SECOND EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING
AND SEISMOLOGY, ISTANBUL AUG. 25-29, 2014

ON THE USE OF CROSS-BORDER MACROSEISMIC DATA TO IMPROVE THE ESTIMATION OF PAST EARTHQUAKES SEISMOLOGICAL PARAMETERS

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ABSTRACT

Historical seismicity characterisation is a key parameter when performing seismic hazard assessment in regions such as France, which undergo low deformation rates and low to moderate seismic activity. Most of significant earthquakes in metropolitan France occur close to the borders, where the tectonic activity concentrates. For these close-border earthquakes, some biases are observed in the azimuthal distribution of Intensity Data Points (IDP) provided by the SisFrance macroseismic database [EDF-IRSN-BRGM]. The estimation of their seismological parameters (location and magnitude), performed using IDP-based methods, can be affected by these gaps in macroseismic information. The best way to fill these gaps of data and improve the location and magnitude computation would be to integrate SisFrance with IDPs from cross-border macroseismic databases. The main difficulty one has to face when integrating macroseismic datasets in Europe is that there is no use of an unique intensity scale. In this study, we perform an analysis of the coherence between the SisFrance MSK intensity assignments and the estimates from neighbouring countries, which use other intensity scales on common localities. Results suggest that globally, the SisFrance MSK assignments are in good agreement with the corresponding EMS-98 estimates up to the higher levels of observed intensity (VIII-IX). The comparison between SisFrance (MSK) and INGV datasets (MCS) shows that estimates are consistent up to intensity VI-VII MSK. A similar comparison is carried out as well between two French agencies, SisFrance (MSK) and BCSF (MSK before 2000 and EMS-98 after 2000). Surprisingly, differences are higher when comparing assignments within the same macroseismic scale (MSK). Following these results we integrate the SisFrance IDPs with the SED-ECOS dataset for the 2005 Vallorcine earthquake, and compute epicentral location and magnitude using the Bakun and Wentworth [1997] methodology. The integration of cross-border macroseismic data allows to improve the epicentral location and has a significant impact on the accuracy of the magnitude evaluation.

INTRODUCTION

Most of France behaves as a rigid block with internal deformation of no more than 0.5mm/yr [Nocquet and Calais, 2004; Walpersdorf et al., 2006]. The Alpine region is the area that undergoes the highest deformation rates, which are nevertheless lower than ~1mm/yr [Nocquet, 2012].This low deformation rate results, for the French metropolitan territory, in a moderate seismic activity. In such a context it is necessary, when performing seismic hazard assessment, to take into account historical seismic data in order to extend the observation period and to be more representative of the seismogenic behaviour of geological structures.

The only information and data available for these past events is of macroseismic nature, expressed as Intensity data points (IDPs), which therefore represent the only quantitative data available forhistorical

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earthquakes. Two main approaches can be used to determine the location and magnitude of historical earthquakes: (i) based on isoseismals drawing and (ii) based on the use of IDPs (see NERIES report NA4 [2008] for an overview of the available methods). As highlighted by the NERIES NA4 report [2008], the main issue of applying IDPs based methods, is the lack of offshore or cross-country macroseismic data when studying coastal or close-border events. Indeed, the geographic distribution of population and/or macroseismic information may bias seismological parameters estimation.

In metropolitan France, most significant earthquakes are concentrated close to or along the borders, inareas where tectonic activity focuses: Alps, Provence, Pyrenees, Armorican to Hercynian front domains and Rhine Graben.
Macroseismic information for French historical earthquakes is collected and gathered together in SisFrance, which is the reference macroseismic database for France. Within SisFrance, macroseismic data are mainly available for French localities, even if macroseismic data from a few cross-border municipalities have been included for most important near-border earthquakes. The consequence of this is an inhomogeneous azimuthal distribution of IDPs for events located close to the borders, which may either, lead to poorly constrained seismological parameters or, worse, prevent from applying IDPs-based methods to estimate seismological parameters of these historical events. It highlights the need of integrating SisFrance database with existing cross-border macroseismic data for these earthquakes.

The first attempt of gathering together macroseismic data about historical earthquakes at the European scale yielded very recently to the European Archive of Historical Earthquake Data (AHEAD) (1000-1899) [AHEAD working group - http://www.emidius.eu/AHEAD/main/]. This impressive collaborative inventory and the associated website are helpful when dealing with past earthquakes data compilation at the European scales, as they provide an organized and centralized overview of the available information for historical earthquakes. Each of the eight origin macroseismic databases, however, are kept in their current state, i.e. the macroseismic intensity scale used by each database is not unique across European countries.

A review of the important and most commonly used macroseismic intensity scales, together with an analysis and some recommendations about their conversions to one another are presented by Musson et al. [2010]. As underlined by the authors, the best approach to convert macroseismic data from one intensity scale to another should be to go back to the original data and reassign values in the desired intensity scale. This procedure is frequently difficult to set up, either because the original data no longer exist, or because of practical constraints of time and effort [Musson et al., 2010]. The use of some form of conversion is therefore preferred.

The main goals of this study are :

1. To perform an analysis of the coherence between intensity assignments from SisFrance and from either, neighbouring countries databases, or the BCSF (Bureau Central Sismologique Français), the agency in charge of collecting and disseminating seismological observations in France ;
2. To analyse the impact of integrating cross-border macroseismic data to SisFrance on location and magnitude estimates accuracy for close-border past earthquakes, when using IDP-based methods.

SISFRANCE MACROSEISMIC DATABASE

In order to improve the knowledge of past earthquakes that have occurred within the French metropolitan territory, EDF (Eléctricité de France), IRSN (Institut de Radioprotection et Sureté Nucléaire) and BRGM (Bureau de Recherche Géologique et Minière) collaborate, since 1975, in implementing and maintaining the SisFrance macroseismic database (http://www.sisfrance.net).

More than 106 000 macroseismic observations are gathered in the SisFrance database. These observations are associated to more than 6000 earthquakes occurred between 217 BC and 2007. Macroseismic data come from historical archives studies (before 1920) and/or analysis of people feedbacks collected through questionnaires sent by the BCSF (Bureau Central Sismologique Français) to the city councils located in an earthquake area. Among these 6000 earthquakes, half of them have sufficient and reliable information to allow the estimate of their epicentral intensity (Iepc) and location. The epicenter location provided by SisFrance is obtained through manual drawing of isoseimals. Epicentral and Observed (Iobs) intensities in SisFrance are expressed in the MSK scale [Medvedev et al., 1964]. A quality index is associated to these parameters (QIE and QIobs), as well as to the estimation of the date (QD) and the epicentral location (QPOS) of the event (table 1).

Table 1. Quality indexes related to events date and epicentral intensity and location

	QIE	QPOS		QIOBS	QD
A	Sure	Really reliable	Use of isoseists	Sure	Good
B	Pretty sure	Reliable		Pretty sure	Average
C	Uncertain	Uncertain	No use of isoseists	Uncertain	Doubtful
D		Likely			
E	Presumed	Presumed			
I	Isolated	Isolated			
K	Calculated				

The spatial distribution of macroseismic data in SisFrance exhibits a bias when dealing with close-border or cross-border events, with intensity data points mainly located in France. Figure 1 presents two examples of such an inhomogeneous spatial distribution of macroseismic data around the epicenter for two close-border earthquakes in SisFrance (upper panels). The spatial distribution that would be obtained after integrating macroseismic data from foreign neighboring databases is shown in the lower panels. Azimuthal distributions are illustrated through the use of windrose diagrams, for the 2005 Jura Suisse (NE Solothurn) earthquake, Iepc = IV MSK [SisFrance] and the 1938 Renaix-Nukerke event, Iepc = VII MSK [SisFrance].

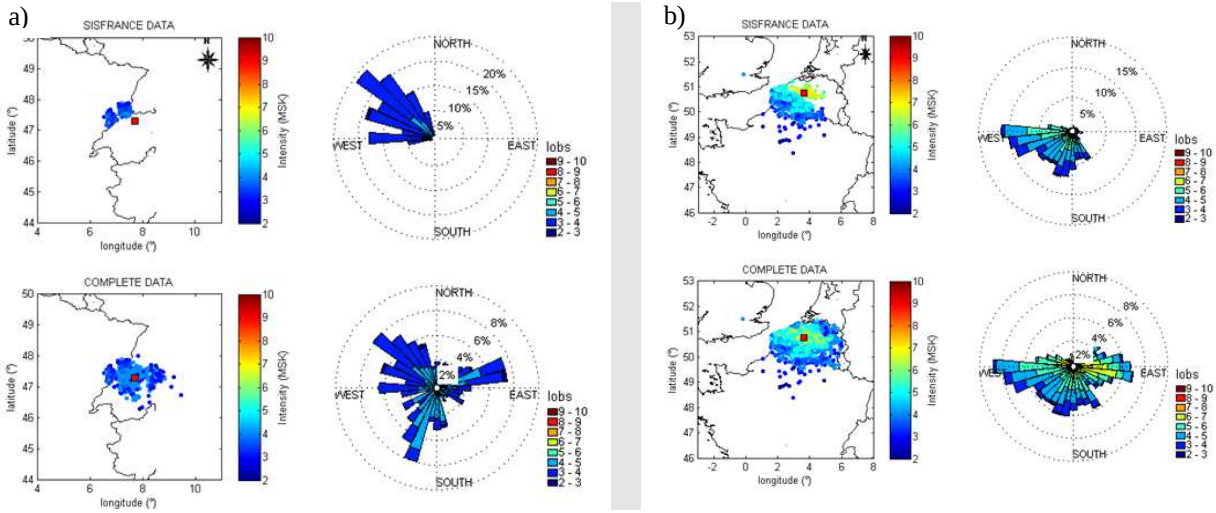


Figure 1: Azimuthal distribution of Iobs before and after integration to SISFRANCE observations of macroseismic data coming from crossborder databases. a) is for the Jura Suisse Solothurn event (12/11/2005) and b) is for the Renaix event (11/06/1938). Windrose diagrams exhibit the 10° by 10° azimuthal distribution of macroseismic observations. Bar lengths represent the amount of observations and colours represent intensity classes (see color scale). Data are normalized three times to remove the potential bias that could be induced by events with large amount of associated macroseismic data: i) by earthquake each intensity class is normalized by the amount of observations, ii) macroseismic intensity classes are then normalized by the amount of events, iii) finally all norms are normalized to have the highest equal to 1.

CROSS BORDER FRANCE INTENSITY DATA COMPILATION AND COMPARISON

Methodology

In this section we perform an analysis of the coherence between the SisFrance MSK estimates and the other intensity scales used in the neighboring countries. In particular, we compare MSK estimates with EMS-98 estimates (used in Switzerland, Belgium, Spain and UK) and with MCS estimates (used in Italy). For the sake of completeness, we also compare SisFrance MSK estimates with either, MSK and EMS-98 intensities provided by the BCSF (Bureau Central Sismologique Français, the agency in charge of collecting and disseminating seismological observations in France) for some major French earthquakes that have occurred either, before or after the year 2000. Indeed, the BCSF used the MSK intensity scale up to 2000, and the EMS-98 afterwards.

Concerning the cross-border coherence analysis, a comparison between intensity assignments from SisFrance and from the cross-border agency is performed on a selection of significant earthquakes complying with the following criteria :

- epicentral intensity larger than IV MSK,
- reliable estimate of the epicenter intensity (QIE A or B),
- at least 50 macroseismic observations available from both, SisFrance and the cross-border agency,
- epicentral location within 50 km from the border on either sides.

117 earthquakes distributed along the French borders and that had occurred during either the historical or the instrumental period comply with these criteria. Macroseismic data from cross-border agencies have been collected for 22 of these earthquakes, located along the Spanish, Italian, Swiss, Belgian and Channel (UK) borders. Figure 2 illustrates the location of the 22 selected earthquakes, and table 2 summarizes their characteristics.

The analysis is performed by comparing macroseismic intensity assignments of duplicated observations, i.e. intensity observation values assigned to a given location X by both, SisFrance ($I_{SisFrance,X}$) and the respective cross-border agency ($I_{databaseJ,X}$). Duplicated localities are identified with the help of a statistical analysis, which allows ensuring the correspondence between localities inventoried in both databases when reported coordinates do not perfectly coincide. The observations brought together in this way are hereafter called "duplicates". Over all the 22 earthquakes, 1330 duplicates are identified, the largest contribution coming from the IGN (Spain) database. The location of the duplicates for each of the selected earthquakes is also shown in figure 2.

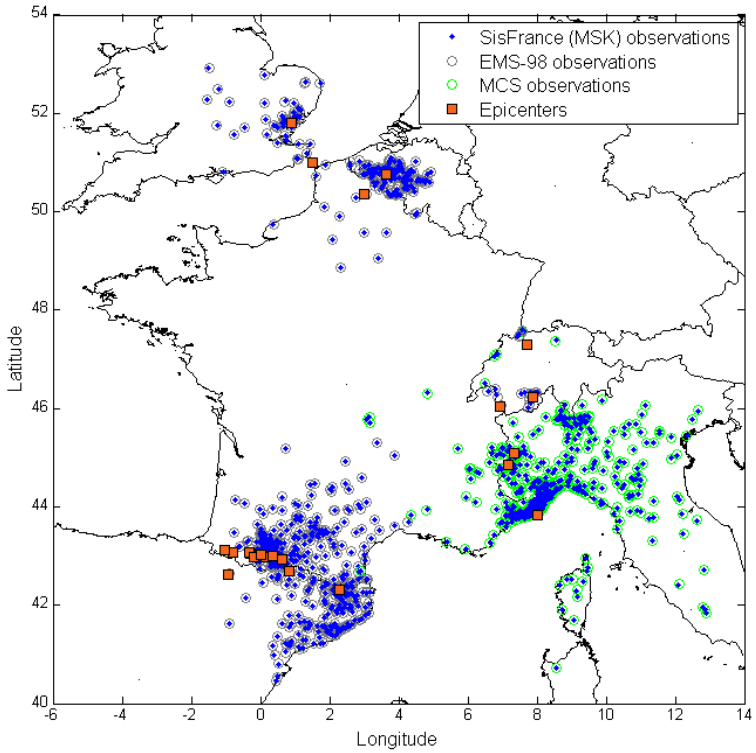


Figure 2. Location of the 22 earthquake epicenters selected for the cross-border intensity scale coherence analysis (orange squares) and of the 1330 duplicates identified when comparing observations from SisFrance (blue dots) and the corresponding cross-border agency database (grey circles for EMS-98 IDP, green circles for MCS IDP).

The use of duplicates allows us to perform a quantitative comparison of macroseismic intensity scales using common Intensity Data Points (IDP). It should be noticed that macroseismic databases assign a single intensity value to a given municipality, this value representing an average of the effects induced by the considered earthquake all over its territory, computed according to the criteria defined by the macroseismic scale in use. In this work the assumption of homogeneity of data sources between Sisfrance and the cross-border

agency is made for a given location. Indeed, we did not perform any historical sources analysis to verify whether the intensity assignments from SisFrance and from the respective cross-border agency are based on the same information sources.

Concerning the coherence analysis between SisFrance and the BCSF intensity assignments within the French territory, six recent significant earthquakes have been selected (figure 3), each of them disposing of at least 100 observations from both databases :

- three earthquakes occurred before 2000 (both databases use the MSK scale) : St. Béat, 1999, Annecy, 1996, Perpignan, 1996 (right panel),
- three earthquakes occurred after 2000 (BCSF database uses EMS-98 scale) Bigorre (Eastern Pyrenees), 2006, Roulans (Jura region), 2004 and Rambervilliers, 2003 (left panel).

The characteristics of these 6 earthquakes are summarized in table 3. The location of the duplicated intensity assignments is illustrated in figure 3. More than 4000 duplicates have been identified in total for the three post-2000 earthquakes, while 1500 duplicates have been identified in total for the three pre-2000 earthquakes.

All the comparisons are performed for felt intensities, i.e. $I_{obs} > II$.

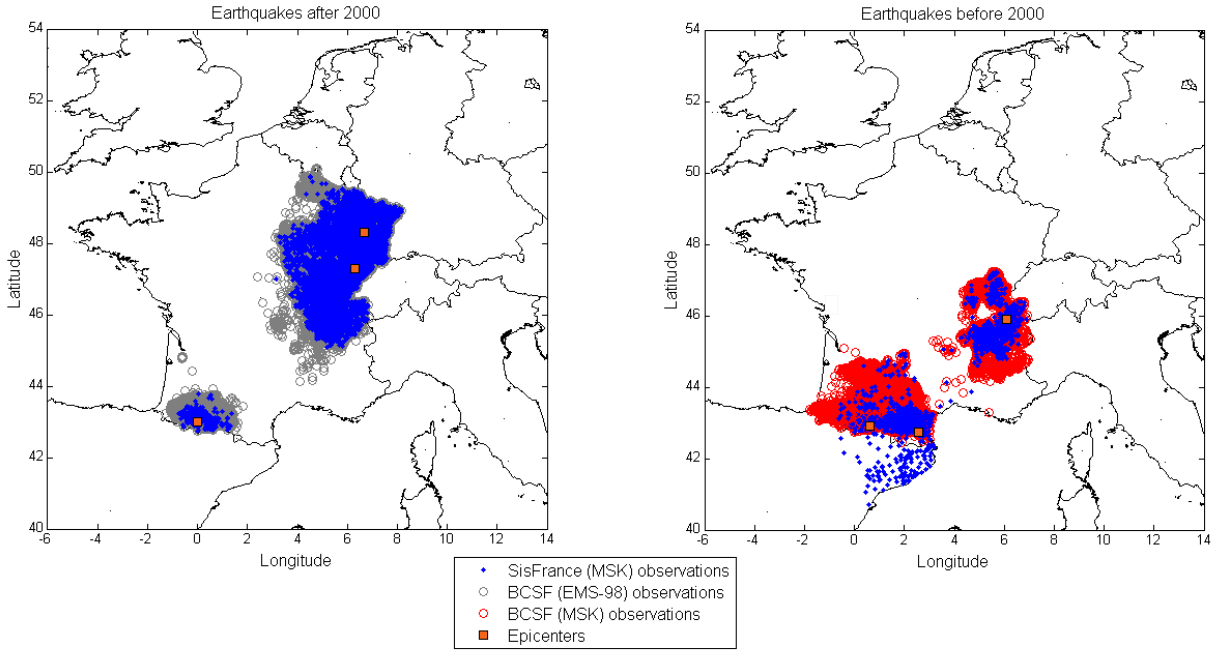


Figure 3. Sisfrance – BCSF macroseismic coherence analysis : location of the 6 selected earthquakes (orange squares) and of the associated intensity data points. Left-panel : three post-2000 earthquakes, blue dots : SisFrance intensity assignments (MSK), grey circles : BCSF intensity assignments (EMS-98).Right panel: three post-2000 earthquakes, blue dots : SisFrance intensity assignments (MSK), red circles : BCSF intensity assignments (MSK).

Table 2. Summary of the 22 earthquakes selected for the macroseismic intensity scale comparison between SisFrance and the respective cross-border seismic agency..

Earthquakes	**Date**	**Epicenter location** *SisFrance*	**Cross border agency**	**Macroseismic intensity scale** *Cross-border agency*	**Epicentral Intensity**	
					Cross-border agency	*SisFrance (MSK)*
Douvres	06/04/1580	51°N 2°E	BGS (UK)	EMS-98	VII-VIII[§]	VIII
Colchester	22/04/1884	52°N 1°E	BGS (UK)	EMS-98	VIII[§]	VIII
Cambresis	02/09/1896	50°N 3°E	ORB (Belgium)	EMS-98	VII[»]	VI
Renaix	11/06/1938	51°N 4°E	ORB (Belgium)	EMS-98	VII[»]	VII
Visp	25/07/1855	46°N 8°E	SED - ECOS (Switzerland)	EMS-98	VIII[‡]	IX
Jura Suisse Solothurn	12/05/2005	47.3°N 7.7°E	SED – ECOS (Switzerland)	EMS-98	IV[‡]	IV
Vallorcine	08/09/2005	46°N 6.9°E	SED (Switzerland)	EMS-98	V[‡]	V
Camprodon - Catalogne	02/02/1428	42.2°N 2.28°E	IGN (Spain)	EMS-98	IX-X[i]	IX
Navarre (Berdun)	10/07/1923	42.5°N 0.8°W	IGN (Spain)	EMS-98	VIII[i]	VIII
Val d'Aran (Viella)	19/11/1923	42.68°N 0.83°E	IGN (Spain)	EMS-98	VIII[i]	VIII
Bigorre	31/01/1950	43.12°N 0.2°E	IGN (Spain)	EMS-98	VII[i]	VII
Bearn	22/02/1924	42.9°N 0.2°W	IGN (Spain)	EMS-98	VIII[i]	VII
Bigorre	25/11/1958	42.9°N 0.4°E	IGN (Spain)	EMS-98	VII[i]	VII
Bearn - Arette	13/08/1967	43°N 0.7°W	IGN (Spain)	EMS-98	VIII[i]	VIII
Ossau (Arudy)	29/02/1980	43°N 0.2°W	IGN (Spain)	EMS-98	VII[i]	VIII
St Jean le Vieux (Pays Basque)	06/01/1982	43°N 1°W	IGN (Spain)	EMS-98	VI[i]	VII
Haut-Comminges (Cierp)	04/10/1999	42.8°N 0.6°E	IGN (Spain)	EMS-98	V[i]	VI
Lavedan	16/05/2002	42.9°N 0.1°W	IGN (Spain)	EMS-98	VI[i]	VI
Bigorre	17/11/2006	42.9°N 0.04°E	IGN (Spain)	EMS-98	V[i]	VI
Torre Pellice - Piedmont	02/04/1808	44.8°N 7°E	INGV (Italy)	MCS	VIII[♯]	VIII
Riviera di Ponente	23/02/1887	43,7°N 7.9°E	INGV (Italy)	MCS	X[♯]	IX
Sacra di San Michele - Piedmont	26/10/1914	45°N 7°E	INGV (Italy)	MCS	VII[♯]	VII

Epicentral intensity values from cross-border agencies are extracted from, respectively:
[§]BGS, UK : http://www.earthquakes.bgs.ac.uk/historical/index.html (last visited : March, 2014);
[»]ORB, Belgium: http://seismologie.be/index.php?LANG=EN&CNT=BE&LEVEL=0 (last visited : March, 2014)
[‡]SED-ECOS, Switzerland: http://www.seismo.ethz.ch/prod/catalog/index_IT (last visited : March, 2014);
[i]IGN, Spain : http://www.01.ign.es/ign/layoutIn/sismoFormularioCatalogo.do (last visited : March, 2014);
[♯]INGV, Italy : http://emidius.mi.ingv.it/DBMI11/ (last visited : March, 2014);

Table 3. Summary of the 6 earthquakes selected for the macroseismic intensity scale comparison between SisFrance and BCSF. Epicentral intensity values from cross-border agencies are extracted from http://www.franceseisme.fr/donnees/intensites.php (last visited : March, 2014).

Earthquakes	**Date**	**Epicenter location** *SisFrance*	**Macroseismic intensity scale** *Cross-border agency*	**Epicentral Intensity** *BCSF*	*SisFrance (MSK)*
St. Béat	04/10/1999	42.93°N 0.6°E	MSK	VI	VI
Annecy	15/07/1996	45.9°N 6.08°E	MSK	VII-VIII	VII
Perpignan	18/02/1996	42.73°N 2.56°E	MSK	VI	VI
Bigorre	17/11/2006	43.08°N 0.01°E	EMS-98	VI	VI
Roulans (Jura)	23/02/2004	47.30°N 6.28°E	EMS-98	V	V-VI
Rambervilliers	22/02/2003	48.37°N 6.64°E	EMS-98	VI	VI-VII

Results

The comparisons between MSK and the other intensity scales from either, the cross-border agencies, or the BCSF are presented in figures 4 and 5. The comparison is made agency-by-agency for each macroseismic intensity scale. All the duplicates available from SisFrance and from a given cross-border agency are thus compared to each other for the whole set of earthquakes considered for the given country (table 2). The number of duplicates as function of intensity considered in the comparison is represented by the color scale on the left-hand grid of figures 4 and 5. An intensity bin width of 0.5 has been used, which can be considered as the uncertainty associated to a given intensity assignment [Musson et al., 2010]. The average (weighted as function of the number of considered duplicates and rounded to the nearest half-point of intensity) and the standard deviation of all duplicates of the considered macroseismic scale are then computed and represented as function of MSK assignments (right-hand plot). This way of representing the results allows to take into account both, the uncertainty associated to the assignment of intensity values, as well as the total variability of intensity value estimates (the standard deviation around the average value is represented by the error bar on right-hand graphs). As shown by figure 4.a to 4.e, in spite of some discrepancies in the formal definition of the MSK and the EMS-98 macroseismic scales, the SisFrance MSK assignments are globally in good agreement with the corresponding EMS-98 estimates up to the higher levels of observed intensity (VIII-IX). The best coherence is found for IGN (Spain) and ORB (Belgium) datasets (figures 4.a and 4.d). Slight departures from the identity line, observed for the BGS (UK) dataset, lie within the variability associated to EMS-98 assignments (figure 4.b). The very small number of duplicates available for the comparison between SisFrance (MSK) and SED dataset (EMS-98) results in a sparse result (figure 4.c). The comparison between SisFrance (MSK) and INGV (MCS) intensity assignments shows a good coherence up to intensity VI-VII MSK. A departure from the identity line is observed for larger intensities. However this departure lies within the variability associated to MCS assignments up to intensity VIII.

The comparison between the SisFrance intensity assignments and the BCSF (that used the MSK scale before the year 2000 and have been using the EMS-98 scale after 2000) is shown in figure 5. The Sisfrance (MSK) vs BCSF (MSK) comparison is performed on three pre-2000 earthquakes (table 3), while the Sisfrance (MSK) vs BCSF (EMS-98) comparison is performed on three post-2000 earthquakes (table 3). Surprisingly, differences between SisFrance and BCSF assignments within the MSK scale tend to overstep differences between SisFrance (MSK) and BCSF (EMS-98), figure 5. Indeed, the BCSF (MSK) assignments tend to be systematically larger than SisFrance MSK assignments (figure 5, upper panel).

These results suggest that one can safely integrate Sisfrance with cross-border macroseismic intensity data when the cross-border agency uses the EMS-98 scale for moderate intensity earthquakes. Careful care is however recommended when considering larger intensity earthquakes. In this case we recommend to perform a specific duplicate comparison analysis in order to verify the coherence between the two macroseismic datasets.

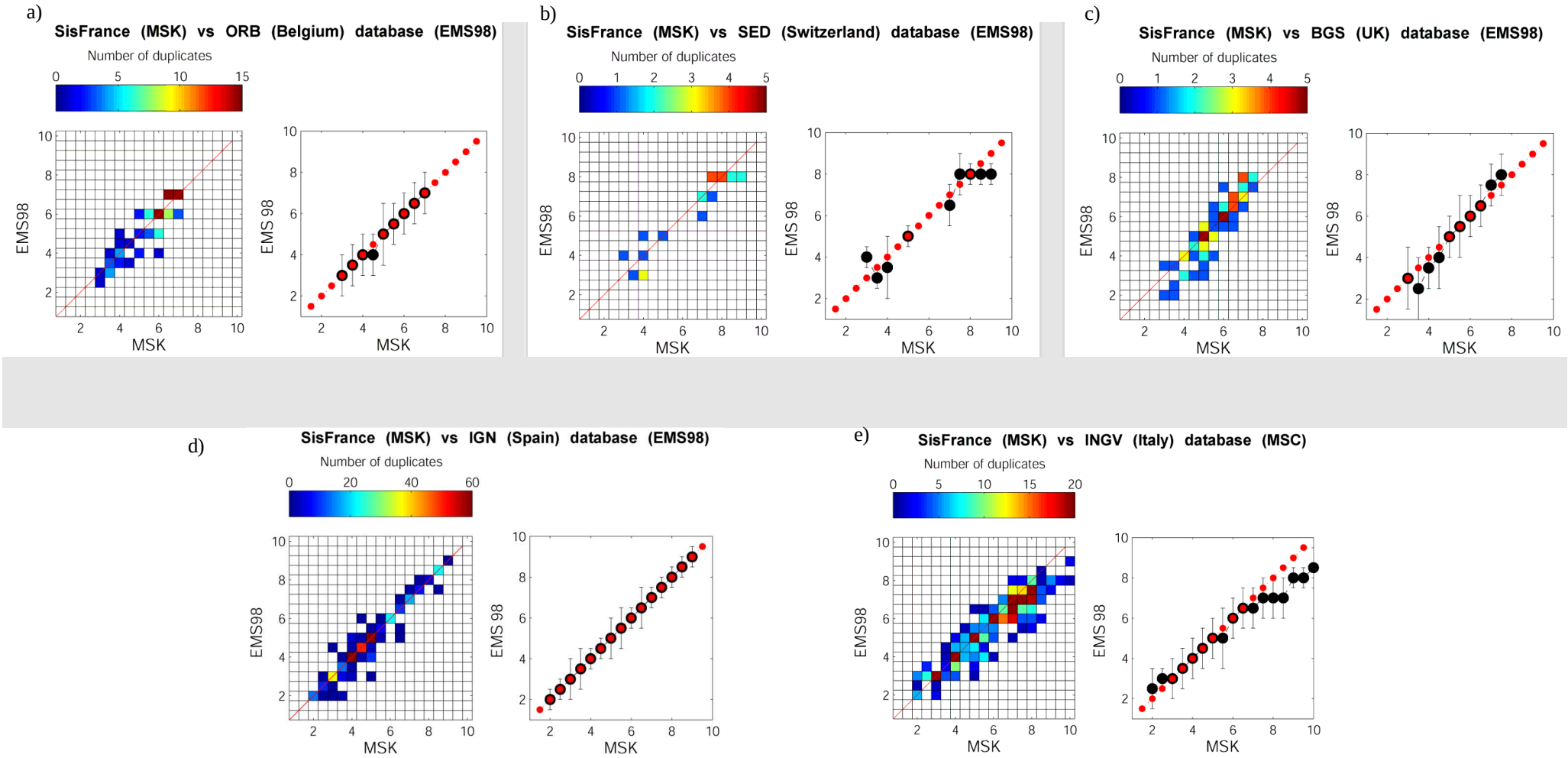


Figure 4. Comparison of intensity assignments from SisFrance (MSK) and all cross-country databases: a) ORB (Belgium) database (EMS98); b) SED (Switzerland) database (EMS98); c) BGS (United-Kingdom) database (EMS98); d) IGN (Spain) database (EMS98) and e) INGV (Italy) database (MSC). Left-hand plots : inventory of all intensity assignments from duplicates as function of the corresponding SisFrance intensity value; the color scale indicates the number of duplicates available for each MSK value. Right-hand plots : mean and standard deviation of MCS assignments from duplicates as function of MSK.

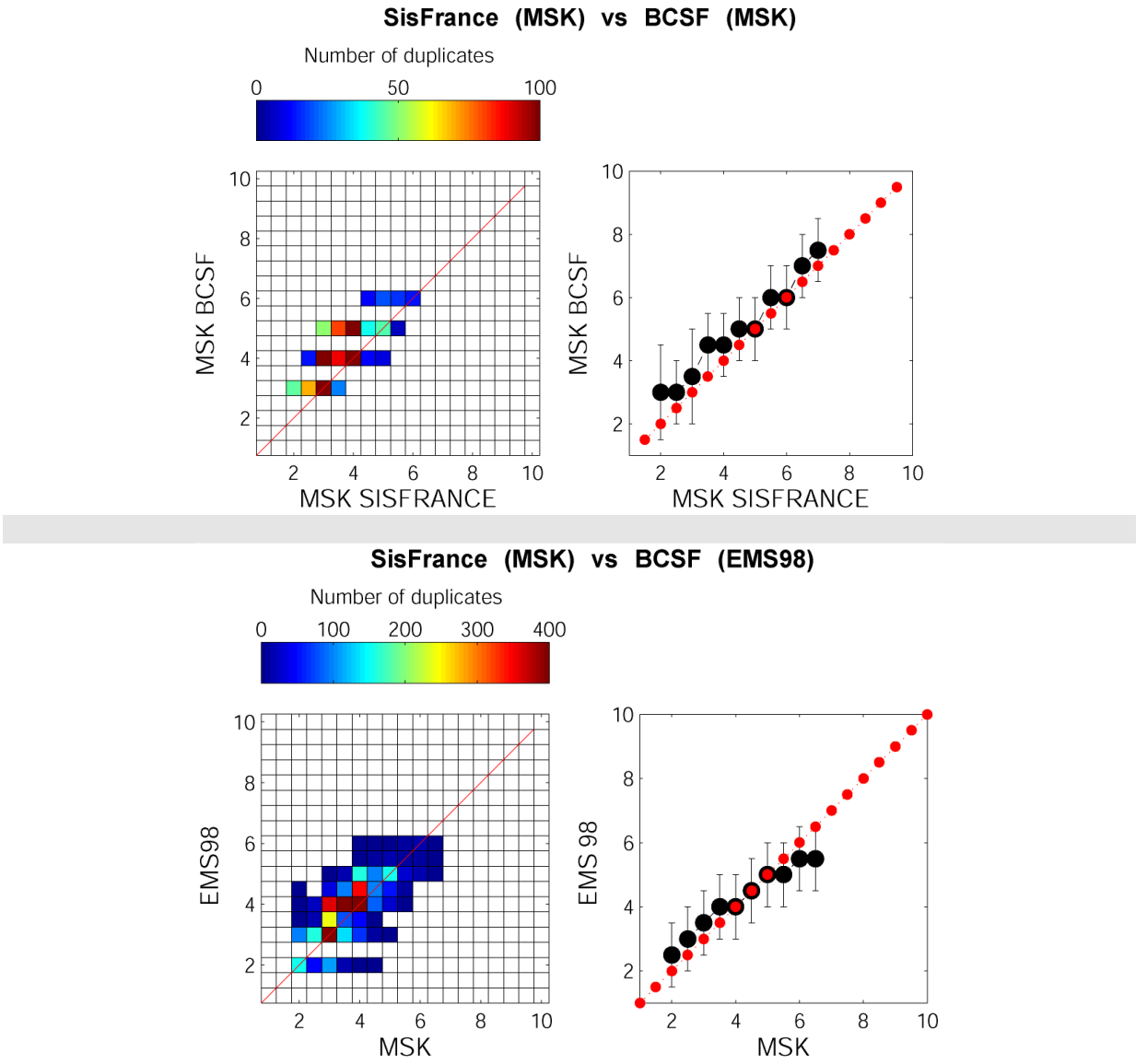


Figure 5 Comparison of intensity assignments from SisFrance and the BCSF. Upper panel : comparison SisFrance-MSK vs BCSF-EMS-98 performed on three post-2000 earthquakes. Lower panel: comparison SisFrance-MSK vs BCSF-MSK performed on three pre-2000 earthquakes. In both panels: left-hand plots are inventory of all intensity assignments from duplicates as function of the corresponding SisFrance intensity value; the color scale indicates the number of duplicates available for each MSK value; right-hand plots represent the mean and the standard deviation of MCS assignments from duplicates as function of MSK.

INTEGRATION OF CROSS-BORDER MACROSEISMIC DATA TO IMPROVE LOCATION AND MAGNITUDE ESTIMATION OF CLOSE-to-THE BORDER EARTHQUAKES

Following the previous results, we integrate the SisFrance macroseismic data of the Vallorcine earthquake, occurred on September 8th, 2005 at the border between France and Switzerland. Figure 6 shows the location of the earthquake epicenter provided by SED from instrumental records analysis, as well as the location of SisFrance and SED intensity data points. The integration of SisFrance with SED data allows to improve the azimutal coverage of intensity observations. To fill completely the azimuthal gap we would need to integrate possible Italian observations, which are not available to us at moment of the writing.

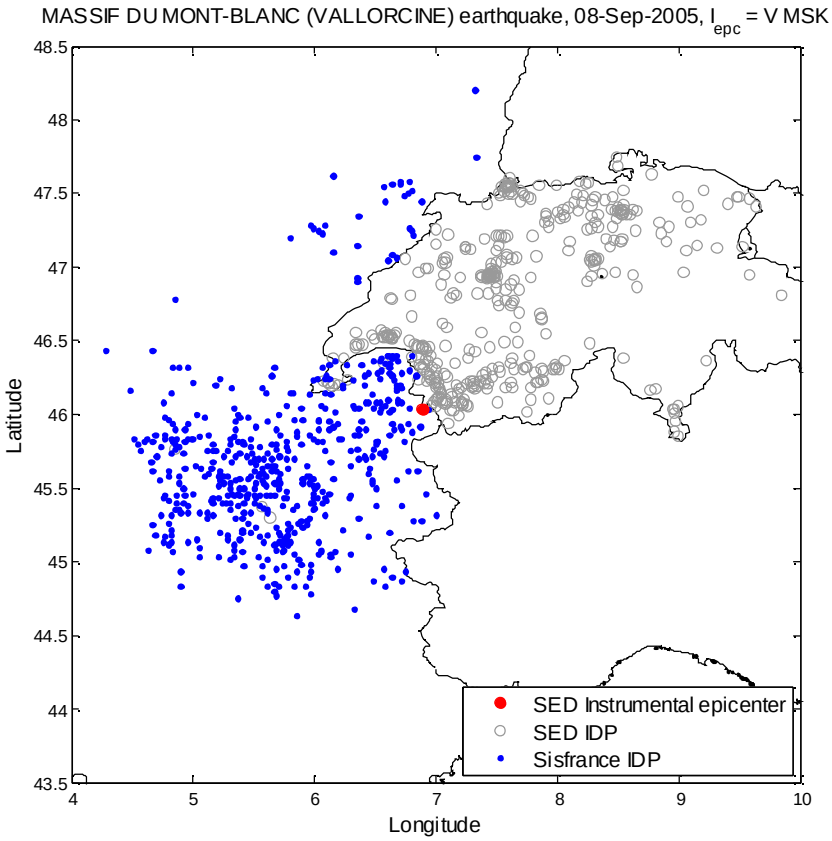
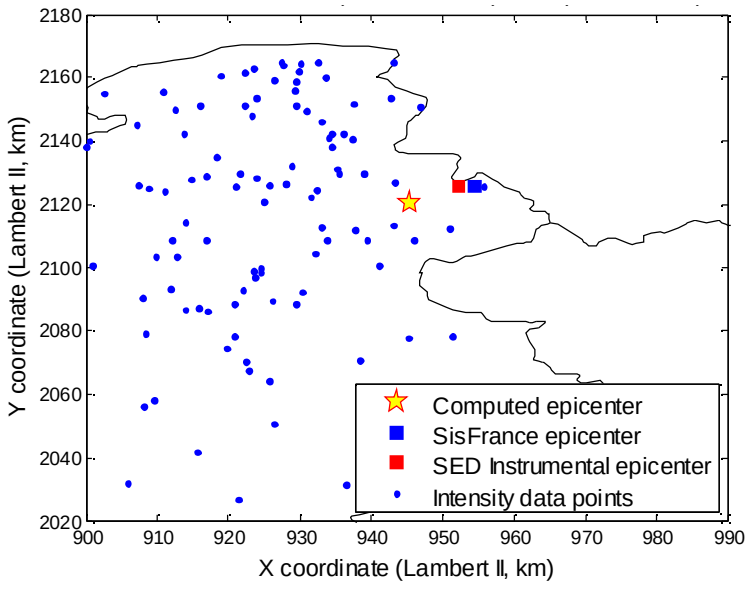


Figure 6 Location map of Vallorcine, 2005 earthquake epicenter, red circle; SisFrance intensity observations : blue dots; SED intensity observations: grey dots.

Figure 7 shows the comparison of the earthquake locations obtained with (lower plot) and without (upper plot) integrating the Swiss IDPs. To estimate the epicenter location and the macroseismic magnitude (M_I) we used the Bakun and Wentworth (1997) methodology over a grid of trail epicenter locations. We used an attenuation model of intensity as function of magnitude and slant distance specifically derived for the alpine region (Traversa et al., in prep.). The integration of Swiss macroseismic data allows to counterweight the geographic bias introduced by the exclusive use of SisFrance macroseismic data, allowing for significant improvements of both, the epicenter location and the macroseismic magnitude estimate. The magnitude provided by the SED for this earthquake is Mw = 4.4. The magnitude corresponding to the Intensity Center (i.e. the trial source location where rms[M_I] is minimum following Bakun & Wentworth (1997) work), passes from 4.06 when only SisFrance data is used, to 4.39 when the SED data is integrated.



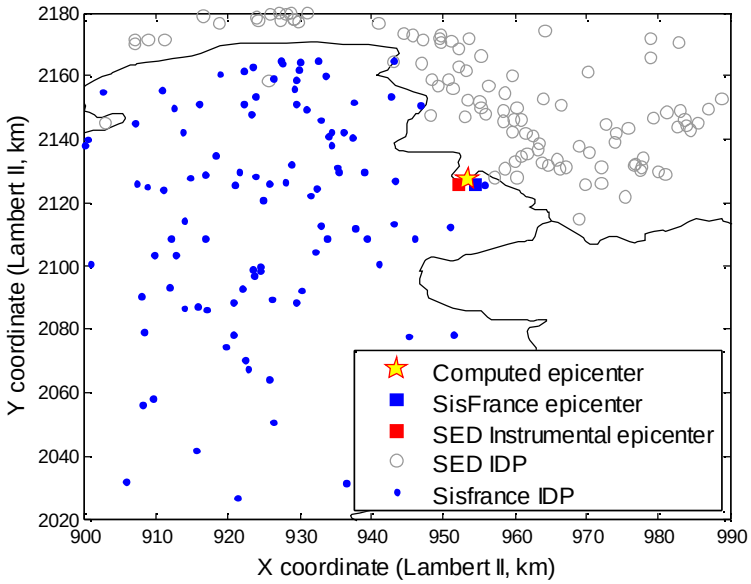


Figure 7. Comparison between earthquake epicenter location from macroseismic data (yellow star) using SisFrance data only (upper panel), and integrated SisFrance plus SED data (lower panel). Blue square : epicentral location provided by SisFrance from manual isoseimal drawing; red square : instrumental epicentral location provided by SED (http://hitseddb.ethz.ch:8080/ecos09/detail.html?id=30331298.00000&map-bbox=46000018912.857142857138820003510 87.14285714284&page=1&tremors=earthquake&time_start=2005/09/0800:00:00&time_end=2005/09/0823:00:00&mw_min=4.0&mw_max=5.0&mw_null=false&io_null=false&no_coord=false)

CONCLUSIONS

Metropolitan France being a low-to-moderate seismicity country, the use of historical earthquake information is essential when performing seismic hazard assessment. Since over the history, most significant earthquakes have occurred close to the borders where tectonic activity focuses, the estimation accuracy of the seismological parameters (location and magnitude) for these past earthquakes would highly benefit from the integration of cross-border data into SisFrance, the reference macroseismic database for France.
Indeed SisFrance mostly include macroseismic data from French localities, which results in an inhomogeneous geographical distribution of the macroseismic data for close-border earthquakes.

The aim of this work is to perform an analysis of the coherence between different intensity scale assignments from SisFrance and from either, neighbouring countries databases, or the BCSF (Bureau Central Sismologique Français), the agency in charge of collecting and disseminating seismological observations in France. This coherence analysis is performed on duplicates, i.e. intensity assignments inventoried by both, SisFrance and the considered dataset for the same locations.
The results show that, in spite of some discrepancies in the formal definition of the MSK and the EMS-98 macroseismic scales, the SisFrance MSK assignments are globally in good agreement with the corresponding EMS-98 estimates up to the higher levels of observed intensity (VIII-IX). The best coherence is found for IGN (Spain) and ORB (Belgium) datasets, while slight discrepancies are observed for the BGS (UK) dataset, which however lie within the variability associated to EMS-98 assignments. The very small number of duplicates available for the comparison between SisFrance (MSK) and SED dataset (EMS-98) results in a sparse result. The comparison between SisFrance (MSK) and INGV (MCS) intensity assignments shows a good coherence up to intensity VI-VII MSK. A slight discrepancy is observed for larger intensities, which lie however within the variability associated to MCS assignments up to intensity VIII.
Surprisingly, differences between SisFrance and BCSF assignments within the MSK scale tend to overstep differences between SisFrance (MSK) and BCSF (EMS-98).

These results confirm the conclusion rose by Musson et al. (2010) : “differences in practice between seismologists tend to outweigh differences between scales”.
They also suggest that one can safely integrate Sisfrance with cross-border macroseismic intensity data when the considered cross-border agency uses the EMS-98 scale for moderate intensity earthquakes. Careful care is

however recommended when considering larger intensity earthquakes. In this case we recommend to perform a specific duplicate comparison analysis in order to verify the coherence between the two macroseismic datasets.

Following these results, the IDPs inventoried by SED-ECOS for the 2005, Vallorcine earthquake have been integrated to SisFrance data. Estimation of seismological parameters (location and magnitude) for this earthquakes, with and without integrating SED data is performed using the Bakun and Wentworth (1997) methodology. Results show that the integration of cross-border IDPs results in an improved accuracy on both, location and magnitude estimates for this earthquake.

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