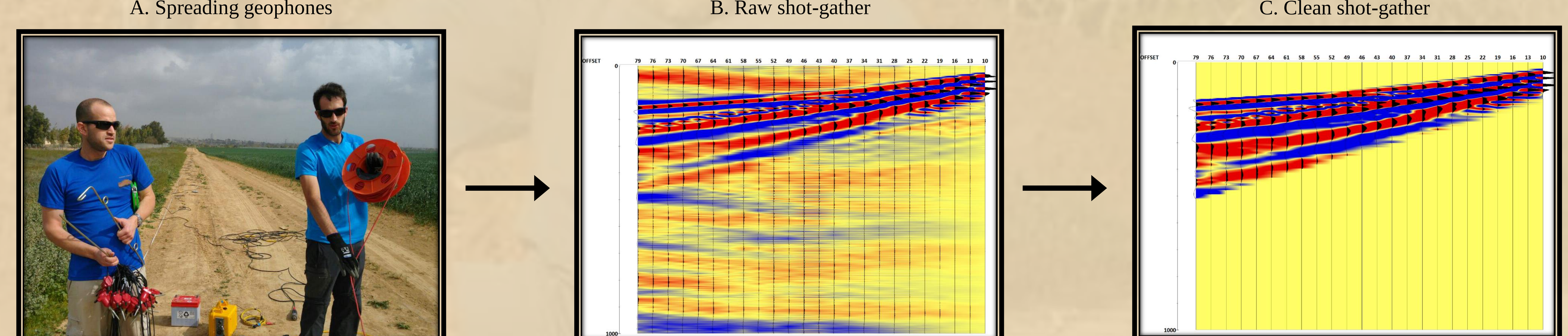
The Multi-channel Analysis of Surface Waves is a seismic method used to evaluate the shear-wave velocities of subsurface materials through the analysis of the dispersion properties of Rayleigh surface waves ("ground roll"). The data are collected on the surface without the need of borehole

We used the MASW method to estimate seismic wave velocity at anomalous sites in Israel.

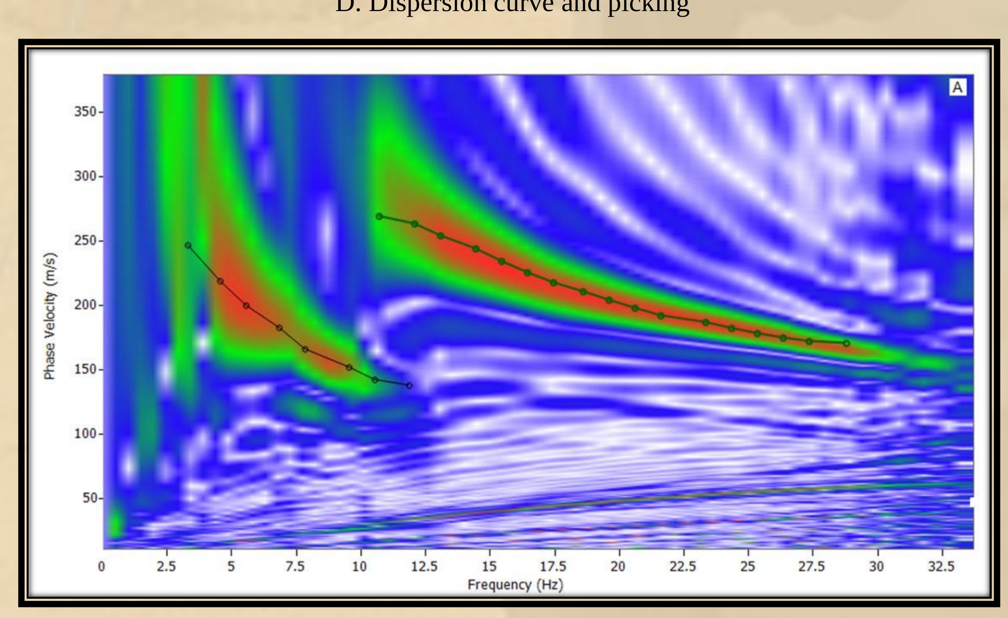
A. Spreading geophones

B. Raw shot-gather

C. Clean shot-gather

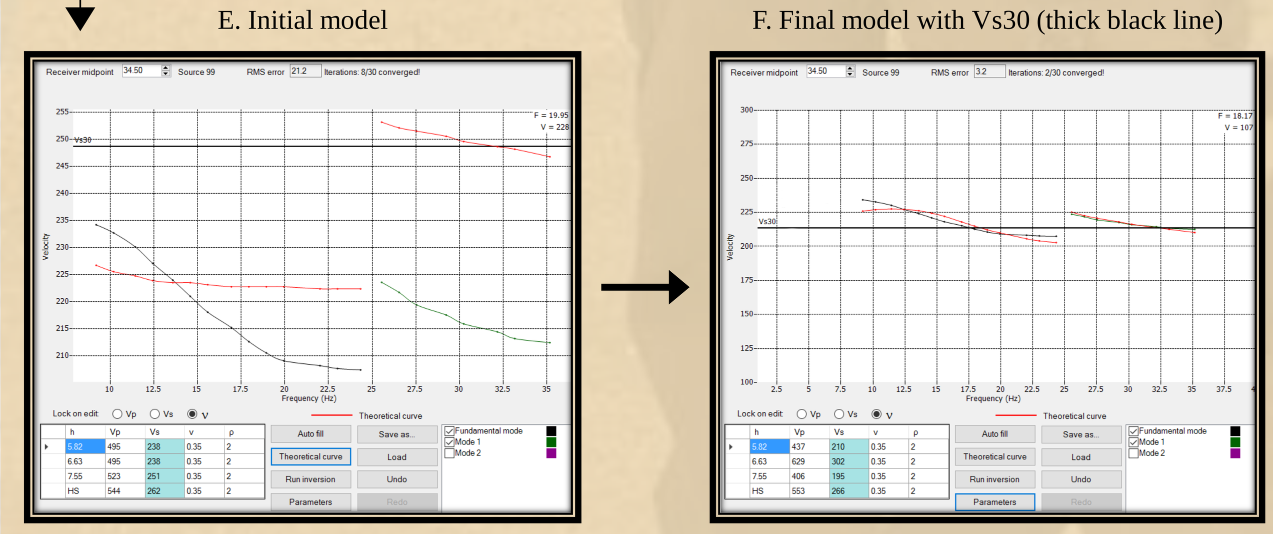


D. Dispersion curve and picking




E. Initial model

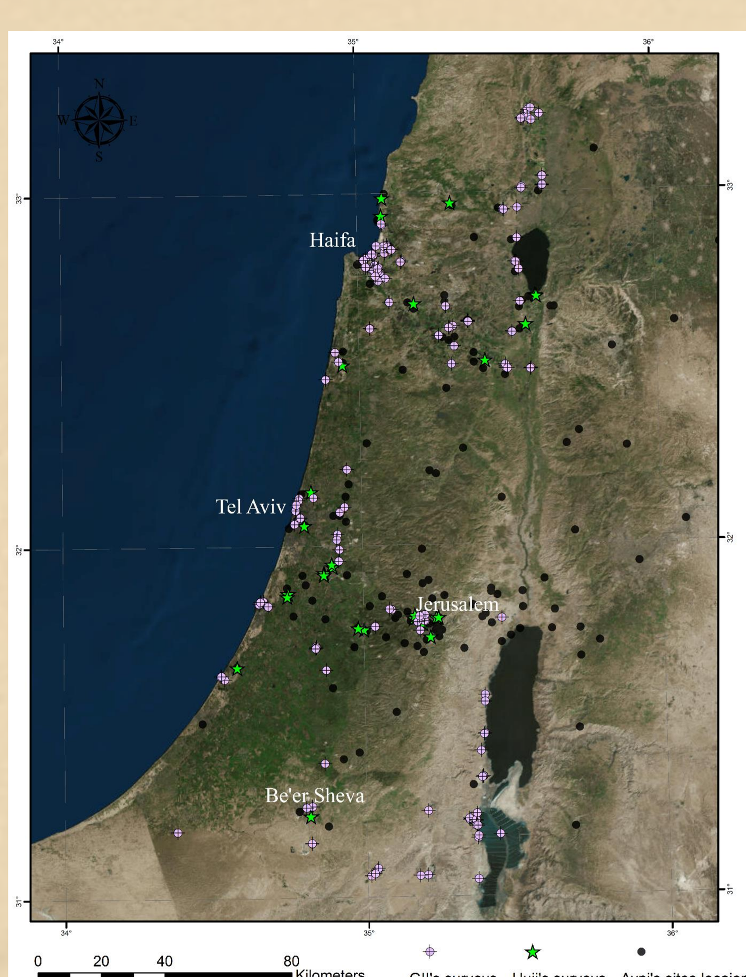
F. Final model with Vs30 (thick black line)



## 4. Methods

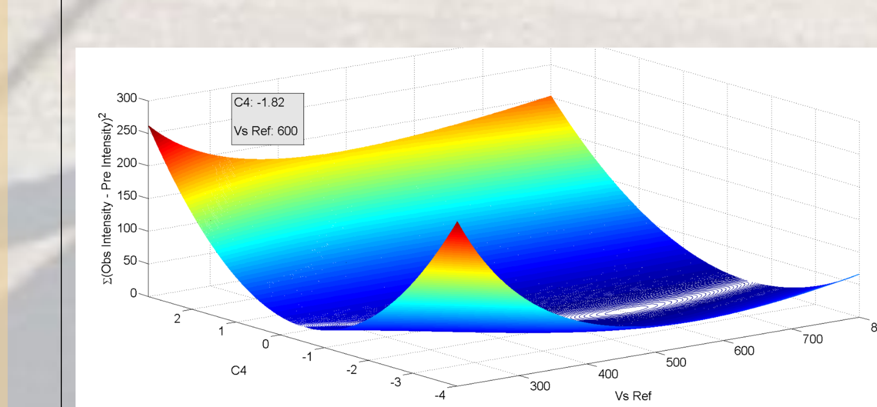
### 4.2 Analysis reports of the Geophysical Institute of Israel (GII)

Aksinenko and Hofstetter (2012) collected seismic refractions and borehole data around 30 cities in Israel. They extracted the shear wave velocities of different layers at each area. Based on that we calculated Vs30 of 186 sites.




### Least Squares Fitting (LSF)

A standard mathematical procedure for finding the best-fitting curve to a given set of points by minimizing the sum of the squares of the offsets ("the residuals") of the points from the curve.



We used LSF to find the best coefficient for the Vs30 term.

## 5. Results & Conclusions

Vs30 is defined in 25 sites: 20 from MASW surveys and five more from GII's report.

This data set yields a new attenuation equation for the Dead Sea region:

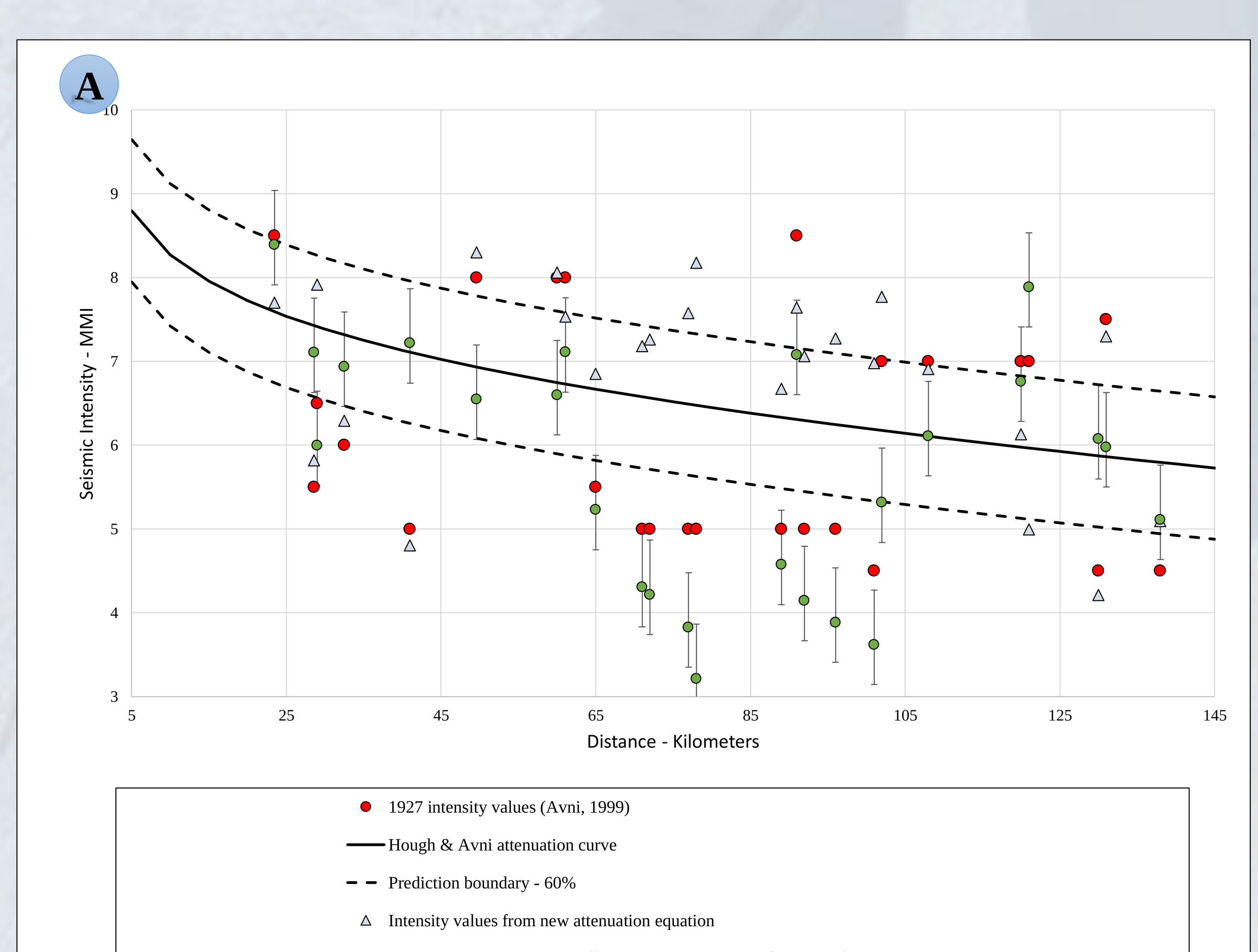
$$MMI = -0.64 + 1.7M - 0.00448d - 1.67 \cdot \log(d) - 1.82 \cdot \ln\left(\frac{Vs30}{600}\right)$$

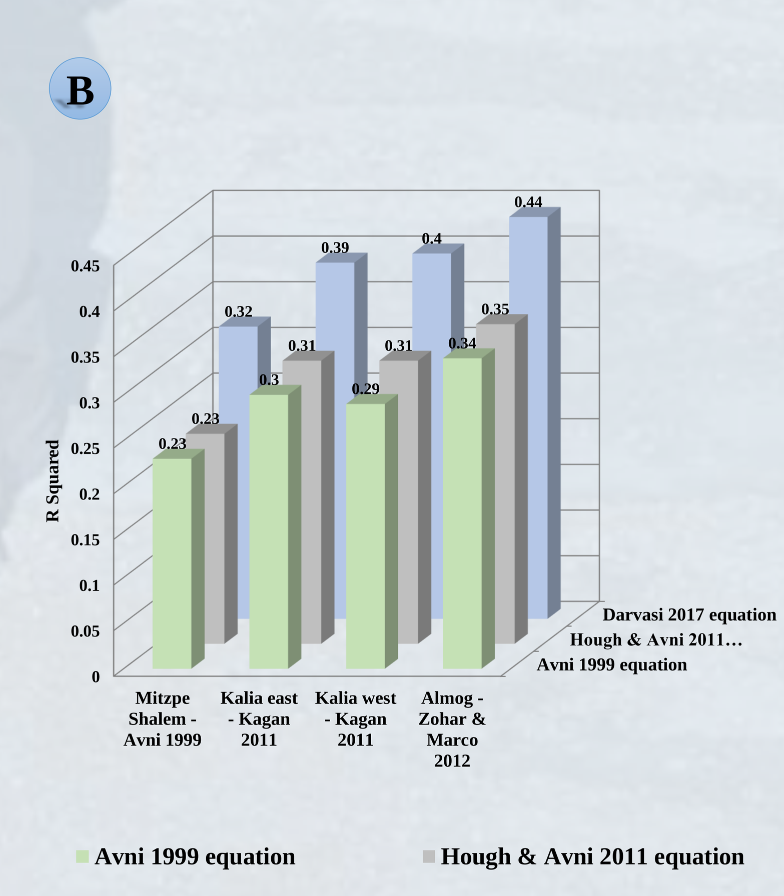
Analyzing Vs30 of all 186 sites, especially those close to each other (maximum distance of 550 meter), while also checking Israel Code #413 of the Standards Institution of Israel, highlight that Vs30 variation at nearest sites is common and can be up to 80%.

Based on the new equation we reduced site effects from Avni's seismic intensity estimates. Out of 25 sites, 64% are converging to 60% prediction boundary (Fig A) and better fit is achieved in comparison to any other attenuation equation (Fig B).

To validate this new equation we need to measure a more significant number of sites and assess fit to the equation. This research considers only site conditions, meaning that there is no reference to other issues such as: rupture directivity, building quality, topography, etc.

Despite this, the data collected is useful for further research and also should be taken into consideration for improving maps of seismic risk.





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