EMS-Intensity prediction equation for Austria

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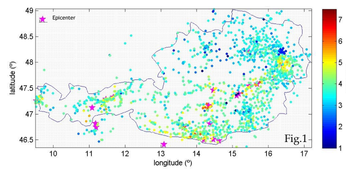
Abstract

Equation that predicts intensity as a function of magnitude and distance, is a key for hazard and risk assessment.
This study aims to determine an ***empirical model*** of the ground shaking intensities produced by an earthquake (ShakeMap). ShakeMap focuses on the ground shaking generated by the earthquake, rather than the parameters describing the earthquake source (magnitude, epicenter, etc).

1. Raw Data - description of the used data

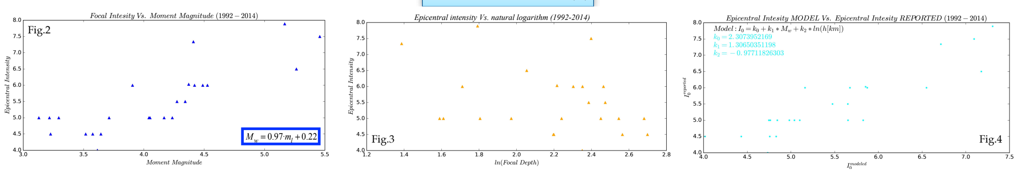
- 285 earthquakes with $M_w \geq 3$ in the period 1411-2014.
- with a total of 22.739 macroseismic data points from Austria and adjoining countries.
- The data was classified in 5 groups. The model presented here corresponds to the period 1992-2014 (Fig. 1).
- Intensities lower than 3 were omitted.
- A total of 38 events and 3.581 reported intensities were used for the model computation.



2. Developed Model (1992-2014) - Least Square Adjustment for the model derivation

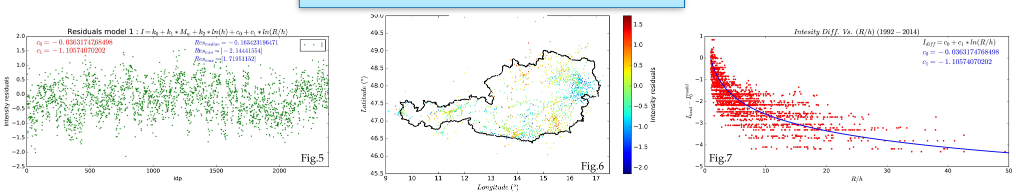
Lineal - Ln Model with M_w and h[km] respectively - By adjusting the epicentral intensity (I_0) to the moment magnitude (M_w) and the depth (h[km]) k_0, k_1 and k_2 constants are obtained.

$$I_0 = k_0 + k_1 \cdot M_w + k_2 \cdot \ln(h)$$



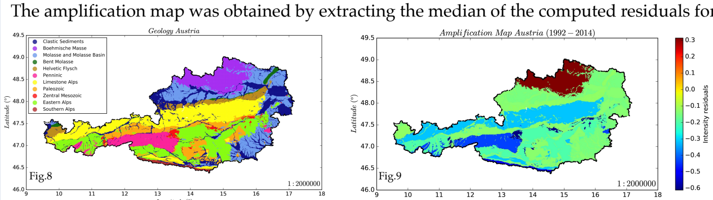
Ln Model with R/ h - By adjusting the local intensity (I_{local}) minus the modelled epicentral intensity (I_0) to the natural logarithm of the hypocentral distance divided by the depth (ln(R/h)) k_0 and k_1 constants are obtained.

$$I_{local} - I_0 = I_{local} - (k_0 + k_1 \cdot M_w + k_2 \cdot \ln(h[km])) = c_0 + c_1 \cdot \ln(R/h)$$



3. Geology Correction - Geology correction was taken into account for 11 different classes and computed for model

The macroseismic amplification (Fig. 9) can be highly influenced by the local geology (Fig. 8).
Sedimentary sites show higher intensities than those sites defined by hard rock geology.
The amplification map was obtained by extracting the median of the computed residuals for each of the classes.

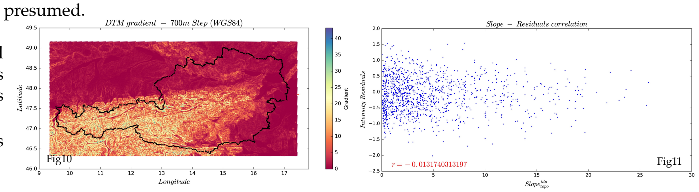


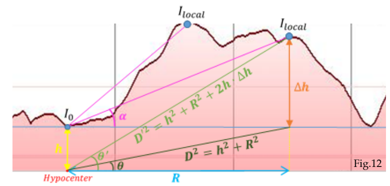
correction1: -0.14	correction41: -0.33
correction11: 0.36	correction43: -0.20
correction23: -0.24	correction48: -0.69
correction24: -0.19	correction51: -0.24
correction28: -0.25	correction66: -0.41
correction32: -0.29	

4. Topography correction - Height and slope of topography (gradient) correlation

After the geology correction is applied a correlation between the topography gradient and the intensity residuals was studied. [4] The basic premise of this technique is that the solider rocks are more likely to have a steep slope. Therefore, in mountainous regions negative residuals are to be expected. On the other hand, deep basin sediments are deposited in environments with very low gradients and positive residuals are presumed.

Based on figure 11, it is difficult to find any evidence of amplification at sites characterised by low gradients for this data set.
Therefore, a new approach was developed:





$$D'^2 = R^2 + h'^2 = R^2 + (h + \Delta h)^2 = R^2 + h^2 + 2h \cdot \Delta h + \Delta h^2$$

$$\tan(\theta') = h'/ R = (h + \Delta h)/ R$$

$$\tan(\alpha) = \Delta h / R$$

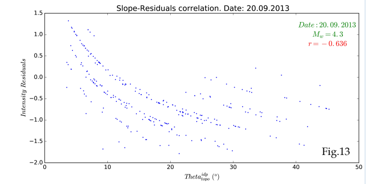


Figure 13 shows a clear relationship between intensity residuals and the slope angle. Since this new approach is just newly obtained no conclusions are made so far. However, these intermediate results seem very promising.

5. ShakeMap - ShakeMaps for the model period (1992-2014) and a historical event

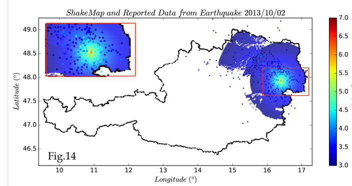


Fig.14: ShakeMap for the 2nd main shock of the Ebreichsdorf earthquake (02/10/2013). With a moment magnitude of 4.3 and a epicentral intensity of V-VI.

The resulting ShakeMaps presented here follow the model obtained with the 1992-2014 calibration period data.

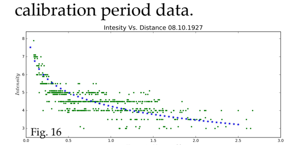


Fig.16: Theoretical model and reported intensities for the Schwadorf earthquake

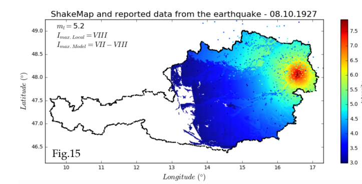


Fig.15: ShakeMap for the Schwadorf (NÖ) earthquake which occurred on the 08/10/1927 with a local magnitude of 5.2 and a epicentral intensity of VIII.

6. Conclusions & Outlook

So far, local intensities have been modelled and reluctant residuals have been used for the generation of the Austrian ShakeMaps.

Firstly, a theoretical model was derived by least square adjustment relating the intensities (local and epicentral) with the moment magnitude, depth, and epicentral distance.

Secondly, an amplification map based on the local geology was obtained for correcting the model. For each of the major geological classes in Austria, a median value was obtained and assigned for each class. The median values were computed among the residuals which met the individual classes.

Finally, for further improvement of the model, we exploit the correlation between topography slope and the residuals obtained after the geology correction was applied. However, no obvious correlation between them was found for our data set. This fact lead us to the development of a new approach, which (hopefully) will correct topographic effects of medium magnitude events.

For many succeeding studies V_{S30} data was introduce in order to correct the topographic effect. However, our main goal in this work is to accomplish an Austrian ShakeMap-model only based on macroseismic data.

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