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SHARE

Report on Declustering SHEEC

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Introduction

This document describes the declustering procedure applied to the SHEEC-catalogue, version 3. The result is added to the data file **SHEEC_EMME_NW_append_Decluster.xls** in column „Main“:
The flags are:

1 = Main shock
0 = Dependent event or event with Mw=0

Data and results are described below.

Data

Data file: SHEEC_EMME_NW_append.xls

The catalogue data was delivered on November 11, 2011, as an Excel file with one empty column called („Main“) depicting whether an event is assumed to be a main shock or not.

The catalogue has for many event parameters that are not available; for example, not all fields of event dates are provided (blanks in day, hour, minute, second) or the moment magnitude is missing. For further analysis and declustering purposes, these fields are either set to a specific value so that the event could be included in the declustering procedure or they are removed from the data file.

The procedure is in detail, (1-3 performed for both catalog parts separately):

1. Import catalog to Matlab (ZMAP format)
    a. Change “c” in column “Comp” to read 1
    b. Change Intensity values in column “Io” to numerical values, e.g. 4-5 becomes 4.5
    c. Export to csv-file
    d. Import to maltab via script
2. Reset all blanks entries (now *nan* in Matlab) for month and day to equal 1

3. Reset all blanks entries (now *nan* in Matlab) for hour, minute, second to equal 0
4. Set all entries that do not provide an M_W-value to Mw=0.
5. Decluster with the Grünthal Matlab-code
6. Flag all events with Mw=0 as dependent event
7. Update Excel file with the flag 1 (main shock) and (0) dependent event.

The catalogue contains 30377 events in the period 1000-2006 with moment magnitudes ranging from $0 \leq M_W \leq 8.5$; 300 events not providing a moment magnitude, all in the period before 1900 (Table 1, Figure 1).

The number of events as a function of time and varying threshold magnitudes is displayed in Figure 2. Although this is a rough overview on the entire catalogue, it is obvious that the completeness threshold of the catalog influences the rate. The rate of Mw≥6.5 events is relatively stable across 8 centuries; starting with Mw≥5.5, a rate change due to enhanced reporting or detection capabilities is visible starting shortly after 1900.

Table 1: Number of entries in the SHEEC catalog. Entry in the catalog is defines one earthquake.

	Number of entries	**Comment**
Entire SHEEC	30377	300 without Mw
No. of Events prior to 1900	4962	T < 1900
No of Events 1900-2006	25415	T ≥ 1900
SHEEC entry without M_W	300	All in the period T<1900
SHEEC with Mw	23986	
Mw range	0-8.5	
Period	1000-2006	

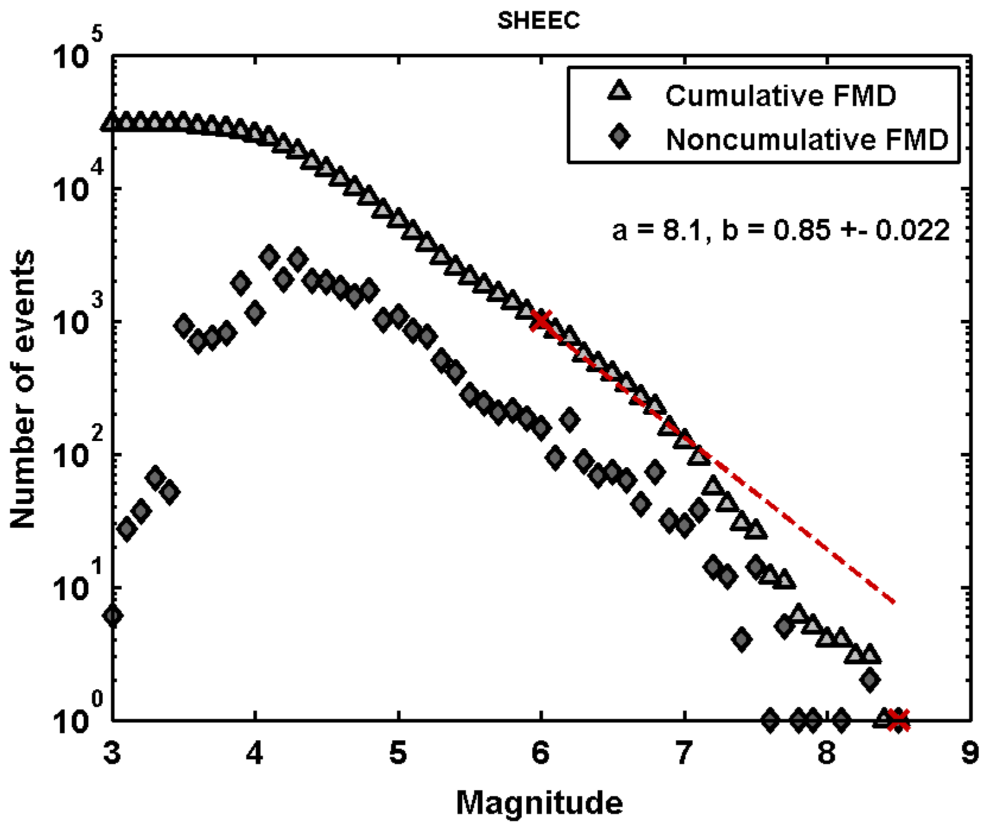

Figure 1: Frequency-magnitude distribution (cumulative and non-cumulative) of SHEEC. Completeness magnitude is set to Mc(Mw)=6.0.

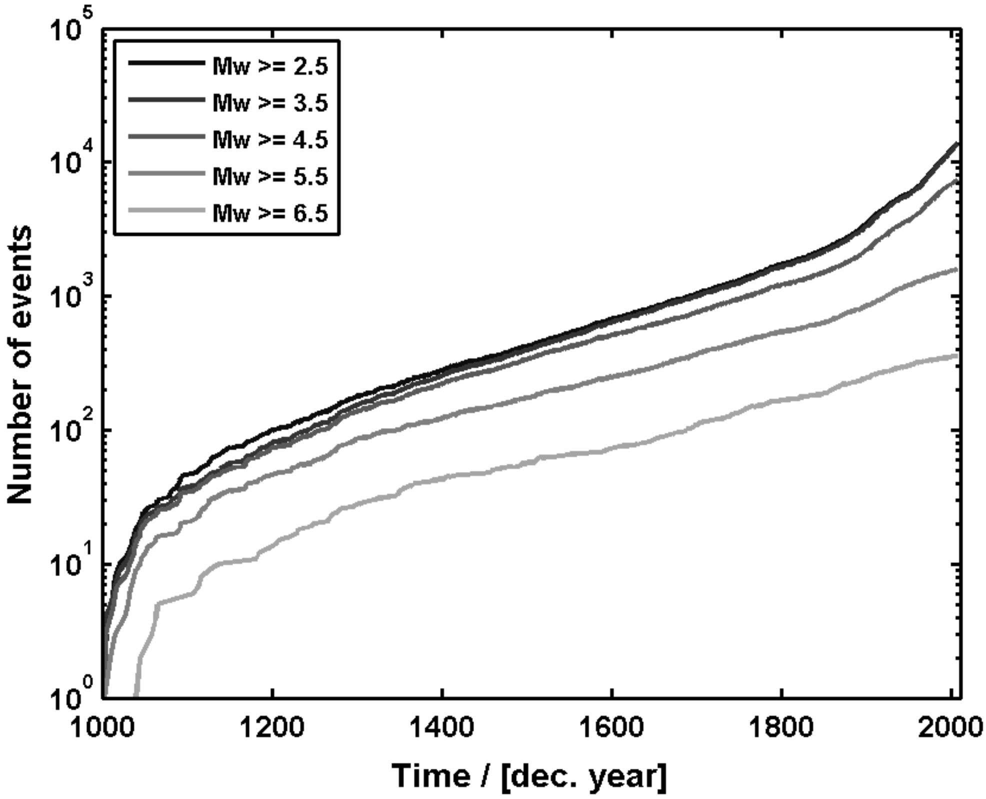

Figure 2: Number of events above a threshold magnitude Mw as a function of time. Rate of magnitude Mw≥6.5 is relatively steady over a long period while an increase in rate due to detection improvement can be seen starting around 1900.

Declustering methods

For declustering, different approaches could be used. At this stage we are only using the windowing approach based on windows provided by Grünthal (1985).

Grünthal - Window declustering:

The window approach follows the a slightly modified method of Gardner and Knopoff (1974) in which it searches for dependent events starting from the first event of a catalog in the a space and time window. The approach is different in that it reflects the situation of foreshocks; as an example assume that a magnitude 4 occurs and a 7 follows in the space-time window of the M=4 event. In this case, the algorithm switches to use the windows of the M=7 event and selects its aftershocks and includes the foreshocks in the cluster.
We use the windows by Grünthal (1985), Burkhardt and Grünthal (2009) and Grünthal et al. (2009) (Figure 3, green line) for this purpose as it is based on the analysis events going back to historic times in contrast to the Gardner and Knopoff (1974) parameters.

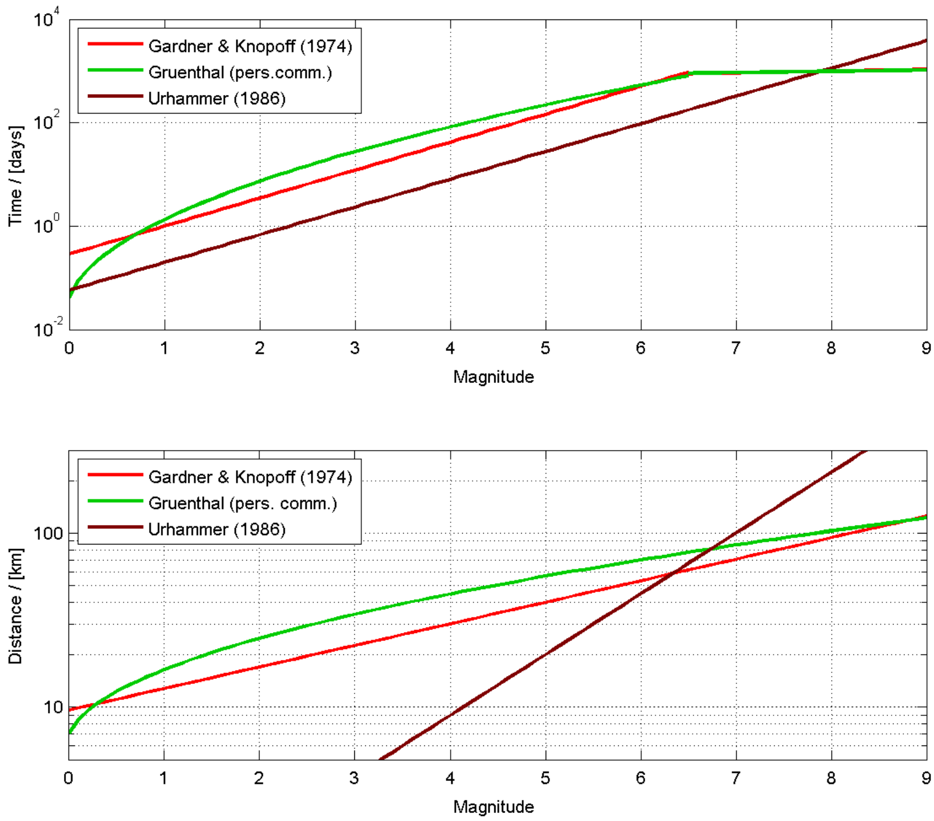

Figure 3: Window size for time and space as a function of magnitude. The green line indicates the window sizes used here.

Results

Grünthal window-declustering

The windowing approach results in a declustered catalog of 13919 main shocks and 16158 dependent events – this excludes the 300 Mw=0 events (see Table 2). The total cumulative seismic moment release of the SHEEC-catalog is M_0(SHEEC)= 3.1791e+22Nm; the declustered catalog remains with M_0(SHEEC)=3.0635e+22Nm, which is 96.37% of the total seismic moment.

Plots of the seismic moment release and the number of events are shown for the entire SHEEC catalog (Figure 4), for the period before 1900 (Figure 5) and for the period after 1900 (Figure 6).

Table 2: Summary of declustering in terms of number of events and moment. The threshold Mw=5.5 is chosen as this is the mimimum event size considered for hazard computations.

Property	Declustered	SHEEC
Total number of **main shocks**	13919	30077 (excluding the 300 without Mw)
M ≥ 5.0	3609	5590
Total number of **dependent events**	16158	
Cumulative seismic moment release of **main shocks** / [Nm]	3.0635e+22	3.1791+22
Cumulative seismic moment release of **dependent events** / [Nm]	1.1553e+21	

Frequency-magnitude distributions are shown for the entire SHEEC-catalog (Figure 1), the declustered catalogue (Figure 7) and the dependent events (Figure 8). Assuming an overall completeness level of Mc=6 – which for sure is not true in space and time - results in a rough (incorrect) *b*-values estimate of b_{all}=0.85 , b_{main}=0.79 and $b_{dependent}$=1.30.

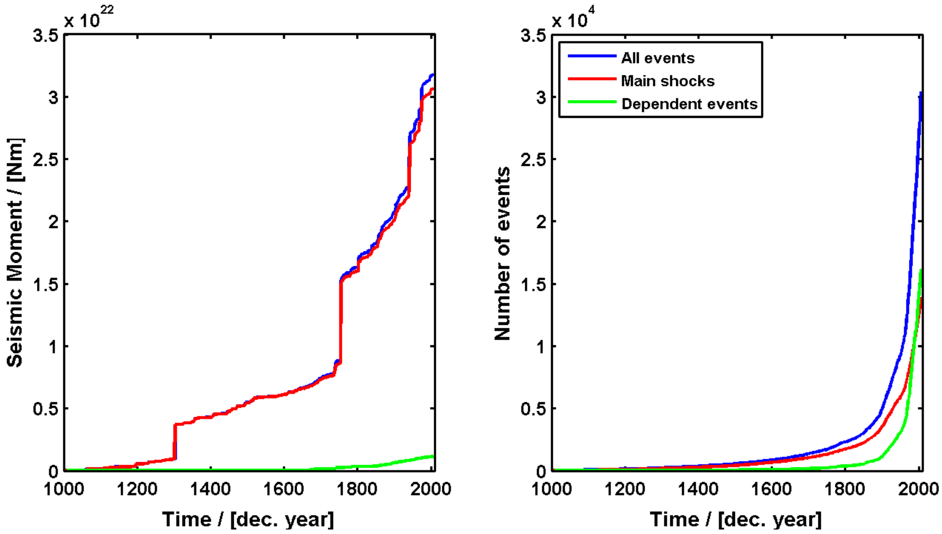

Figure 4: SHEEC cumulative seismic moment release (left) and cumulative number of events (right). Entire SHEEC catalog (blue), declustered catalog (red) and dependent events (green).

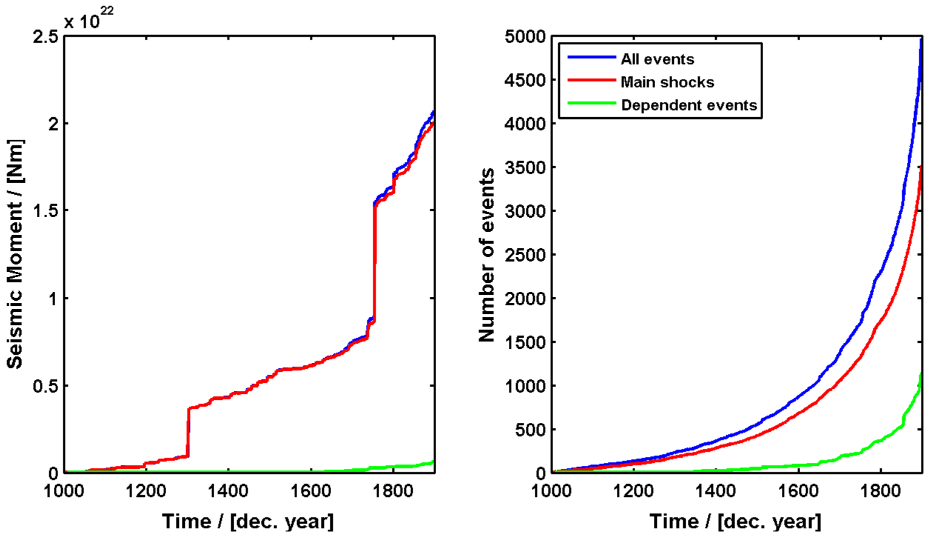

Figure 5: For the period T < 1900. SHEEC cumulative seismic moment release (left) and cuumative number of events (right). Entire SHEEC catalog (blue), declustered catalog (red) and dependent events (green).

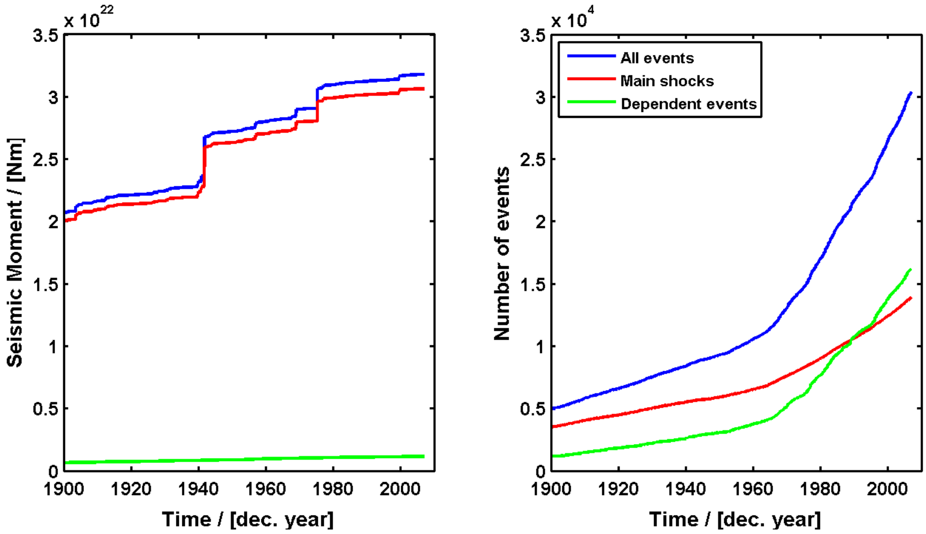

Figure 6: For the period T≥1900: SHEEC cumulative seismic moment release (left) and cuumative number of events (right). Entire SHEEC catalog (blue), declustered catalog (red) and dependent events (green).

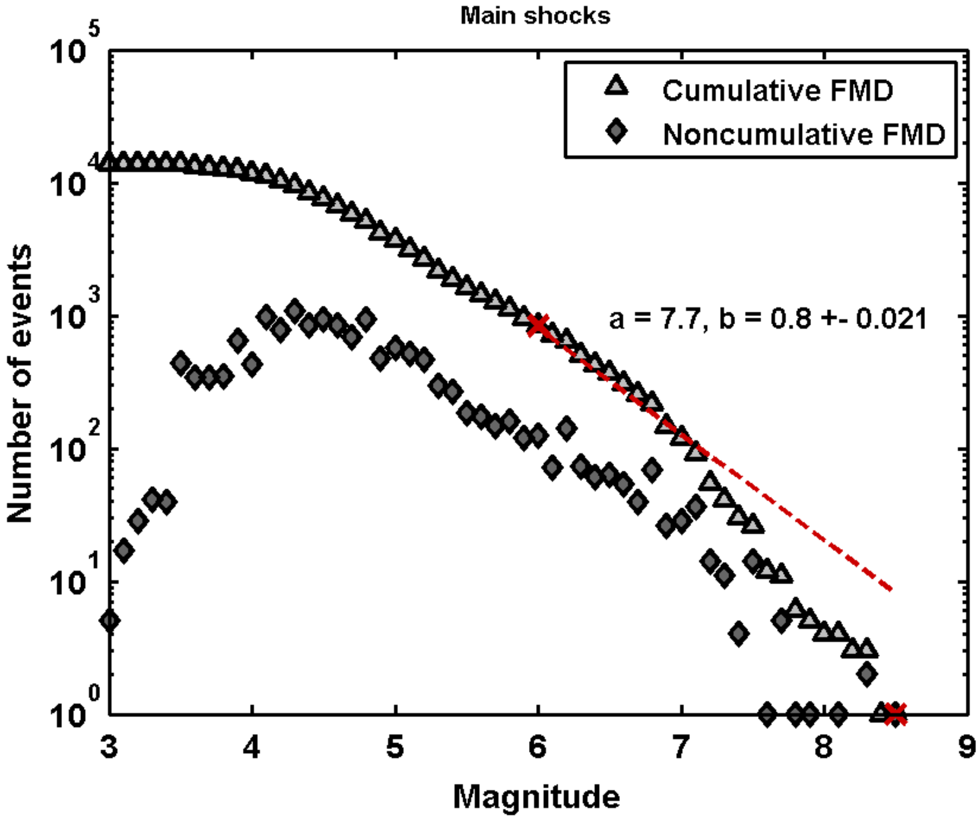

Figure 7: Frequency magnitude distribution of main shocks in the decustered catalog. Assuming a completeness magnitude of Mc(MW)=6, the b-value is 0.80+-0.021.

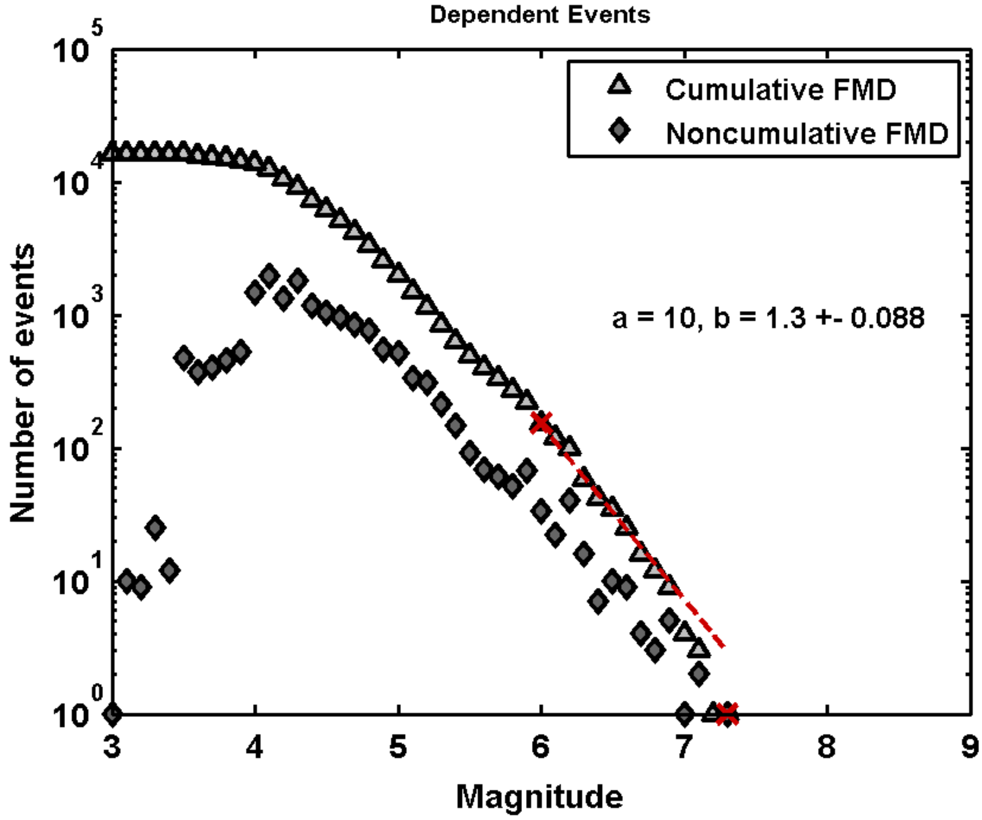

Figure 8: Frequency-magnitude distribution of dependent events. Assuming a completeness value of Mc(Mw)=6, the b-value is 1.30+-0.09.

References

Gardner, J. K., and L. Knopoff (1974), Is the sequence of earthquakes in Southern California, with aftershocks removed, Poissonian?, Bull. Seis. Soc. Am., 64(5), 1363-1367.

Grünthal (1985), The up-dated earthquake catalogue for the German Democratic Republic and adjacent areas - statistical data characteristics and conclusions for hazard assessment. Proceedings of the 3rd International Symposium on the Analysis of Seismicity and Seismic Risk. Vol. I, 3rd International Symposium on the Analysis of Seismicity and on Seismic Risk (Prague 1985), 19-25.

Burkhard, M., Grünthal, G. (2009): Seismic source zone characterization for the seismic hazard assessment project PEGASOS by the Expert Group 2 (EG 1b). Swiss Journal of Geosciences, 102, 1, 149-188.

Grünthal, G., Bosse, C., Stromeyer, D. (2009): Die neue Generation der probabilistischen seismischen Gefährdungseinschätzung der Bundesrepublik Deutschland : Version 2007 mit Anwendung für die Erdbeben-Lastfälle der DIN 19700:2004-07 'Stauanlagen', Scientific Technical Report ; 09/07, Deutsches GeoForschungsZentrum GFZ, 81.

Kanamori, H. (1977), The energy release in great earthquakes. JGR, 82, 2981-2987.