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STATISTICAL TREATMENT OF A COMPREHENSIVE SET OF ISOSEISMALS OBSERVED IN FRANCE DURING ONE CENTURY

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ABSTRACT

Isoseismals of the comprehensive set of earthquakes felt in France during a one century period of time are processed in order to derive their statistical features. Considering only epicentral intensities I_0 larger or equal to VI ($I_0 \geq$VI), the set comprises 194 events. It results that, for a given epicentral intensity, radii of isoseismals (I≥V) are log-normally distributed. Intensity attenuation formulas are presented, which give the mean value and the standard deviation of isoseismal radii versus I_0-I, for VIII-IX $\geq I_0 \geq$VI and I≥V, with most determination coefficients larger than 0.95.

For the purpose of scenarii associated to a given epicentral intensity I_0, formulas are proposed, which provide statistical description of the epicentral isoseismal radius and, associated to it through their correlation coefficient, the rate of isoseismal radius decrease versus I_0-I.

Keywords: Historical seismicity; Isoseismals; Statistics; France

1. INTRODUCTION

For more than 10 years the OECD (OECD 2015) has been recommending that PSHA outputs are tested against instrumental seismicity, historical seismicity and paleoseismicity. In this context the present paper deals with characterization of historical seismicity at the scale of the French territory. The approach is applicable to any territory with a similarly documented historical seismicity.
In order to get a reliable estimate of the historically observed seismic risk at the scale of a territory, it is necessary to get:

a) Statistical data of earthquakes felt in the territory, including their epicentral intensities,
b) For a given epicentral intensity I_0, an evaluation of the isoseismal radii for $I \leq I_0$.

The purpose of this paper is to address point b).

A series of isoseismal maps in the French territory was published by Levret et al. (1994). However it consisted of selected events, not of a compilation of events on a given period of time. In the frame of the SIGMA project (Senfaute 2016), Lambert et al. (2015) processed the comprehensive set of historical earthquakes listed in the SisFrance database (www.sisfrance.net), with epicentral MSK intensities $I_0 \geq$ VI, felt in the French metropolitan territory in the years 1900 to 2007. Macroseismic data of a total of 194 events were gathered and processed, including 82 events with epicenter out of the French territory. The distribution of epicentral intensities is presented in Table 1.

Lambert et al.'s output (2015) consists of an atlas of isoseismal maps, which we process in order to derive empirical intensity attenuation curves. (In the following, intensity values are noticed in Arabic numbers; for instance I=7.5 means VII-VIII intensity.)

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2 INPUT DATA

In their atlas, Lambert et al. (2015) attach a type to every isoseismal, with the following definitions:

- Type 0: The area of this isoseismal is zero;
- Type 1: The area of the part located in France is known but the total area is unknown;
- Type 2: The total area is known;
- Type 3: The total area is positive but unknown.

For our purpose we select the only isoseismals of type 0 and 2, which results in Table A1 presented in the Appendix. For every of the 194 events, the SisFrance identification number is reported, as well as the date and the name of the event, the epicentral intensity, and the radii of the isoseismals (for instance radii of isoseismals I=6 are reported in the column R6). For practical reasons, we limit our analysis to I≥5. The comprehensive set of isoseismal radii included in Table A1 constitutes our input data. Incidentally it can be noticed that some events (most with epicenter located out of France) do not provide any radius value because of our above mentioned isoseismal Type filter.

Out of Table A1, we designate as 'Class I_0:I' the set of isoseismals I associated to an epicentral intensity I_0. The number of isoseismals per class is indicated in Table 2. For instance the database includes 23 isoseismals I=6 associated to an epicentral intensity I_0=6.5.

Table 1. Number of events per epicentral intensity I_0

I_0	9	8.5	8	7.5	7	6.5	6
Nb of events	1	3	3	15	51	33	88

Table 2. Number of isoseismals per class I_0:I

I_0	9	8.5	8	7.5	7	6.5	6
I=8	0	2	1	∅	∅	∅	∅
I=7	0	2	2	7	27	∅	∅
I=6	0	2	2	5	35	23	62
I=5	0	2	2	6	34	21	69

3 ANALYSIS BY CLASSES

3.1 Statistics

For every class I_0:I, we calculate the mean of the isoseismal radii, and if the number of items in the class is at least five, the standard deviation. Results are presented in Table 3. For instance the class 7:6

Table 3. Mean and standard deviation of radii per class (km)

I_0	8.5	8	7.5	7	6.5	6
			Mean			
I=8	9.10	2.92	∅	∅	∅	∅
I=7	28.54	13.17	8.52	4.57	∅	∅
I=6	69.00	27.74	23.76	13.42	7.06	4.45
I=5	152.83	63.60	58.97	33.92	25.80	15.71
			Standard deviation			
I=8	/	/	∅	∅	∅	∅
I=7	/	/	6.35	3.77	∅	∅
I=6	/	/	17.75	11.00	4.55	4.44
I=5	/	/	42.95	23.63	19.25	13.68

(which consists of 35 isoseismals I=6 associated to an epicentral intensity I_0=7) has a 13.42 km mean radius and an 11.00 km standard deviation.

For classes with at least five items, we test the assumption that the radii are log-normally distributed: For every class we establish the observed standardized repartition of the natural logarithm of the radii in the class (y variable, calculated as per Equation 1) and compare it to the standardized Gaussian repartition. Two example of this comparison are presented in Figure 1, illustrating an excellent fit. Determination coefficients calculated from the series of natural logarithms of observed radii are presented in Table 4, confirming the validity of the assumption.

$$y = (r - \bar{r}) / \sigma_r \quad \text{with } r = \mathrm{Ln}(R) \qquad (1)$$

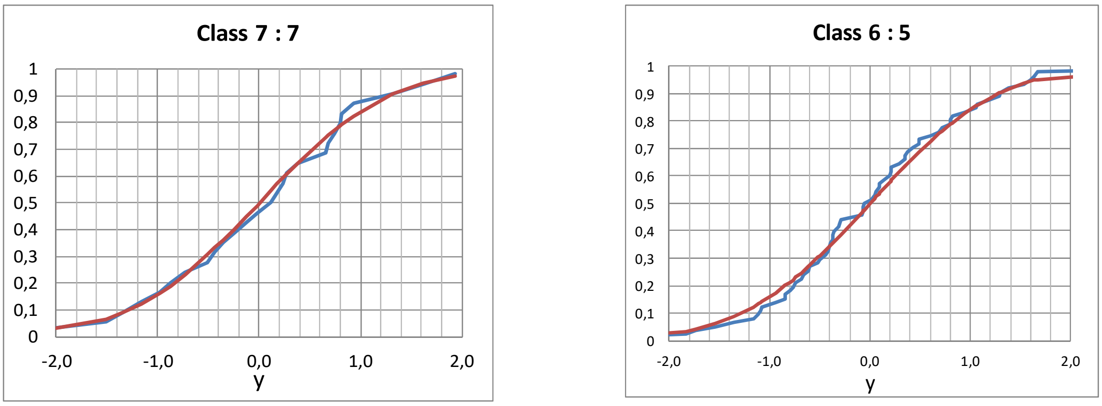

Figure 1. Observed repartition of natural logarithms of radii of isoseismals (blue) compared to the theoretical repartition (red) for two classes of isoseismals.

Table 4. Coefficients of determination for log-normal distributions

I_0	8,5	8	7,5	7	6,5	6
I=8	/	/	Ø	Ø	Ø	Ø
I=7	/	/	0.847	0.990	Ø	Ø
I=6	/	/	0.974	0.965	0.982	0.971
I=5	/	/	0.944	0.956	0.964	0.974

3.2 Intensity attenuation curves

Logarithms of mean, $\bar{R}$, and standard deviation, σ_R, values presented in Table 3 are plotted versus I_0-I in Figure 2. We observe empirical linear relationships represented in the figure by the regression dotted straight lines, corresponding to Equations 2-a and 2-b. As usual for lognormal distributions, we derive the median radius value, R_0, and the dispersion coefficient β_R, which are given by Equations 2-c and 2-d. It is remarkable that β_R is constant (not I_0-I dependant). It comes from the fact that the observed empirical coefficient of variation is constant: COV=$\sigma_R/\bar{R}$ =0.85.

$$\bar{R} = 4.7\, e^{I_0 - I} \quad , \quad \sigma_R = 4\, e^{I_0 - I} \quad , \quad \bar{R} \text{ and } \sigma_R \text{ in km.} \qquad \text{(2-a), (2-b)}$$

$$R_0 = 3.6\, e^{I_0 - I} \quad , \quad \beta_R = 0.74 \quad , \quad R_0 \text{ in km.} \qquad \text{(2-c), (2-d)}$$

It is concluded that, in the French seismo-tectonic context, for an event of epicentral intensity I_0 ($I_0 \geq 6$), the isoseismal I radius ($I \geq 5$) appears as a sample of the log-normally distributed random variable characterized by the above Equations 2-a to 2-d.

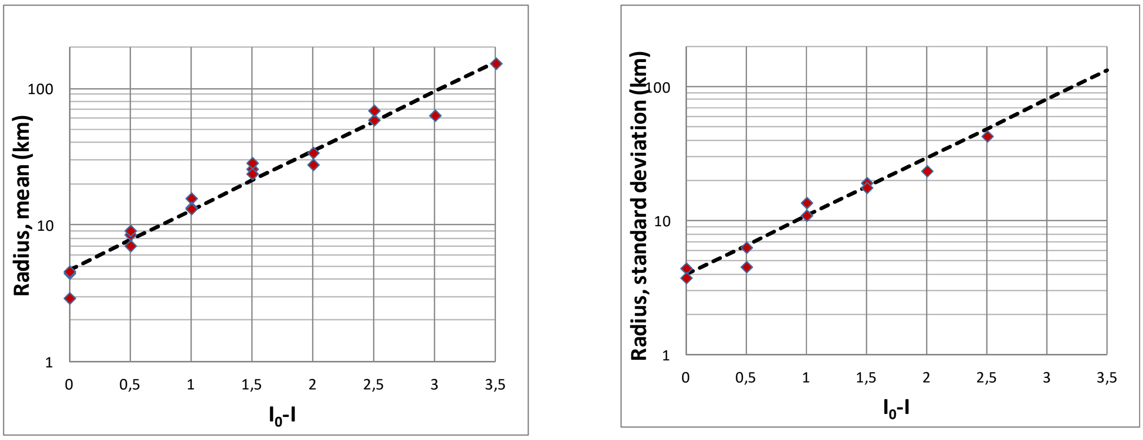

Figure 2. Mean value (left) and standard deviation (right) of isoseismal radii versus I_0-I

This result is very useful to conduct seismic risk analyses at the scale of the French territory. However, it is not sufficient to describe a possible set of isoseismals attached to a given epicentral intensity because in such a scenario, isoseismals cannot be regarded as samples of independent variables.

4 FEATURES OF INDIVIDUAL EARTHQUAKES

In order to analyse the set of isoseismals corresponding to a given event, we select out of Table A1 those 35 events presented in Table A2, which provide at least three isoseismals. For every of them we calculate, in the form of Equation 3, the linear regression between I_0-I and the natural logarithm of the corresponding radius. Four examples of such linear regressions are presented in Figure 3.

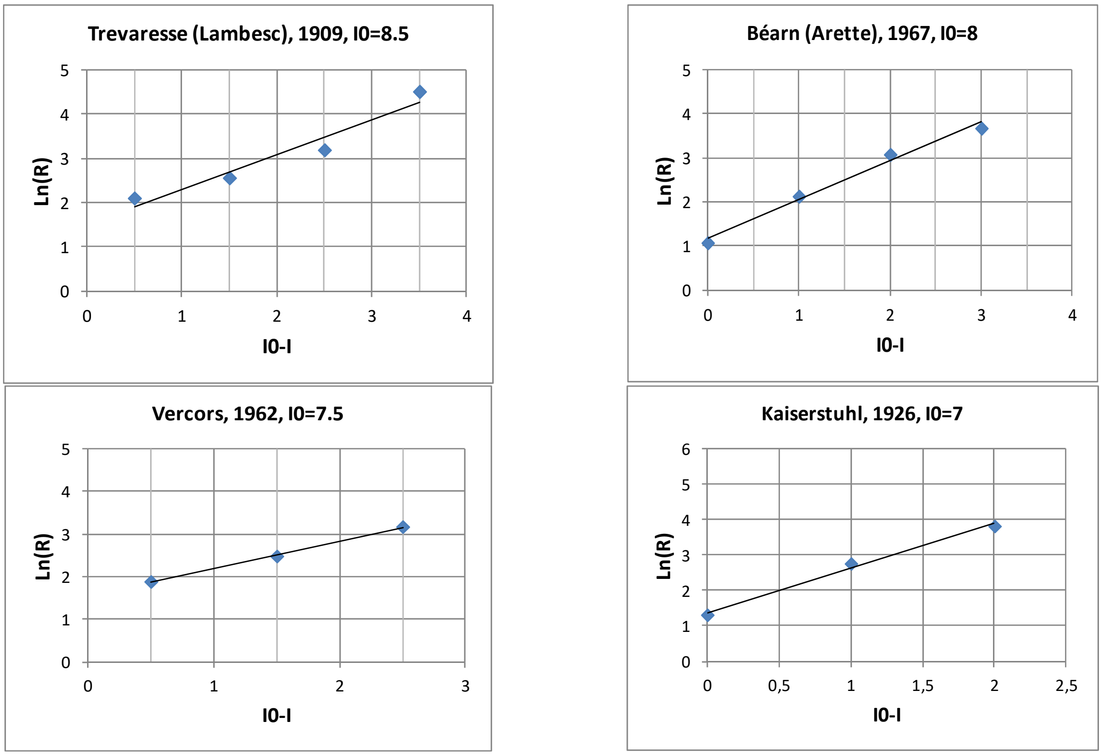

Figure 3. Examples of linear regressions between I_0-I and natural logarithm of radii (km)

$Ln(R)= a(I_0-I)+b$, R in km (3)

The list of a and b values is included in Table A2. Statistical treatment of a and b shows that a is log-normally while b is normally distributed, with a significant correlation. Numerical values of a and b mean and standard deviation are given in Equation 4, as well as the correlation coefficient, ρ, between Ln(a) and b. The negative value of ρ means that for a given epicentral intensity, the trend is that a faster isoseismal radius decrease is associated to a larger radius of the epicentral area.

$$\bar{a} = 0.95, \quad \sigma_a = 0.27 \quad ; \quad \bar{b} = 1.32, \quad \sigma_b = 0.88 \quad ; \quad \rho(Ln(a), b) = -0.43 \qquad (4)$$

To simulate a possible set of isoseismal radii ($I \geq 5$) associated to a given epicentral intensity I_0 ($I_0 \geq 6$), it is necessary, first to get a sample of (a, b) according to Equation 4 taking into account that a is log-normally and b normally distributed, and second to apply Equation 3.

Note: It should be noted that, when applied to the subset of Table A2 events, the procedure presented in 3.1 results in slightly different outputs, which reads:

$$\bar{R} = 5.5\, e^{0.9(I_0 - I)} \quad , \quad \sigma_R = 4.2\, e^{0.9(I_0 - I)} \quad , \quad \bar{R} \text{ and } \sigma_R \text{ in km}. \qquad (5\text{-a}), (5\text{-b})$$

Formulas 2 and 5 are corresponding to the same mean value and the same standard deviation for I_0-I =1.5.

5 CONCLUSION AND PERSPECTIVES

On the basis of an atlas of isoseismal maps, encompassing all the events felt in France with intensity equal to or larger than VI during one century, we have derived statistical features of expected isoseismal radii associated to a given epicentral intensity. The method can be used for any territory with a sufficiently documented historical seismicity. It is expected that the output should be similar for territories that are located in a similar sismo-tectonic context.
In order to evaluate the historically observed seismic risk at the scale of the French territory, it is still necessary that a statistical model of expected epicentral intensities be established and that an analysis be carried out, separating areas affected by a given intensity that are located inside the French metropolitan territory from those that are located abroad. This work is in progress.

6. ACKNOWLEDGMENTS

EDF is sincerely acknowledged for having provided the database presented in Table A1.

7. REFERENCES

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APPENDIX

Table A1. The 194 events in the Lambert et al. (2015) database and their Type 2 isoseismal radii

Num.	date			Name	I_0	R8	R7	R6	R5
40065	1912	2	9	EMBRUNAIS (ST-ANDRE)	6			1.6	6.3
40067	1913	5	14	MOYENNE-DURANCE (VOLX)	7.5		1.4		
40082	1933	9	19	UBAYE (LE LAUZET)	6.5			2.5	7.4
40092	1949	3	22	UBAYE (LE LAUZET)	6			3.3	9.9
40099	1951	11	30	HAUT-VERDON (CHASTEUIL)	7.5		1.0	5.3	16.2
40109	1959	4	5	UBAYE (ST-PAUL)	7.5		9.7	22.9	40.1
40140	1937	9	30	MOYENNE-DURANCE (LURS)	6			1.2	
40176	1984	6	19	PREALPES DE DIGNE (AIGLUN)	6			2.8	7.5
40203	1997	10	31	PREALPES DE DIGNE (PRADS-HTE-BLEONE)	6				13.5
50032	1904	7	12	BRIANCONNAIS (BRIANCON)	7		3.9	10.7	28.6
50043	1935	3	19	EMBRUNAIS (ST-CLEMENT)	7		12.9	22.8	40.7
50050	1937	12	17	QUEYRAS (GUILLESTRE)	6				14.5
50052	1938	2	15	EMBRUNAIS (CHATEAUROUX)	6				10.4
50057	1938	7	18	QUEYRAS (GUILLESTRE)	7			13.4	30.1
50099	1991	2	11	BRIANCONNAIS (BRIANCON)	6				7.6
110005	1950	6	28	CORBIERES (CAMPLONG-D'AUDE)	6.5			9.8	35.4
120003	1939	5	16	VALLEE DE L'AVEYRON (SEVERAC-LE-CH.)	6			3.6	9.8
130057	1909	6	11	TREVARESSE (LAMBESC)	8.5	8.2	13.0	24.4	91.2
130059	1909	7	10	TREVARESSE (LAMBESC)	6			5.0	22.9
130064	1909	9	22	TREVARESSE (LAMBESC)	6			3.6	14.4
130118	1984	2	19	BASSE-PROVENCE (MIMET)	6			1.1	8.6
160012	1935	9	28	ANGOUMOIS (ROUILLAC)	7		6.6	12.1	30.5
170069	1903	10	27	AUNIS (LA ROCHELLE)	6			2.6	19.5
170077	1958	7	20	ILE D'OLERON	6			1.7	28.7
170079	1972	9	7	ILE D'OLERON	7		6.2	24.2	63.8
180010	1925	9	26	MARCHE-BOISCHAUT (CHATEAUMEIL.-La CHATRE)	6.5			7.8	30.5
200013	1978	4	3	CASTAGNICCIA (CERVIONE)	6			2.2	9.2
230010	1925	12	3	MARCHE-BOISCHAUT (LA CHATRE)	6			5.4	16.6
260097	1901	5	13	BAS-PLATEAUX DAUPHINOIS (MANAS)	7		2.5	8.1	14.9
260120	1934	5	11	TRICASTIN (ROUSSAS)	6			4.3	8.7
260122	1934	5	12	TRICASTIN (VALAURIE)	7		1.0	4.4	7.5
260126	1934	5	16	TRICASTIN (VALAURIE)	6			4.5	10.6
260127	1934	5	16	TRICASTIN (BOUCHET)	6			3.0	10.1
260138	1934	6	24	TRICASTIN (VALAURIE)	6			1.8	4.0
260142	1934	12	9	TRICASTIN (VALAURIE)	6			0.5	2.0
260150	1936	2	13	TRICASTIN (LA GARDE-ADHEMAR)	6			1.5	7.8
260175	1952	6	8	BARONNIES (PIERRELONGUE)	7		0.5	1.1	6.5
290030	1959	1	2	CORNOUAILLE (MELGVEN)	7		7.3	21.2	65.7
300014	1946	9	30	COSTIERE (LE PONT-DU-GARD)	6.5			1.7	6.4
310037	1999	10	4	HAUT-COMMINGES (CIERP)	6			3.1	12.8
380053	1938	12	8	BAS-PLATEAUX DAUPHINOIS (LA SONE)	6			1.5	4.2
380058	1941	8	10	BAS-PLATEAUX DAUPHINOIS (COTE-St-ANDRE)	6			2.6	10.1
380070	1962	4	25	VERCORS (CORRENCON-EN-VERCORS)	7.5		6.6	12.0	23.9
380075	1963	4	25	VERCORS (MONTEYNARD)	7		5.8	10.0	18.6
380080	1963	4	27	VERCORS (MONTEYNARD)	7		1.6	3.9	9.1
380083	1963	12	4	VERCORS (CORRENCON-EN-VERCORS)	6			4.5	8.4

380084	1963	12	7	VERCORS (CORRENCON-EN-VERCORS)	6			3.0	7.5
380085	1963	12	12	VERCORS (CORRENCON-EN-VERCORS)	6			2.1	6.5
380099	1979	11	22	VERCORS (MONTEYNARD)	6			2.1	7.0
390016	1971	6	21	JURA (VAUX-LES-SAINT-CLAUDE)	7		1.5	3.5	5.5
440040	1907	12	12	PAYS DE CHATEAUBRIANT (TREFFIEUX)	6			3.4	15.2
450009	1933	10	3	VAL DE LOIRE (TIGY)	6			3.1	12.2
560019	1902	12	5	ILE DE BELLE-ILE (LE PALAIS)	6			5.5	15.8
560027	1930	1	9	LANDES DE LANVAUX (MEUCON)	7		2.2	9.7	45.6
610009	1927	11	19	BOCAGE NORMAND (FLERS)	6			6.7	30.3
630059	1913	10	16	COMBRAILLE (PIONSAT)	6			3.1	
630069	1957	3	25	LIMAGNE (RANDAN)	6			5.7	12.1
640001	1980	2	29	OSSAU (ARUDY)	7.5		11.1	27.2	49.0
640003	1980	2	29	OSSAU (ARUDY)	6			5.1	34.9
640272	1902	5	6	BEARN (LURBE-SAINT-CHRISTAU)	7		5.9	16.6	63.5
640284	1902	9	8	BEARN (OLORON-SAINTE-MARIE)	7		4.6	11.3	35.7
640292	1911	7	24	BEARN (BENEJACQ-COARRAZE)	7			10.9	42.0
640330	1952	2	7	BEARN (ARETTE)	6			3.4	13.2
640362	1967	8	13	BEARN (ARETTE)	8	2.9	8.4	21.7	39.3
640375	1973	12	13	BEARN (NAY-BOURDETTES)	6.5			4.9	14.2
640385	1977	9	12	PAYS BASQUE (STE-ENGRACE)	6.5			4.7	15.1
640417	1981	2	5	BEARN (NAVARRENX)	6			6.0	12.2
640431	1982	1	6	PAYS BASQUE (ST-JEAN-LE-VIEUX)	6.5			12.0	35.1
640444	1982	8	25	BEARN (S. ARTHEZ-D'ASSON)	6			4.0	12.0
640462	1984	2	25	PAYS BASQUE (BAIGORRY)	6			5.5	15.7
650221	1904	7	13	BIGORRE (BAGNERES-DE-BIGORRE)	7		6.5	28.6	62.8
650244	1905	7	28	BIGORRE (BAGNERES-DE-BIGORRE)	6.5			16.0	33.4
650273	1912	9	15	ARAGON (JACA)	6.5				
650287	1924	2	22	BEARN (S. ARTHEZ-D'ASSON)	7		10.0	17.4	29.9
650324	1930	10	13	LAVEDAN (ARGELES-GAZOST)	6			1.7	6.4
650361	1948	3	16	BIGORRE (CHEUST-JUNCALAS)	6				9.2
650366	1950	1	31	BIGORRE (CAMPAN)	7			14.2	30.8
650374	1952	4	5	LAVEDAN (ARGELES-GAZOST)	6			10.4	21.3
650377	1953	10	13	BIGORRE (CAMPAN)	6			8.8	20.9
650382	1958	11	25	BIGORRE (HECHES)	6.5			7.0	30.3
650500	2002	5	16	LAVEDAN (AUCUN)	6			1.3	8.2
650505	2006	11	17	BIGORRE (GAZOST)	6			6.6	18.5
660061	1920	11	28	FENOUILLEDES (ST-PAUL-DE-FENOUILLET)	7		2.7	6.4	27.1
660068	1922	9	23	FENOUILLEDES (ST-PAUL-DE-FENOUILLET)	6.5			5.9	21.9
660073	1922	12	28	PLAINE DU ROUSSILLON (MILLAS)	6			7.6	13.4
660095	1996	2	18	FENOUILLEDES (ST-PAUL-DE-FENOUILLET)	6			7.8	20.0
670096	1952	9	29	OUTRE-FORET (WISSEMBOURG)	6.5			5.2	
670102	1952	10	8	OUTRE-FORET (WISSEMBOURG)	6.5			9.2	
670106	1959	9	4	PLAINE DE BASSE-ALSACE (ERSTEIN)	6			3.6	9.8
680065	1901	5	22	PLAINE DE HAUTE-ALSACE (ST-LOUIS)	6			3.0	14.0
680091	1980	7	15	PLAINE DE HAUTE-ALSACE (HABSHEIM)	6.5			5.2	26.3
700013	1955	11	3	AVANT-PAYS JURAS. (MONTARLOT-LES-RIOZ)	6			1.1	5.4
700017	1955	11	23	AVANT-PAYS JURAS. (MONTARLOT-LES-RIOZ)	6			2.7	8.0
730165	1947	5	27	LAC DU BOURGET (JONGIEUX)	6			1.2	6.1
730174	1958	3	30	LAC DU BOURGET (CONJUX)	6.5			5.9	14.2
730177	1958	9	15	BUGEY (LA BALME-DE-SILLINGY)	6			1.5	4.8
740060	1905	4	29	MASSIF DU MONT-BLANC (LAC D'EMOSSON)	7.5		19.4	51.4	114.8

740067	1905	8	13	MASSIF DU MONT-BLANC (CHAMONIX)	7			13.0	
740069	1909	2	17	CHABLAIS (ABONDANCE)	6			2.9	10.5
740079	1936	4	17	AVANT-PAYS SAVOYARD (FRANGY)	7			3.7	10.6
740094	1968	6	27	CHABLAIS (ABONDANCE)	6.5			2.6	5.1
740097	1968	8	19	CHABLAIS (ABONDANCE)	7		2.4	8.7	31.9
740119	1980	12	2	BAUGES (FAVERGES)	6.5			3.7	16.0
740150	1994	12	14	GENEVOIS (LES VILLARDS-SUR-THONES)	6			5.8	20.9
740153	1996	7	15	AV. PAYS SAVOYARD (EPAGNY-ANNECY)	7		1.8	8.8	23.0
830006	1932	5	1	MEDITERRANEE (S. MARSEILLE)	6				
840066	1905	4	10	BARONNIES (VAISON-LA-ROMAINE)	7		1.1	3.5	15.3
840068	1924	9	24	COMTAT (CADEROUSSE)	6.5			1.4	4.0
840074	1927	7	24	BARONNIES (MALAUCENE)	7		1.3	3.6	7.7
860021	1901	11	18	BRANDES DU HAUT-POITOU (CHARROUX)	6			6.6	24.9
880053	1984	12	29	HAUTES-VOSGES (ELOYES-REMIREMONT)	6			5.8	16.1
880077	2003	2	22	PAYS FORESTIER SOUS-VOSGIEN (RAMBERV.)	6.5			11.4	32.9
1100014	1938	6	11	FLANDRES (RENAIX-OUDENAARDE)	7		16.7	56.5	87.8
1100022	1983	11	8	PAYS DE LIEGE (LIEGE)	7.5				
1100079	1965	12	15	HAINAUT (MAURAGE)	7		3.0	4.4	9.1
1100083	1966	1	16	HAINAUT (CARNIERES)	7		3.3	7.1	10.6
1100110	1992	4	13	LIMBOURG (ROERMOND)	6.5				
1100119	1928	1	14	HAUTES-FAGNES (VERVIERS)	6			3.6	13.1
1110017	1926	6	28	VALLEE DU RHIN (KAISERSTUHL)	7		3.7	15.8	45.4
1110019	1957	8	29	JURA SOUABE (TAILFINGEN)	6			6.1	
1110021	1965	9	19	FORET NOIRE (ST-BLASIEN)	6			4.2	26.9
1110022	1974	5	21	FORET NOIRE (WEHR)	6			2.5	
1110059	1903	3	22	VALLEE DU RHIN (KARLSRUHE)	6.5			5.5	10.1
1110061	1911	11	16	JURA SOUABE (EBINGEN)	8.5	10.0	44.1	113.6	214.4
1110062	1913	7	20	JURA SOUABE (TUBINGEN)	6			34.1	105.6
1110063	1915	6	2	JURA FRANCONIEN (INGOLSTADT)	7				
1110065	1924	12	11	JURA SOUABE (EBINGEN)	6.5			11.5	
1110066	1924	12	12	JURA SOUABE (EBINGEN)	6.5				
1110068	1930	10	7	ALPES BAVAROISES (NAMLOS)	7				
1110069	1933	2	8	VALLEE DU RHIN (RASTATT)	7		4.2	15.6	36.4
1110070	1933	2	21	JURA SOUABE (PFEFFINGEN)	6				
1110074	1935	6	27	JURA SOUABE (KAPPEL)	7.5				
1110075	1935	12	30	VALLEE DU RHIN (OFFENBURG)	6				
1110076	1935	12	30	VALLEE DU RHIN (OFFENBURG)	7			16.6	67.9
1110077	1943	5	2	JURA SOUABE (EBINGEN)	7				
1110078	1943	5	28	JURA SOUABE (BALINGEN)	7				
1110079	1947	4	14	JURA SOUABE (EBINGEN)	6				
1110080	1947	6	28	JURA SOUABE (ONSMETTINGEN)	6.5				
1110083	1948	6	7	VALLEE DU RHIN (KARLSRUHE)	7				
1110085	1952	2	24	VALLEE DU RHIN (LUDWIGSHAFEN)	6.5			19.4	65.7
1110086	1969	2	26	JURA SOUABE (TAILFINGEN)	7				
1110087	1970	1	22	JURA SOUABE (ONSMETTINGEN)	7				
1110091	1978	9	3	JURA SOUABE (ONSMETTINGEN)	7.5				
1110096	1951	3	14	HAUTES-FAGNES (EUSKIRCHEN)	7.5				
1110221	2004	12	5	BADEN-WURTTEMBERG (WALDKIRCH)	6				
1120023	1924	4	15	VALAIS (VISP)	7				
1120028	1946	1	25	VALAIS (CHALAIS)	7.5		10.5		
1120031	1946	1	26	VALAIS (CHALAIS)	7				

1120033	1946	5	30	VALAIS (CHALAIS)	7			
1120035	1954	5	19	VALAIS (N-W. SION)	7			
1120037	1954	7	29	VALAIS (MONTANA)	6.5			
1120038	1960	3	23	VALAIS (BRIG)	7			
1120044	1925	1	8	JURA SUISSE (ORBE-LIGNEROLLE)	6.5		6.1	61.4
1120077	1910	5	26	JURA SUISSE (LAUFEN)	6		8.8	35.5
1120078	1964	3	14	UNTERWALD (SARNEN)	7			
1120086	1929	3	1	PLATEAU SUISSE (YVERDON)	6.5			
1120109	1984	9	5	ZURICH	6			
1120261	1915	8	25	BAS-VALAIS (MARTIGNY)	6.5			
1120271	1933	8	12	PLATEAU SUISSE (MOUDON)	6.5			
1130067	1905	5	30	PIEMONT (FOSSANO)	6			24.7
1130068	1906	8	11	RIVIERA DI PONENTE (TAGGIA)	6			14.3
1130070	1920	9	7	TOSCANE (FIVIZZANO)	9			
1130078	1936	12	11	PIEMONT (PIGNA)	6			9.6
1130082	1958	5	4	PIEMONT (VALDIERI)	6		9.4	36.3
1130085	1963	7	19	MEDITERRANEE (S. IMPERIA)	7			
1130086	1963	7	19	MEDITERRANEE (S. IMPERIA)	7.5			109.9
1130088	1963	7	27	MEDITERRANEE (S. IMPERIA)	7.5			
1130091	1966	4	7	PIEMONT (ENTRACQUE)	6.5		3.2	10.3
1130092	1968	4	18	RIVIERA DI PONENTE (DIANO MARINA)	6		4.5	10.0
1130098	1972	1	18	RIVIERA DI PONENTE (PIETRA LIGURE)	6		3.9	17.2
1130101	1976	5	6	FRIOUL (UDINE)	8.5			
1130104	1941	2	23	PIEMONT (PRAZZO)	6			
1130107	1955	5	12	PIEMONT (STROPPO)	7		11.1	24.2
1130108	1955	6	20	PIEMONT (PRAZZO)	7			
1130121	1914	10	26	PIEMONT (SACRA DI SAN MICHELE)	7		40.1	95.6
1130122	1947	2	17	PIEMONT (PRAZZO)	7.5			
1130129	1927	12	11	PIEMONT (SUSA)	6			17.2
1130131	1968	6	18	VAL D'AOSTE (ARNAZ)	6.5			
1130132	1901	10	30	LOMBARDIE (W. BRESCIA)	8			
1130133	1948	11	13	SARDAIGNE	6			
1130135	1980	1	5	PIEMONT (PINEROLO)	7	4.1	10.6	28.6
1130146	1981	4	22	MEDITERRANEE (S. SAN REMO)	6			
1130214	1918	1	13	LOMBARDIE (MILANO)	6			
1130362	1938	12	23	CANAVESE (LOCANA)	6			
1130560	1995	4	21	RIVIERA DI PONENTE (VINTIMILLE)	6			
1140018	1903	4	20	CATALOGNE (ROSAS)	6			
1140020	1927	3	12	CATALOGNE (MONTSENY)	6			
1140024	1923	11	19	VAL D'ARAN (VIELLA)	8	18.0	33.8	87.8
1140026	1924	2	27	VAL D'ARAN (VIELLA)	6			28.6
1140046	1919	11	29	VAL D'ARAN (BOHI)	6			33.2
1140048	1923	7	10	NAVARRE (BERDUN)	7.5			
1140126	2004	9	21	CERDAGNE	6			
1150008	1931	6	7	MER DU NORD (DOGGER BANK)	7			
1150020	1926	7	30	JERSEY	6.5			66.1

Table A2. Events with at least three isoseismals, and associated linear regressions

Num.	I_0	R8	R7	R6	R5	a	b
130057	8.5	8.2	13.0	24.4	91.2	0.79	1.52
1110061	8.5	10.0	44.1	113.6	214.4	1.01	2.02
640362	8	2.9	8.4	21.7	39.3	0.88	1.17
1140024	8		18.0	33.8	87.8	0.79	2.04
40099	7.5		1.0	5.3	16.2	1.40	-0.63
40109	7.5		9.7	22.9	40.1	0.71	1.97
380070	7.5		6.6	12.0	23.9	0.64	1.55
640001	7.5		11.1	27.2	49.0	0.74	2.09
740060	7.5		19.4	51.4	114.8	0.89	2.55
50032	7		3.9	10.7	28.6	1.00	1.37
50043	7		12.9	22.8	40.7	0.57	2.56
160012	7		6.6	12.1	30.5	0.77	1.83
170079	7		6.2	24.2	63.8	1.16	1.89
260097	7		2.5	8.1	14.9	0.89	1.02
260122	7		1.0	4.4	7.5	1.02	0.14
260175	7		0.5	1.1	6.5	1.31	-0.90
290030	7		7.3	21.2	65.7	1.10	1.97
380075	7		5.8	10.0	18.6	0.58	1.74
380080	7		1.6	3.9	9.1	0.86	0.49
390016	7		1.5	3.5	5.5	0.65	0.47
560027	7		2.2	9.7	45.6	1.51	0.78
640272	7		5.9	16.6	63.5	1.19	1.73
640284	7		4.6	11.3	35.7	1.02	1.49
650221	7		6.5	28.6	62.8	1.13	1.99
650287	7		10.0	17.4	29.9	0.55	2.30
660061	7		2.7	6.4	27.1	1.14	0.91
740097	7		2.4	8.7	31.9	1.30	0.86
740153	7		1.8	8.8	23.0	1.26	0.71
840066	7		1.1	3.5	15.3	1.31	0.05
840074	7		1.3	3.6	7.7	0.90	0.30
1100014	7		16.7	56.5	87.8	0.83	2.95
1100079	7		3.0	4.4	9.1	0.55	1.05
1100083	7		3.3	7.1	10.6	0.58	1.25
1110017	7		3.7	15.8	45.4	1.25	1.38
1110069	7		4.2	15.6	36.4	1.08	1.52