Supplemental Material for the paper "An Impact-Based and Time-Evolutive Earthquake Early Warning Method [Built on the Real-Time Tracing of the Strong Shaking Prediction Zone]."

by

Aldo Zollo, Simona Colombelli, Alessandro Caruso*, Luca Elia

Department of Physics, University of Naples Federico II

Contents of this file

Introduction

The following text contains additional material to complement the main manuscript. Specifically, details about the selected database are provided here. Moreover, the text contains information about the empirical scaling relationships used to predict the earthquake magnitude and the expected PGV at any location within the interest area. For each empirical scaling relationship, plots and retrieved coefficients are provided.

* now at RFI, Rome, Italy

Text S1: Dataset description

The database used in this work is originally composed by 286 events with magnitude ranging between 3.5 to 6.0 occurred within the Italian territory. We selected 504 stations with epicentral distance between 1 and 540 km, for a total number of 3786, 3-component waveforms. Stations used in this study are part of the Accelerometric National Network RAN (Rete Accelerometrica Nazionale) and of the INGV network (Instituto Nazionale di Geofisica e Vulcanologia). Waveforms are made freely available by the Italian Accelerometric Archive, ITACA 2.0 (http://itaca.mi.ingv.it), and by the INGV real-time Strong Motion Data Web Portal (http://ismd.mi.ingv.it/). The epicenters of the selected events and the histogram distribution of records is shown in Figure S1. Starting from the original dataset, we then selected records up to a maximum distance of 150 km for the calibration of empirical scaling relationships.

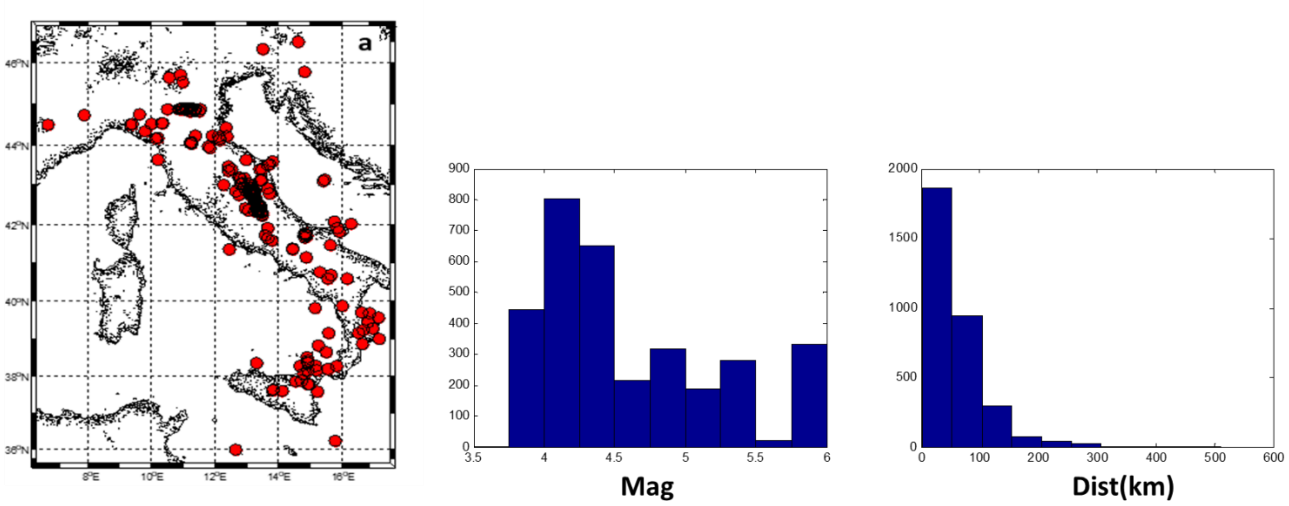

Figure S1: Calibration dataset. The figure shows the epicentral position of the events used to calibrate the empirical scaling relationships in this study. The histogram distribution of all available records as a function of magnitude and distance are also shown in right-side panels.

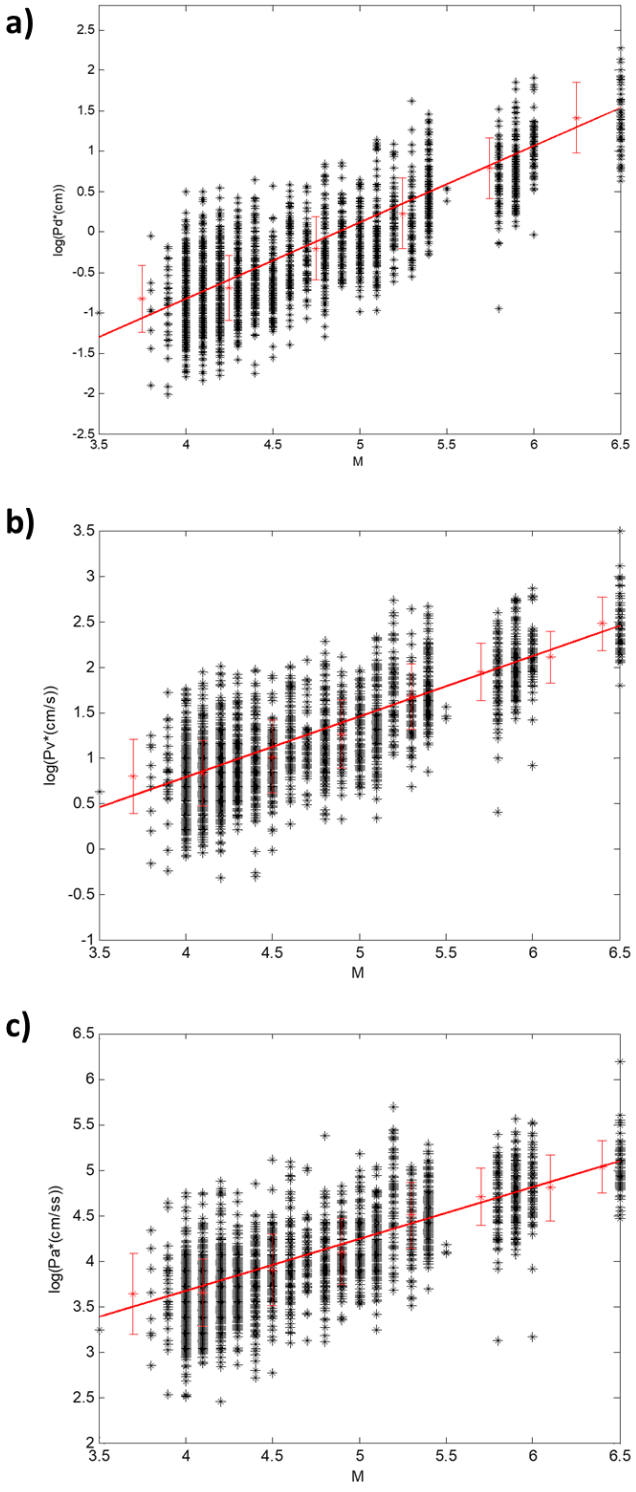

Figure S2: Magnitude Scaling Laws. The figure shows the peak amplitude parameters Pd (a), Pv (b) and Pa (c) as a function of magnitude, after correction for the distance effect. The whole available dataset is shown with black crosses; data used for the linear fit are shown with red symbols and the regression relationship is shown as a red line. For each parameter, the empirical regression relationship has been obtained through a weighted linear fit, by using the average amplitude values

in 0.5 magnitude bins (red dots) and the related uncertainties. Wights on data are inversely proportional to the uncertainty on the average value. In all panels, the peak amplitude parameters are corrected for the distance effect using coefficient C of Table S1.

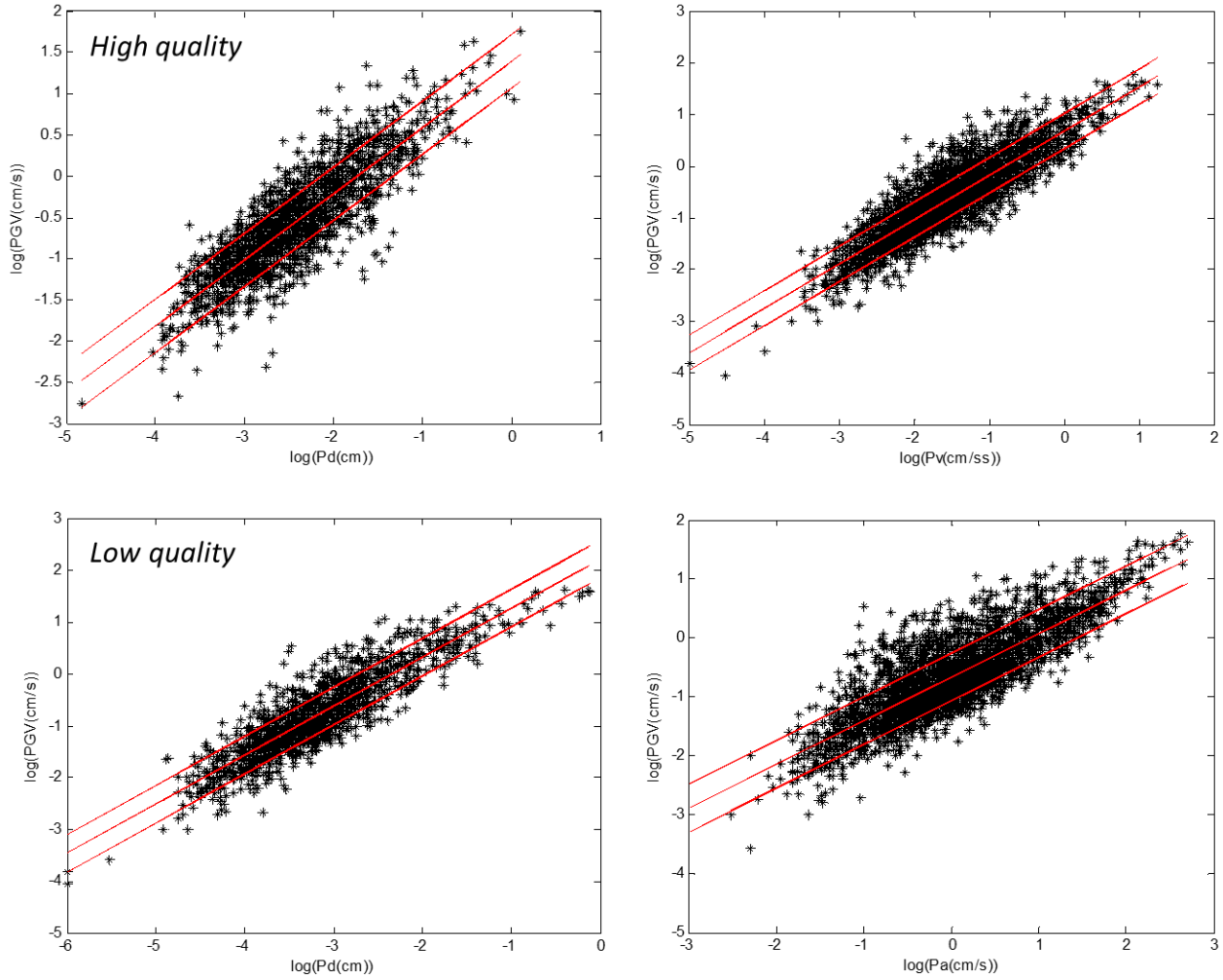

Figure S3: Px-PGV Scaling Laws. The figure shows data (black crosses) used to derive the empirical scaling relationship to predict the earthquake magnitude, starting from the peak amplitude parameters Pd (high-quality and low-quality, depending on the selected filter), Pv and Pa ,for a 3-s time window.

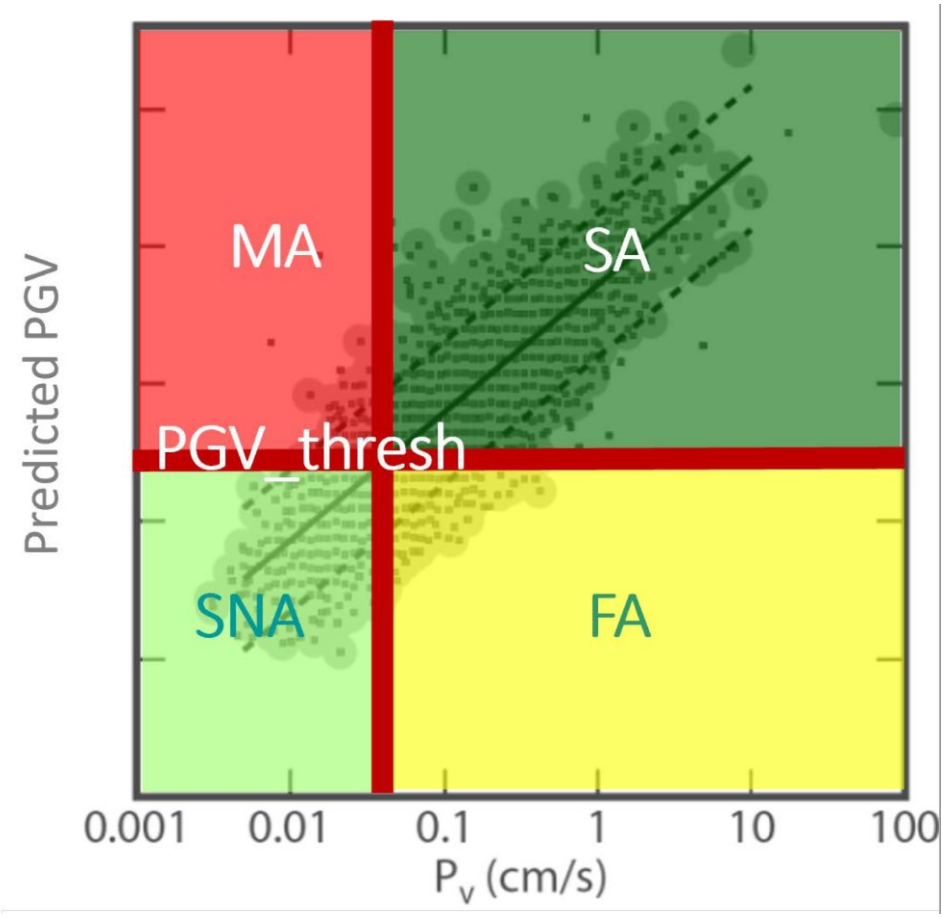

Figure S4: Partition scheme of alerts. The figure shows an example of the empirical attenuation relations between PGV and Pv. For a given PGV threshold and a measured value of Pv, the diagram is partitioned in 4 regions, around the predicted PGV point: the regions of SAs (dark-green, top-right), SNAs (light-green, bottom-left), FA (yellow, bottom-right) and MA (red, top-left).

Px	A	B	C	SE
Pd	3.65 (±0.09)	1.02 (±0.14)	1.97 (±0.31)	0.34
Pv	1.67 (±0.20)	1.40 (±0.50)	2.90 (±0.78)	0.32
Pa	-2.44 (±0.28)	1.75 (±1.20)	4.05 (±1.50)	0.36

Table S1: Pd-M,R Regression Relationships. The table contains the A, B and C coefficients (and their uncertainties) for each empirical scaling relationship used to estimate the earthquake magnitude. The standard error of the fit is also reported in the last column of the table.

1sec: PGV vs Px	**D**	**E**	**SE**
Pd	1.42 (±0.11)	0.75 (±0.04)	0.34
Pv	0.70 (±0.04)	0.73 (±0.02)	0.46
Pa	−0.49 (±0.02)	0.58 (±0.02)	0.50
2sec: PGV vs Px	**D**	**E**	**SE**
Pd	1.46 (±0.08)	0.79 (±0.03)	0.35
Pv	0.72 (±0.03)	0.82 (±0.02)	0.40
Pa	-0.59 (±0.02)	0.68 (±0.02)	0.45
3sec: PGV vs Px	**D**	**E**	**SE**
Pd	1.39 (±0.06)	0.80 (±0.02)	0.32
Pv	0.67 (±0.03)	0.86 (±0.02)	0.34
Pa	-0.66 (±0.01)	0.74 (±0.02)	0.40
4sec: PGV vs Px	**D**	**E**	**SE**
Pd	1.31 (±0.04)	0.80 (±0.02)	0.31
Pv	0.61 (±0.02)	0.86 (±0.02)	0.32
Pa	-0.71 (±0.01)	0.76 (±0.02)	0.39
5sec: PGV vs Px	**D**	**E**	**SE**
Pd	1.20 (±0.04)	0.79 (±0.02)	0.30
Pv	0.54 (±0.02)	0.86 (±0.01)	0.31
Pa	-0.75 (±0.01)	0.77 (±0.02)	0.37

Table S2: PGV-Px Regression Relationships. The table contains the D and E coefficients (and their uncertainties) for each empirical scaling relationship (from 1 to 5 seconds) and the related standard error (last column).