Zeitschrift: Eclogae Geologicae Helvetiae
Herausgeber: Schweizerische Geologische Gesellschaft
Band: 96 (2003)
Heft: 2

Artikel: Earthquake Catalogue of Switzerland (ECOS) and the related macroseismic database

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DOI: https://doi.org/10.5169/seals-169017

0012-9402/03/020219-18
DOI 10.1007/s00015-003-1087-0
Birkhäuser Verlag, Basel, 2003

Eclogae geol. Helv. 96 (2003) 219–236

Earthquake Catalogue Of Switzerland (ECOS) and the related macroseismic database

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Key words: Earthquakes, catalogue, moment magnitude, macroseismic intensity, Switzerland

ABSTRACT

The Swiss historical earthquake catalogue and the macroseismic database have not been significantly improved since 1978. We therefore revised the catalogue and concluded this work in 2002. Three levels of investigation were conducted, depending on the size and location of an event: historical, macroseismic and seismological. For the earthquakes of the last 1000 years with Intensity VI or higher, all available historical information was collected and macroseismic fields were established. The source parameters (epicenter, hypocentral depth class, epicentral intensity, maximum intensity, macroseismic magnitude) and their uncertainties were then determined. Earthquakes with epicentral intensity smaller than VI that occurred inside Switzerland have been reviewed for the period since 1878, or when information was found in historical sources. In total, more than 600 events have been reassessed through historical investigations. Of these events, 177 earthquakes reach intensity VI in the new catalogue and therefore caused damage. About 260 events could be identified as fake events or multiple entries for the same event due to different calendar styles, misprints, or misinterpreted compilations. The catalogue provides a uniform estimate of the moment magnitudes Mw for all events. This uniform earthquake size estimate in terms of magnitude required a magnitude/intensity calibration and reassessment of the instrumental magnitude.

Our new earthquake catalogue and the related macroseismic database can be accessed via the Webpage of the Swiss Seismological Service (http://seismo.ethz.ch) The catalogue covers the region included in the Swiss national map at the scale of 1:500'000 (Swiss km-coordinates: 460-880 / 20-310; Geographic coordinates: 5.6-11.1E / 45.3-47.9N).

ZUSAMMENFASSUNG

Der historische Erdbebenkatalog der Schweiz und die Makroseismische Datenbank wurden seit 1978 nicht verbessert. Dies war der Grund für eine Revision, welche im Jahr 2002 abgeschlossen wurde. Die Untersuchung erfolgte in drei Stufen, einer historischen, einer makroseismischen und einer seismologischen Stufe. Die Tiefe der Untersuchung war abhängig von der Grösse und dem Ort des Erdbebens. Für die Erdbeben der letzten 1000 Jahre und mit Intensität VI oder grösser wurden alle historischen Informationen gesammelt und in Form von makroseismischen Feldern ausgewertet. Daraus wurden die Quellenparameter (Epizentrum, Herdtiefenklasse, Epizentralintensität, Makroseismische Magnitude) und deren Unsicherheit bestimmt. Erdbeben mit einer Epizentralintensität kleiner als VI, mit Epizentrum innerhalb der Schweiz, wurden nur für die Zeitperiode seit 1878 revidiert, oder wenn historisches Material zur Verfügung stand. Im gesamten wurden mehr als 600 Ereignisse durch historische Untersuchungen neu beurteilt. Von diesen Ereignissen erreichen 177 Ereignisse die Intensität von VI. Sie haben somit Schäden an Gebäuden verursacht. Ungefähr 260 Ereignisse konnten als falsche Ereignisse oder Duplikate erkannt werden, welche aufgrund von Datumsfehlern, Abschreibfehlern oder durch eine Fehlinterpretation in Kompilationen im alten Katalog erzeugt wurden.

Der neue Katalog gibt für jedes Ereignis eine einheitlich bestimmte Momentenmagnitude an. Eine Voraussetzung dazu war die Überprüfung der instrumentell bestimmten Magnituden und die Erarbeitung einer Kalibriermethode zwischen Magnitude und Intensität.

Unser neuer Erdbebenkatalog und die dazugehörige makroseismische Datenbank sind über die Internetseite des Schweizerischen Erdbebendienstes zugänglich (http://seismo.ethz.ch). Der Katalog deckt das Gebiet der Schweizerkarte im Massstab 1:500'000 ab (Schweizer Koordinaten: 460-880 / 20-310; Geographische Koordinaten: 5.6-11.1E / 45.3-47.9N).

RESUME

Le catalogue de sismicité historique suisse et ses données macrosismiques n'avaient pas été revus depuis 1978. Nous l'avons donc reconsidéré et conclu ce travail en 2002. Selon la taille et la localisation de l'événement, trois niveaux de recherche ont été abordés: historique, macrosismique et sismologique. Pour les séismes d'intensité de VI ou plus de millénaire passé, toutes les informations historiques disponibles furent collectées pour établir les cartes macrosismiques. Les paramètres de base (épicentre, profondeurs hypocentrale, intensité épicentrale, intensité maximale, magnitude macrosismique) et leurs incertitudes ont été déterminées. Pour les séismes d'intensité épicentrale plus faible que VI, ayant eu lieu en Suisse soit depuis 1878, soit pour des dates antérieures, lorsque des sources historiques ont pu être trouvées, ont été réétudiés. Au total, plus de 600 événements ont ainsi été reconsidérés. Parmi ceux-ci, 177 séismes ont atteint l'intensité VI dans le nouveau catalogue et ont occasionné des dommages. Environ 260 événements étaient des faux événements ou des duplications du même événement suite à l'utilisation de calendriers différents ou de compilations mal interprétées.

Le catalogue revisité fournit une estimation uniforme des magnitudes de moment Mw pour tous les événements. L'uniformisation de ce catalogue a nécessité une calibration magnitude/intensité et la réévaluation de la magnitude instrumentale.

Ce nouveau catalogue et la base de données macrosismique associée est accessible depuis la page Web du Service Sismologique Suisse (http://seismo.ethz.ch). Le catalogue couvre toute la région incluse dans la carte de Suisse à l'échelle 1:500'000 (Coordinates Swiss: 460-880 / 20-310; Coordinates Geographic: 5.6-11.1E / 45.3-47.9N).

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Introduction

The Swiss earthquake catalogue available on the Webpage of the Swiss Seismological Service (SED) until the beginning of 2002 consisted of the Macroseismic Earthquake Catalogue Of Switzerland (MECOS) compiled by Sägesser & Mayer-Rosa (1978), with some modifications by Rüttener (1995), and of the Instrumental Earthquake Catalogue of Switzerland (IECOS) with entries since 1975. Before 1975, earthquake parameters were based on macroseismic data. These were obtained from the critical evaluation of the main compilers and of several primary sources for Swiss earthquakes (Basler-Hoffman & SED 1975, 1976, 1977), from printed information included in the yearly reports of the Swiss Seismological Service (Schweizerische Erdbebenkommission 1879–1912, Schweizerischer Erdbebendienst 1913–1963, Schweizerischer Erdbebendienst 1972–1974), and from the earthquake records and data collection of the Swiss Seismological Service, with a few additions from international bulletins. For earthquakes since 1917, the SED had transferred available information into files with intensity points based on the MSK scale, which can be used to map the macroseismic field. Neither isoseismal maps nor hypocentral parameters have been computed from these event files. Unfortunately, for some events the original macroseismic information has been lost, most notably for the 1946 Wallis earthquake, the largest event in Switzerland during the 20th century.

Instrumental recording started in Zurich in 1911. Until 1975, instrumental locations were based on a small number of stations (up to 5) and for larger events were supplemented with data from the Bureau Central International de Sismologie (BCIS) and later the International Seismological Centre (ISC). Since 1975, earthquakes have been recorded with high precision by the Swiss seismographic network. Mapping of macroseismic fields complements the numerical solutions for events with Io ≥ IV. With the advent of modern digital technology and broadband sensors, the Swiss Seismological Service began to modernize its entire network in 1997, replacing the short-period sensors by three-component STS-2 broad-band instruments. With the increasing number of stations in the national seismic network since 1975, the completeness of the instrumental catalogue gradually approached M_L 1.8 for most regions under consideration. The annual publication of SED reports was resumed in 1996 (Baer et al. 1997, 1999, 2001; Deichmann et al. 1998, 2000, 2002).

The catalogue and macroseismic database available at SED until now had limitations which hindered its application to modern hazard assessment. The limitations can be summarized as follows: (a) the database of site intensity-points existed for only some events after 1917, (b) different intensity scales (Rossi Forel, MS, MSK64, EMS98) were used in the database, (c) there was no complete central archive of compilers or primary sources for Swiss events, (d) little documentation existed on how the historical earthquake parameters in the catalogue were obtained, or about their homogeneity and uncertainties, (e) some significant earthquakes (Io ≥ VIII) had never been studied in detail, and (f) magnitude scales for the historical and instrumental periods had not been equalized.

For these reasons, the SED revised the earthquake catalogue, an undertaking summarized here. A complete description of this revision is given in an internal report of the SED available on our website. The new catalogue is now used to perform probabilistic hazard assessment for Switzerland and probabilistic seismic hazard assessment for Swiss nuclear power plants (PEGASOS – Probabilistische Erdbeben-Gefährdungs-Analyse für die KKW-StandOrte in der Schweiz).

Revision of the earthquake catalogue

Three levels of investigation were conducted, depending on the size and location of an event: they can be classified into historical, macroseismic and seismological investigations. This three-layer structure is also maintained in the ECOS database (Fig. 1).

Historical level. The old MECOS lists 785 events with Intensity VI or higher. From these earthquakes 135 events with intensity VII or higher and 220 events with intensity VI and VI-VII are located in the Western and Central Alpine region. This list has been checked against the Basic European Earthquake Catalogue and Database (BEECD; Camassi et al. 1997; Stucchi et al. 1998) and national catalogues in neighboring countries for inconsistencies, duplicates and false events. The work is summarized in Albini et al. (2000). Existing seismological literature has then been analyzed. We conducted historical investigations in libraries and archives for primary sources such as annals, chronicles written by clergy and laymen, private and official documents, newspapers, journals and so forth. All relevant earthquake reports, studies, catalogues and available macroseismic databases previously assembled in Switzerland and in neighboring countries were evaluated and merged in the database. A homogeneous quality level for the whole database and catalogue has been maintained, revealing an unexpectedly large amount of new information and unpublished results. About 260 events in MECOS could be identified as fake events or multiple entries for the same event due to different calendar styles, misprints, or misinterpreted compilations. Reported epicentral intensities of fake events as high as IX were found.

Macroseismic level. For all earthquakes that produced significant intensity (>V/VI) within Switzerland, we assessed intensities for all Swiss locations and mapped the resulting intensity field. Intensity points for localities outside Switzerland were imported from available compilations.

The term macroseismic intensity or intensity site point is used in the sense of a classification of the severity of ground shaking based on observed effects on human beings, animals, objects, buildings and the environment. It expresses a set of heterogenous information as a single number. For the intensity

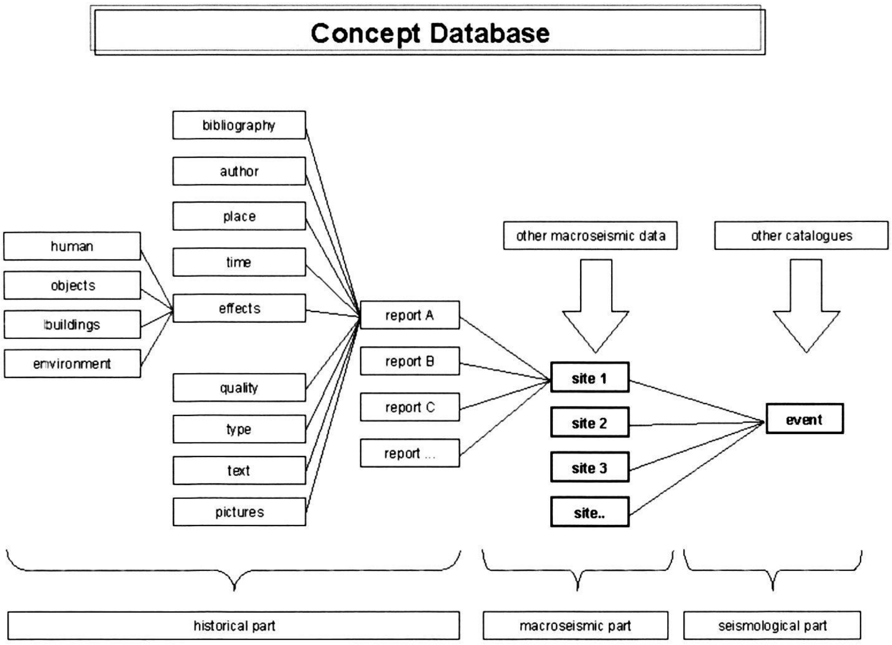


Fig. 1. Structure of the database and levels of investigation.

assignment we adopted the European Macroseismic Scale EMS98 (Grünthal et al. 1998), and points imported from other databases have been transformed into EMS98.

Earthquakes with epicentral intensity smaller than VI that occurred inside Switzerland have been reviewed for the period since 1878, or when information was found in historical sources. In total, more than 600 events have been reassessed by historical and macroseismic methods. Of these events, 177 earthquakes caused damage and are thus assigned an intensity of VI in the ECOS catalogue.

Seismological level. For all earthquakes with a sufficient number and distribution of intensity points, we derived source parameters (epicenter, hypocentral depth class, epicentral intensity, maximum intensity, macroseismic magnitude) and their uncertainties using regression schemes that account for regionalized intensity attenuation and hypocentral depth. To produce a catalogue with a uniform earthquake size estimate in terms of magnitude, the magnitude/intensity calibrations and the instrumental magnitudes computed in recent times have been reassessed through a range of investigations (Braunmiller et al. 2002). These include: analyzing seismograms from key European observatories to derive homogeneous instrumental magnitudes for significant Swiss earthquakes since the beginning of the 20th century; analyzing digital waveforms collected since the late Seventies to compute digital magnitudes and re-calibrate the M_L scale used by SED; rescaling of magnitudes computed since 1975 by the SED to a uniform scale; computing homogeneous regressions between different magnitude scales.

The three levels of investigation will be discussed in detail below.

Historical Level

Revision of the macroseismic earthquake catalogue (MECOS-02)

For all earthquakes located in or outside Switzerland that produced significant effects (Intensity>V/VI) in Switzerland, we conducted a historical investigation covering over 600 events and a time span of 14 centuries. Both the historical catalogues and the so-called compilations have been analyzed. Compilations have a long tradition: even in the annals and chronicles of the Middle Ages we find copies of older manuscripts. Earthquake compilations - among others - were published since the 16th century, such as the works of Lycosthenes (1557), Rasch (1591), Scheuchzer (1706-1718) and Bertrand (1756/1766). One of the most famous examples is Volger's compilation (1857). Copies and interpretations always contain the possibility of errors and often only simulate a broad base of data. Nevertheless, these compilations led us to search libraries and archives for primary sources such as annals, chronicles written by clergy and laymen, private and official documents, newspapers, journals and so forth. Many of the documents needed paleographical, philological preparatory work or translations, because they were hand-written and composed in languages such as Middle High German, Latin, Romance, French and Italian. Besides written documents, earthquake depictions were also found for sites in Switzerland. These depictions are usually purely fictitious or illustrative and in many cases yield no useful seismological information (Fig. 2, top). In other cases the depictions may be reproductions of actual damage (Fig. 2, right).

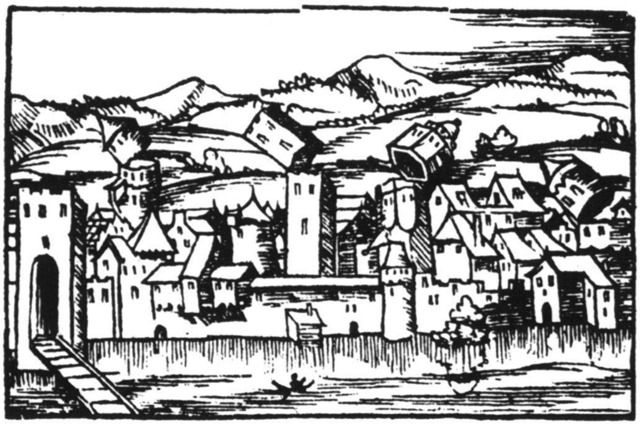


Fig. 2. Top: Woodcut illustration of the effects of the 1356 Basel earthquake taken from Sebastian Münster's Cosmographei [sic] (1550). Right: Depiction of the earthquake in 1506 published in "Schweizer Bilderchronik des Luzerners Diebold Schilling" (1513).

A reliable basis for statements about earthquakes asks for independent contemporary documents. Reliable copies of lost sources can complete these documents. When interpreting historical documents it is important to consider that the texts were written for a particular purpose at that time and not for later historical studies. Authors were influenced by the paradigm prevailing at the time of writing. Aspects of thinking and writing skills have therefore to be considered as well as intention and circumstances of document production. All documents collected during this revision were analysed by using a formalistic procedure, based on historical methods concerning the distance between an event and its description, the document's function, the author's intention in producing the record and the context of the document. The MECOS02-database documents all this information.

The ideal case of several primary sources allows cross-checking. But it was not always possible to find enough primary sources to do so. Since only described damage allows us to define a damaging earthquake, the short descriptions of events so often found in the Middle Ages must be interpreted with great caution.

All information from the different historical sources has been introduced into the database. Thus, earthquake compilations can be compared with contemporary sources to confirm that the basic message is reliable and that dates and places are set correctly. One result of our historical investigations is a new genealogical tree of texts to help us understand the historiographical tradition of an event. One example of such a tree is given in Figure 3 for the earthquake of 20 December 1720 in the Lake of Constance area. Gisler et al. (2003) re-evaluate this event and show that the event size has been overestimated due to a translation error by Bertrand in 1756 which was subsequently copied by different compilers. The epicentral intensity of this event was corrected to intensity VI, rather than intensity VIII in MECOS.

For different time periods, different earthquake information is available, as summarized below.

Early and High Middle Ages

Generally, historical information on earthquakes is very rare. The first truly known event is in 849; an uncertain event in 250 in Augusta Raurica (Augst) and a misinterpreted rockslide of 563 in the Wallis were found. The events in the annals of the Early and High Middle Ages are characterized through very short descriptions as "an earthquake happened on the day of ...", but any indication of intensity is often missing. In 1117, the first description of damage appears. And just at the end of the 13th century certain annals give longer descriptions, as for example in the Annales Colmarienses for the event 1295 (Chur). However, we must remember that annals are primarily compilations.

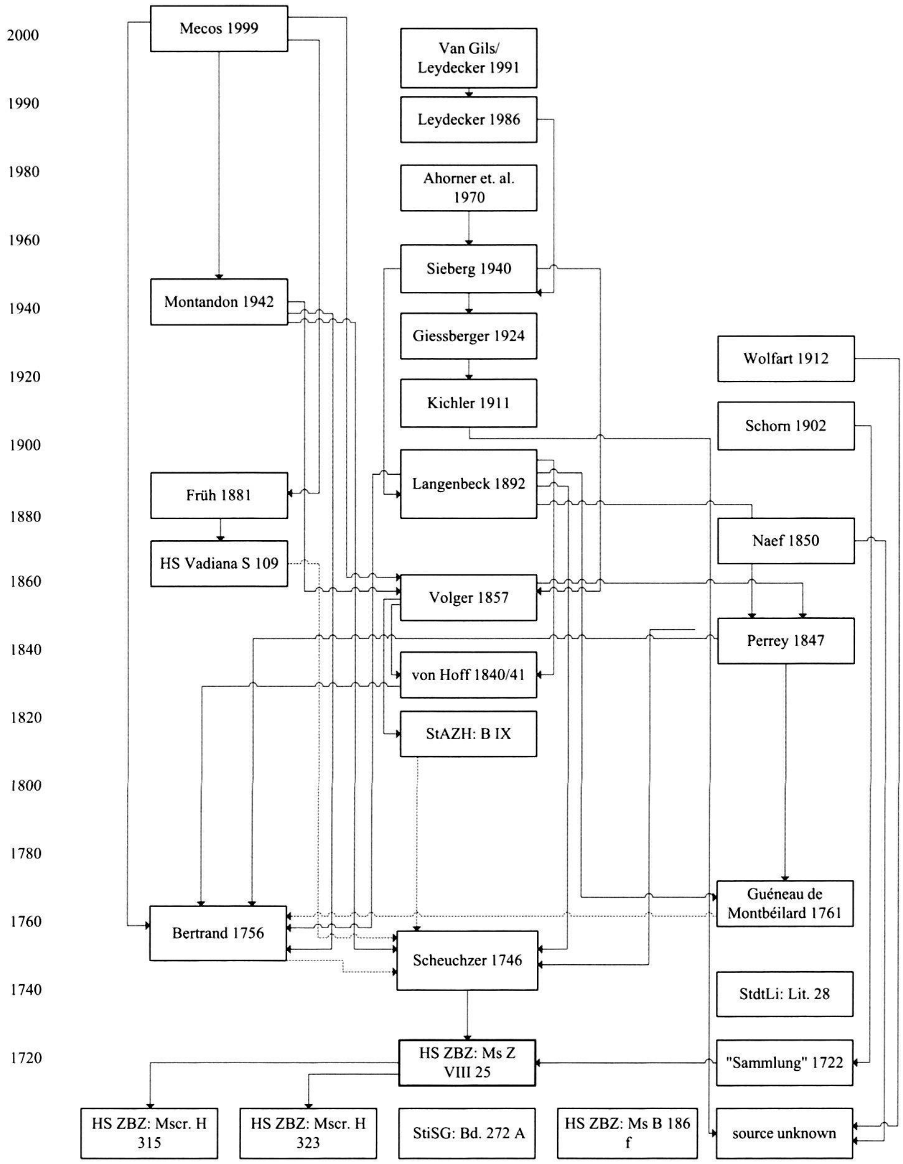


Fig. 3. Genealogical tree of the Dec.20, 1720 earthquake in eastern Switzerland (modified from Gisler et al. (2003)).

Late Middle Ages

In the 14th century the first chronicles of towns appear in Switzerland and their authors recorded descriptions of natural phenomena, having been sensitized through a series of natural disasters in the middle of that century, as in the Villach earthquake of 1348. Thus, the famous event of October 1356 in Basel is described in several chronicles, letters and other documents. In 1399 the oldest known diary with nature observations started in the Basel region. This diary contains weather and astronomical observations as well as two earthquake descriptions. In the middle of the 15th century a gap in the information exists, probably because of the wars during this time.

16th and 17th centuries

The amount of information grows in different kinds of documents like chronicles, diaries, official registers and scientific and religious writings. But even the most interesting events, like those in 1584 (Aigle) and 1601 (Unterwalden), show gaps in the reported places. For example, a destructive earthquake around Sion in 1524, discovered during this project, is reported by only one witness.

18th century

In the first half of the 18th century scientific interest in Switzerland increased. We find a number of hand-written documents

Tab. 1. Completeness of observed intensities for different regions in Switzerland for given time periods. n: no primary sources found; u: completeness unknown. The Swiss regions are illustrated in Figure 4.

Completeness	Swiss regions							
Time span	1 (InnerCH)	2 (ZH/SG)	3 (BE/WestCH)	4 (Basel)	5 (Wallis)	6 (Tessin)	7 (GR)	8 (GL)
563-799	n	n	n	n	u	n	n	n
800-899	u	u	n	n	n	n	n	n
900-999	n	u	n	n	n	n	n	n
1000-1099	n	u	n	n	n	n	n	n
1100-1199	n	VII	n	n	n	n	n	n
1200-1299	n	n	n	u	n	n	VIII	n
1300-1399	n	n	u	VIII	n	n	n	n
1400-1499	n	VII	n	VII	n	n	n	n
1500-1599	u	VII	VII	u	VIII	VIII	u	u
1600-1679	VIII	VII	n	VIII	n	VIII	n	n
1680-1730	VII	V	VII	VI	VIII	VIII	VII	VI
1730-1750	VII	VI	VII	VI	VIII	VIII	VII	V
1751-1800	VI	VI	VI	VI	VII	VII	VI	V
1801-1850	VI	V	VI	VI	VII	VI	VI	VI
1851-1878	VI	V	VI	VI	VI	VI	VI	VI
1878-1963	V	V	V	V	V	V	V	V
1964-1974	IV	IV	IV	IV	IV	IV	IV	IV

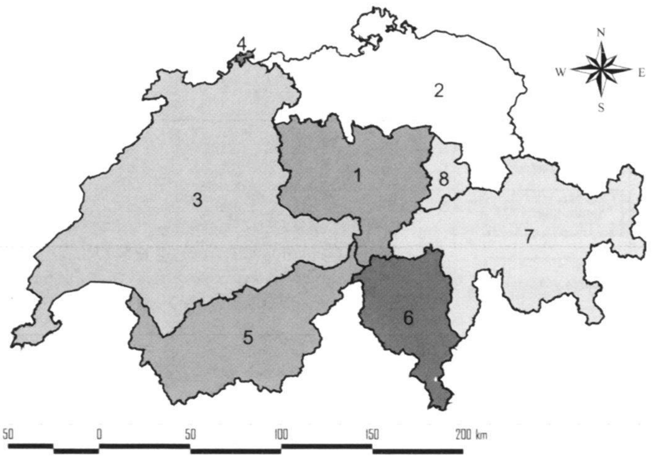


Fig. 4. Geographical distribution of catalogue completeness, according to Table 1.

on several natural phenomena, including earthquakes. Particular attention was paid to the 1755 earthquake in the Valais because of the Lisbon earthquake a month before. By the second half of the century, scientists were not that interested in earthquakes anymore, so we had to focus on private documents such as journals, letters and so forth.

19th century

In the 19th century the production of newspapers increased enormously. Therefore, most information on earthquakes has been taken out of newspapers, in conjunction with scientific papers like those produced by the "Naturforschende Gesellschaft" (established in 1746). For the 1855 earthquake in the Valais, Volger's investigation has been analyzed among many other documents.

20th century

For the 20th century, different types of documents have been consulted: newspapers, the yearly reports of the Swiss Earthquake Commission (established in 1879) and the earthquake record cards of the SED. Existing macroseismic data were completely reviewed.

Completeness of the catalogue

The documents and earthquake records available for the investigated time period (250-2000) are very heterogeneous both in time and space. An overview of the completeness of observed intensities is provided in Table 1 and Figure 4 for the period before 1975, when the Swiss Seismological Service started to operate the network.

The practice of written records changed often over the centuries. Nevertheless, the growth of written documents is obvi-

Tab. 2. Examples of fake events that have been corrected in ECOS.

year	month	day	hour	lat	lon	Io	ax	comment	error type
1905	12	10		45.9	10.3	7	Breno/I	No primary sources or literature found for this entry	Compilation error
1771	7	30					Wattwil	Duplication due to dating error	Dating error
1650	9	7				7		Duplication of an event with Io=6 (21.9.1650)	Dating error
1650	9	10				6-7		Duplication of an event with Io=6 (21.9.1650)	Dating error
1650	9	11				6		Duplication of an event with Io=6 (21.9.1650)	Dating error
1618	8	25		46.3	9.5	7	Chiavenna/I	Rockslide in Plurs due to mining activities and heavy rainfall as well as error in the dating	No earthquake, dating error
1531	1	26		47.6	7.6	8	Basel	Confusion with the event in Lisbon, 1531 or 1532	Interpretation error
1513	2	10		46.2	9.0	9	Bellinzona	Rockslide and error in date (1513-09-30)	No earthquake, dating error
1512				46.4	9.0	7	Biasca,Val Blenio/TI	Rockslide and error in date (1513-09-30)	No earthquake, dating error
1394	3	22		46.3	8.0	8	Brig/VS	Damage in Brig is a wrong interpretation of Montandon (1940)	Interpretation error
1170	6	29				7-8	Admont, Steiermark (A)	Confusion in the Annales Admontenses of "Styria" (Steiermark) with "Syria" (Syrien). This event belongs to Syria	Error in the location
1152							Neuchâtel	This event doesn't belong to Neuchatel/CH; but probably to Monte Cassino (near Rome)/I, because of mistranslation of the expression "Welschland"	Error in the location
1021	5	12	9	47.5	7.6	9	Basel/BS	Event located in Bavaria, but damage-reports from Basel due to confusion with war damages from the Hungarian Invasion around 917	Interpretation error

ous and the results of our investigation are very much influenced by this fact. Therefore, a catalogue entry might be based on 3 (sometimes even less) or several hundred intensity data points.

The completeness of events over the centuries is not linear. For a particular chronicler, the political situation, for example, may have been much more important than an earthquake (i. e. the French and Swiss revolution at the end of the 18th century). On the other hand, there were time periods when science bloomed, e.g. 1510-1525 or 1680-1750, and scientists were very much interested in natural phenomena such as earthquakes. For such periods, they left behind a bundle of scientific papers. But by the second half of the 18th century, earthquakes were not in focus and were recorded only rarely. However, it can be assumed that all of the extreme events have been recorded in the last millennium (e.g. the large earthquake in 1117 close to Verona, Italy).

In the course of the Early and High Middle Ages, earthquakes reported by eyewitnesses are found only in the few annals of monasteries in northeast Switzerland. In the 12th and 13th century, scientific knowledge and interest increased, and the first two earthquakes with damage descriptions appear. For this time span, all the printed sources have been evaluated. For the period until 1259, Alexandre's (1990, 1994) investigations of the printed primary sources of Central Europe are introduced into MECOS-02. We believe that the most prominent events of this time period have been recognized.

In the 14th and 15th century the 1356 event terrified the population and increased sensitivity of the observers in the towns, mainly Basel. During this time education improved and paper mills and printing were invented, which increased the number of reported damaging events. But events with intensity VII and higher are not complete due to gaps in the chronicles of the middle 15th century. During the 16th and 17th centuries the amount of information grew, except for the mountain areas (Graubünden, Central Switzerland, Tessin and Wallis).

Finally, not all archives in Switzerland handle documents with the same care. In some archives the access to and investigation of new documents is very difficult for various reasons. There are some regions where one would expect a large number of events, as for example in the Valais. Due to difficulties in accessing their archives and investigated documents, we found only few events for the early period of the catalogue. Other archives such as the Staatsarchiv Zug have around 40'000 of the "Ratsprotokolle 1552-1798" accessible in a database as a summary.

Calendar and locality problems, with resulting fake earthquakes

During the Middle Ages and early modern times, several calendars existed in parallel, generating dating problems for us. During the Middle Ages three systems existed: Roman dating with "calendae", "nones" and "ides", dating with name days, and the counting of every day in a month. Between the 4th and the 15th of October 1582 Pope Gregor corrected the difference between the astronomical year and the Julian calendar. This new system is named "the Gregorian" style or calendar. Officially, the first Catholic cantons in Switzerland

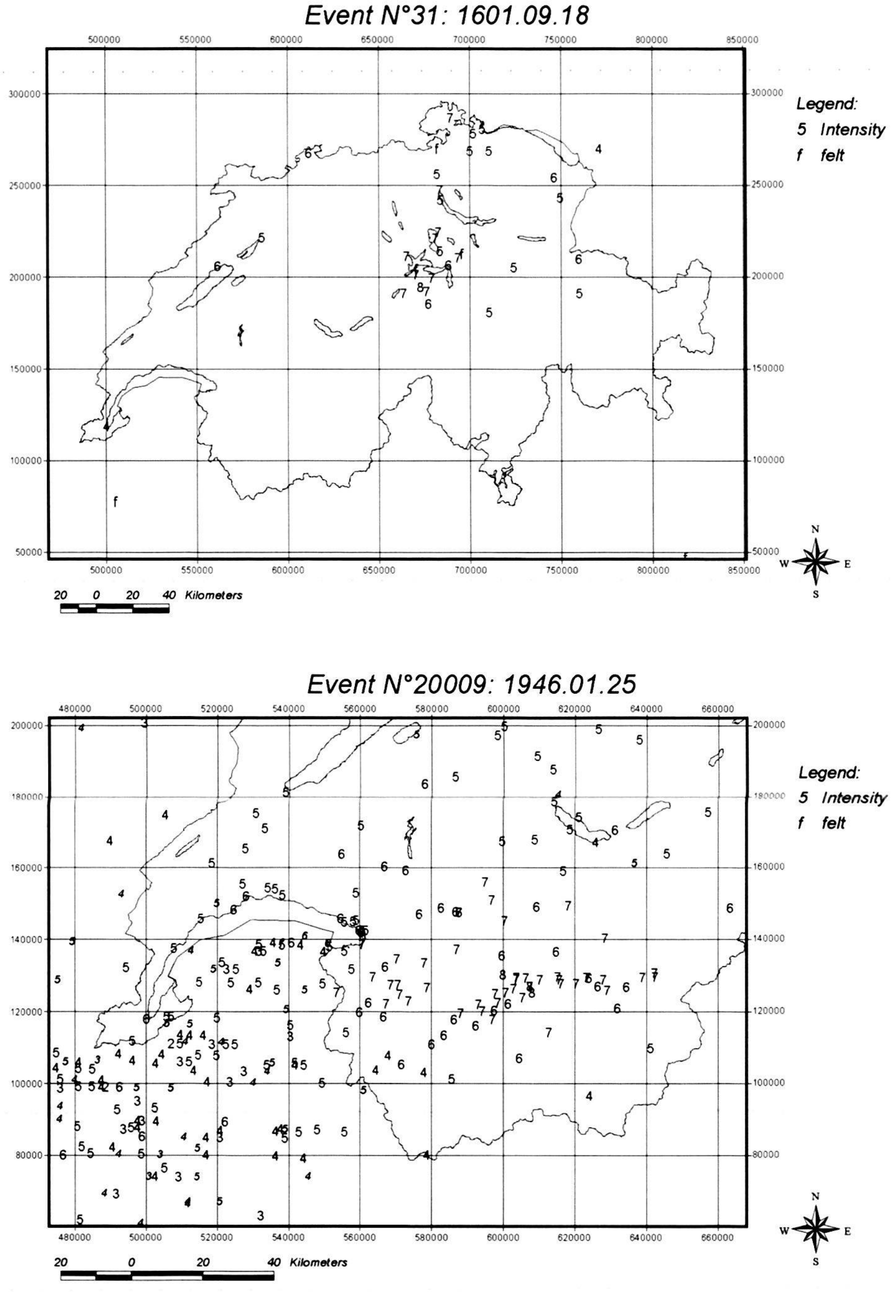


Fig. 5. Macroseismic field of the 1601 and 1946 earthquakes.

Tab. 3. Number of events for the different time perioids.

Year	Io<V	Io=V	Io=VI	Io=VII	Io=VIII	Io=IX	(Mw≥2.5)
-1877	**481**	**311**	**71**	**33**	**7**	**2**	**-**
1878-1963	**1223**	**267**	**75**	**18**	**5**	-	-
1964-1974		**37**	**6**	**6**	-	-	**316**
1975-2001		**47**	**9**	**-**	**-**		**674**

changed to the Gregorian calendar in January 1584. Canton Unterwalden followed in 1587 and the Wallis region in 1655. Several Protestant cantons changed in January 1701, others in 1724 and canton Graubünden followed between 1760 and 1812. However, since the private and official uses of the calendar style were often different, there were many event duplications in this period. Therefore, researchers today need to know the weekday or at least the region of the observation to identify the style. The last Julian dated event in the old MECOS catalogue occurred in 1796, but heterogeneity in calendar style can be observed even up to the 19th century. In the ECOS catalogue, all dates after 1584 have been converted to Gregorian style.

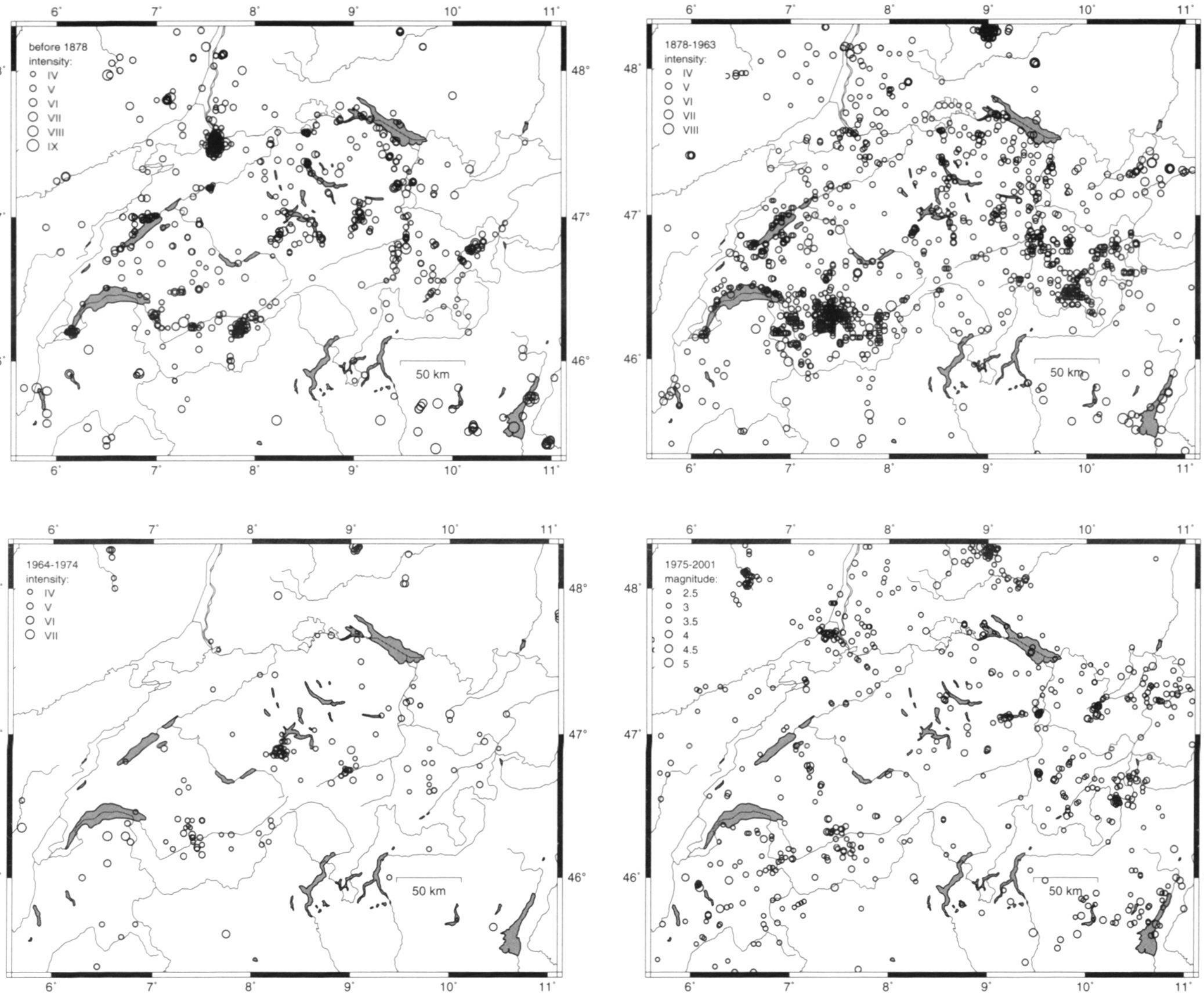


Fig. 6. Events in the new catalogue for the time periods a) before 1878, b) 1878–1963, c) 1964–1974 and d) 1975–2001. The number of events are given in Table 3.

During the Middle Ages, time followed the schedule in monasteries, so that time of earthquakes could be estimated. Sundials were also known. Some errors in the old earthquake catalogue go back to expressions like "around St. …", or to the different use of the word "vigilia" for the evening or the evening of the day before. In general, events during the night can be interpreted differently even through witnesses. Other errors are due to misprinted dates in compilations, which created many new events. Some prominent examples of errors (fake earthquakes) in the old MECOS catalogue are given in Table 2. One of the most fundamental errors from Stumpf's chronicle (1548) confused damage from a war in Basel with a Bavarian earthquake on May 12, 1021.

Old names of localities were re-identified and translated through encyclopedias such as *Orbis Latinus* by Graesse (1972). Wrong translations were recognized, as for example the expression "Welschland" for Romandie or Neuenburg, which had to be corrected to "Italy", the correct translation at that time. A fake event in Styria (Steiermark) could be backtracked to Syria (see Table 2).

Macroseismic level

We established macroseismic site intensities from the historical information. The European macroseismic scale EMS98 (Grünthal 1998) has been adopted and is used for the whole database; all intensity points assessed in MECOS-02 are in EMS98.

The problem in assessing site intensities was that we had to interpret historical information within a time span of 1000 years on an equal level, though the meaning of such information was not the same over all centuries. "Terraemotus magnus" in the

12th century for example does not mean the same as "ein grosser Erdbidem" in the 18th century, but it still has to be interpreted as "strong event". The same problem arises for the descriptions of human reactions, effects on buildings, environment, etc.

In addition to estimating intensities for all Swiss localities, we imported intensity values for earthquakes from all available databases and compilations. Two examples for large events in 1601 and 1946 are shown in Figure 5.

The resulting number of events in the new catalogue for the time periods before 1878, 1878-1963, 1964-1974 and 1975-2001 are given in Table 3 and the earthquakes are plotted in Figure 6. For some of the events the intensity had to be completely revised, in most cases to a lower epicentral intensity. The most prominent example of the latter is the December 20, 1720 event near the Lake of Constance, whose epicentral intensity was revised from Io=VIII to Io=VI (Gisler et al. 2003).

Revision of the period 1878-1963 for non-damaging earthquakes (Io<VI)

The Swiss Seismological Commission was founded in 1878 and, until 1963, published yearly bulletins containing a list of macroseismic data, isoseismal maps, detailed descriptions of prominent earthquakes, and, starting in 1914, a list of instrumentally recorded earthquakes with travel time readings from the already existing seismographs. The isoseismal maps do not include individual intensity points and are mostly expressed in the Rossi-Forel intensity scale. For some events, tables with macroseismic intensity points exist.

For events with intensities V and below, the yearly reports of the Swiss Seismological Service (Schweizer Erdbebenkommission 1879 - 1912; Schweizerischer Erdbebendienst 1913 - 1963), earthquake record cards (Erdbebenkatalog auf Karteikarten 1878 - 1974) from the archive of the Swiss Seismological Service, and existing data files were reviewed. The reassessment was performed according to a consistent set of rules to assess the heterogeneous data objectively. As a result, the review guarantees a homogeneous assessment of earthquakes with small intensities. More than 300 new events, mainly below intensity IV, were introduced to the new database and additional information was added. The catalogue contains about 2600 events in this time period. The events with epicentral Intensity larger than III are shown in Figure 6b.

Revision of the period 1964-1974 for non-damaging earthquakes (Io<VI)

Between 1963 and 1974 many changes occurred at the Swiss Seismological Service. The yearly reports ceased to be issued in 1963. From 1972 on, yearly seismological bulletins were published again, the new seismological network started to be developed and became operational in 1975. The following sources were reviewed considering all available earthquake information:

- Earthquake record cards for the period 1964-1974 (Schweizerischer Erdbebendienst, Erdbebenkatalog auf Karteikarten 1878-1974).
- Partial information from NAGRA bulletin NTB 83-08. The NAGRA printed catalogue covers only the northeast of Switzerland, the region 47-48N and 7.5-9.0E (Mayer-Rosa et al. 1983).
- An earthquake list for the period 1964-1970 (Schweizerischer Erdbebendienst, Jahresberichte 1964-1971, Printout of a computer file (1993)) with phase readings and amplitudes from stations ZUR, NEU, and BAS (Zurich, Neuchatel, Basel), location, magnitude (M_d or M_L) and some macroseismic information with localities and intensities (MSK).
- Yearly bulletin of the SED 1972, 1973, 1974 (Jahresberichte des Schweizer Erdbebendienstes, 1972-74).

The catalogue for this period has been modified extensively. The number of entries increased from 248 to about 310 with Mw>2.5. More than half of the existing entries were modified, changing magnitudes mainly, and additional information was introduced. The additional events correspond either to those in the border areas of Switzerland or, in most cases, to small events with low magnitude or intensity. The events with epicentral Intensity larger than III are shown in Figure 6c. Completeness of the events in the period 1964-1971 is not better than magnitude 3.5, or epicentral intensity IV (see Table 1). For the period 1972-1974 the magnitude completeness is down to about magnitude 3.

Seismological level

Instrumental period since 1975

Although instrumental records of earthquakes in Switzerland and surrounding regions have existed since the beginning of the 20th century, a truly nationwide seismograph network was put into operation by the SED only in the early Seventies. Thus, for completeness and uniformity of data, this instrumental earthquake catalogue begins with the year 1975. For the early period it includes events complete down to magnitude $M_L \geq 3.0$. After 1975 station density in Switzerland increased and routine processing at the SED was improved. With the increasing number of stations in the national seismic network since 1975, the completeness of the instrumental catalogue gradually approaches M_L 1.8 for most regions under consideration. The events are shown in Figure 6d.

External Data

Switzerland is a small country with many borders. As a consequence, much of Swiss seismicity takes place close to the borders and significant Swiss earthquakes produce effects in bordering countries. Therefore, we included in the ECOS earthquake source parameters from existing national databases in

Tab. 4. Catalogues included in ECOS.

Country	Agency	Description of Agency and Catalogue
Switzerland	SED	Swiss Seismological Service (SED) / MECOS
Switzerland	SED	Swiss Seismological Service (SED) / MECOS02
Switzerland	SED	Swiss Seismological Service (SED) / IECOS
Germany	BGR	Bundesamt für Geowissenschaften und Rohstoffe (BGR) / Instrumental catalogue
Germany	BGR	Bundesamt für Geowissenschaften und Rohstoffe (BGR) / Leydecker Catalogue
Germany	LED	Landeserdbebendienst Baden-Württemberg (LED) / Instrumental catalogue
Germany	Karlsruhe	Universität Karlsruhe / Instrumental catalogue
Italy	CNR/GNDT	Consiglio Nazionale delle Ricerche, Milano / Historical catalogue NT4.1.1
Italy	INGV	Istituto Nationale di Geofisica e Vulcanologia / Instrumental catalogue
France	BRGM	Bureau de Recherche Géologiques et Minière, Electricité de France, Institut de Protection et de Sureté Nucléaire / Historical catalogue Sisfrance
France	LDG	Laboratoire de Detection Géophysique / Instrumental catalogue
Austria	ZAMG	Zentralanstalt für Meteorologie und Geodynamik / Historical Catalogue
Germany	GFZ	GeoForschungsZentrum Potsdam / GSHAP catalogue
France	IPSN	Recherche des characteristique de séismes historique en France (Book)
GB	ISC	International Seismological Center / Instrumental catalogue

neighboring countries. An overview of these national catalogues is given in Table 4.

Seismic parameters and their uncertainty

For each event in the catalogue we derived seismic parameters (location, depth class, epicentral and maximum intensity, magnitude) and their uncertainty. The strategy for parameterizing historical earthquakes was established to derive homogeneous source parameters for all historical events in Switzerland and then equalize macroseismic with instrumental parameters. The main goal was a uniform catalogue with homogeneous assessment of uncertainty through the whole historical and instrumental period.

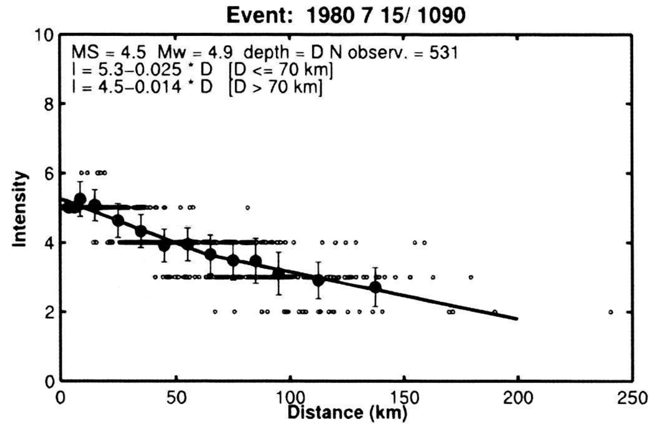
To compile a uniform catalogue for seismic hazard analysis, we adopt moment magnitude M_W as the size estimator for all events in ECOS, because M_W is directly related to the physical properties of the source, unlike other magnitude scales based on seismogram amplitude measurements (like the body wave, surface wave, and local magnitude scales). All original magnitudes or size estimates reported by other sources are saved in the event records.

A Mw value is assigned to each earthquake in the ECOS catalog. Direct measurements of seismic moment (and thus Mw) exist only for a small subset of recent, relatively strong earthquakes that could be analyzed using waveform modeling techniques. These events are marked in the ECOS catalog. All other Mw values are converted from other magnitude estimates using empirical regressions that in some cases involve several steps. For stronger 20th century earthquakes in and near Switzerland, we determined surface wave magnitude M_S from original analog recordings. To convert these historic M_S measurements to Mw, we regressed M_S versus Mw for recent events and ported the calibration function to the older events. For events recorded by short period networks, local magnitude ML (or duration magnitude MD) was calibrated against Mw. For ML determined by the SED, we regressed ML versus Mw (for preliminary results see Braunmiller et al. 2002). For events outside Switzerland, other short-period networks provide location and size estimates. For such events, we first regressed the foreign magnitudes (ML or MD) against SED's ML, and in a second step, using the SED ML-Mw-relation, converted foreign magnitudes to Mw. In the end, we obtain an earthquake catalog that contains directly comparable size estimates for each earthquake in terms of Mw, our unified magnitude. The details of the procedure are described in the internal report of the Swiss Seismological Service.

In order to parameterize the historical earthquakes, we first performed a comprehensive test using a number of well-calibrated and well-distributed earthquakes of the 20^{th} century. Our analysis was based on four main steps:

1. selection of a set of calibration events;
2. assessment of attenuation of intensity with distance for the Swiss region;
3. calibration of a macroseismic magnitude scale;
4. systematic processing of all historical earthquakes.

The set of calibration events was selected among well-controlled earthquakes in the 20^{th} century with a well-distributed macroseismic field and with homogeneously computed instrumental magnitudes. The set consists of 15 events distributed over the whole Swiss region, spanning a wide magnitude range



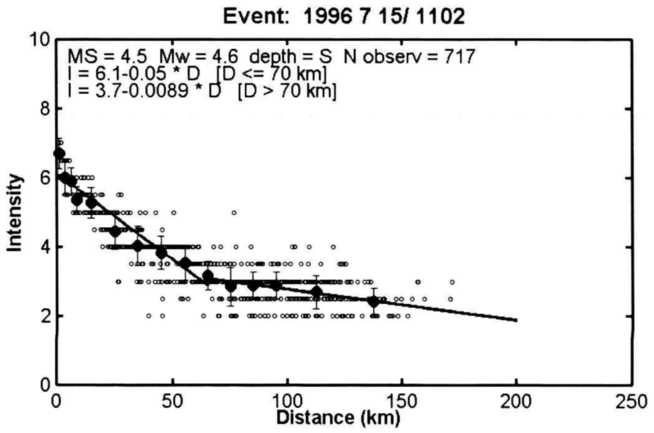


Fig. 7. Intensity versus epicentral distance for two events, the 1980 Sierentz event (top) and the 1996 shallow Annecy event in the French Alps (bottom). Open circles represent individual intensity values. Mean intensities with distance (in 2.5, 10 and 25 km bins) are shown as solid circles. Errors bars are ±1 standard deviation of the data. The intensity-distance relationship is fitted with a bi-linear function (solid line) in the 0–200 km range with the hinge at about 60 to70 km.

and with large macroseismic fields comprising 400 Intensity Data Points (IDP) on average. Events were grouped in two depth classes, according to the characteristics of the macroseismic field and the instrumental information: shallow (S) events are characterized by high attenuation of intensity with distance in the epicentral area while deep (D) events show a lower attenuation.

We adopt an empirical approach based on a simple general formulation with a minimum number of free parameters:

$$I(\mathbf{M}, d) = a + b\,\mathbf{M} + c\,f(d)$$

where the intensity field I(M,d) depends only on the magnitude of the event, **M,** and on a function of distance, *f*(d).

For the set of calibration events we analyzed the intensity variation with distance by experimenting with several intensity functions I(M,d) and different distance functions. The most robust results are obtained by using a mean intensity (i.e. the arithmetic mean of intensity estimates at different sites located at the same epicentral distance) for defined distance ranges (see e.g. Gasparini, 2001). The functional form *f*(d) which provides the best fit to the mean intensities is a bi-linear function, with the hinge at about 60 to 70 km distance. Figure 7 shows the distribution of Intensity observations with epicentral distance for two events and the resulting fit to the bi-linear function in the 0-200 km range. Attenuation is high in the first 60 to 70 km, but once the macroseismic field reaches 70 km intensity decays very smoothly with distance. This effect is also very well seen in the attenuation of instrumental weak and strong motion data (Bay et al. 2003), and it is explained by the energy contributed by the reflected shear waves at the Moho.

For the distance range up to about 60 to 70 km, the resulting slope values range from -0.02 to -0.05. Lower absolute values correspond to deeper events, while very steep slopes are obtained for shallow events. A slope of -0.04 separates shallow from deep events. Intercepts at zero distance increase linearly with magnitude of the events, and form groups according to the event depth class.

Typical slopes in the distance range 70-200 km are equal to about –0.01 and indicate low attenuation with distance. Slopes in this second branch do not show significant variations with focal depths; they do show a regional variation, with lower attenuation for events in the Alpine area compared to the Alpine Foreland.

For the magnitude estimate M_i we obtain relations of the following form:

$$M_i = (I_i + c_0 + c_1\, d_i)/c_2$$

I_i is the EMS98 Intensity value at site i, d_i is the distance (km) from the source location to site i and c_0, c_1, c_2 are constants derived from the calibration set of events. For sites in the near distance range we obtain:

Shallow: $M_i = [I_i - 0.096 + 0.043\, d_i] / 1.27$
Deep: $M_i = [I_i + 1.73 + 0.030\, d_i] / 1.44$

For sites in the 70-200 km distance range we obtain:

Shallow-Foreland: $M_i = [I_i + 1.65 + 0.0115\, d_i] / 1.27$
Shallow-Alpine: $M_i = [I_i + 1.93 + 0.0064\, d_i] / 1.27$
Deep-Foreland: $M_i = [I_i + 2.76 + 0.0115\, d_i] / 1.44$
Deep-Alpine: $M_i = [I_i + 3.04 + 0.0064\, d_i] / 1.44$

Following the Bakun & Wentworth (1997) grid search approach, we determine earthquake parameters directly from the intensity data points (IDP). We first calculate the macroseismic magnitude **Mm** and **rms[Mm]** over a grid of trial source locations:

Mm = mean (M_i),

The epicentral region is bounded by contours of **rms [Mm]**:

rms [Mm] = rms $[Mm - M_i] - rms_0\,[Mm - M_i]$.

with

$$rms\,[Mm - M_i] = \{\Sigma_i\,[w_i\,(Mm - M_i)]^2 / \Sigma_i\, w_i^2\}^{1/2}$$

and $rms_0\,[Mm - M_i]$ is the minimum $rms\,[Mm - M_i]$ over the grid trial source locations.

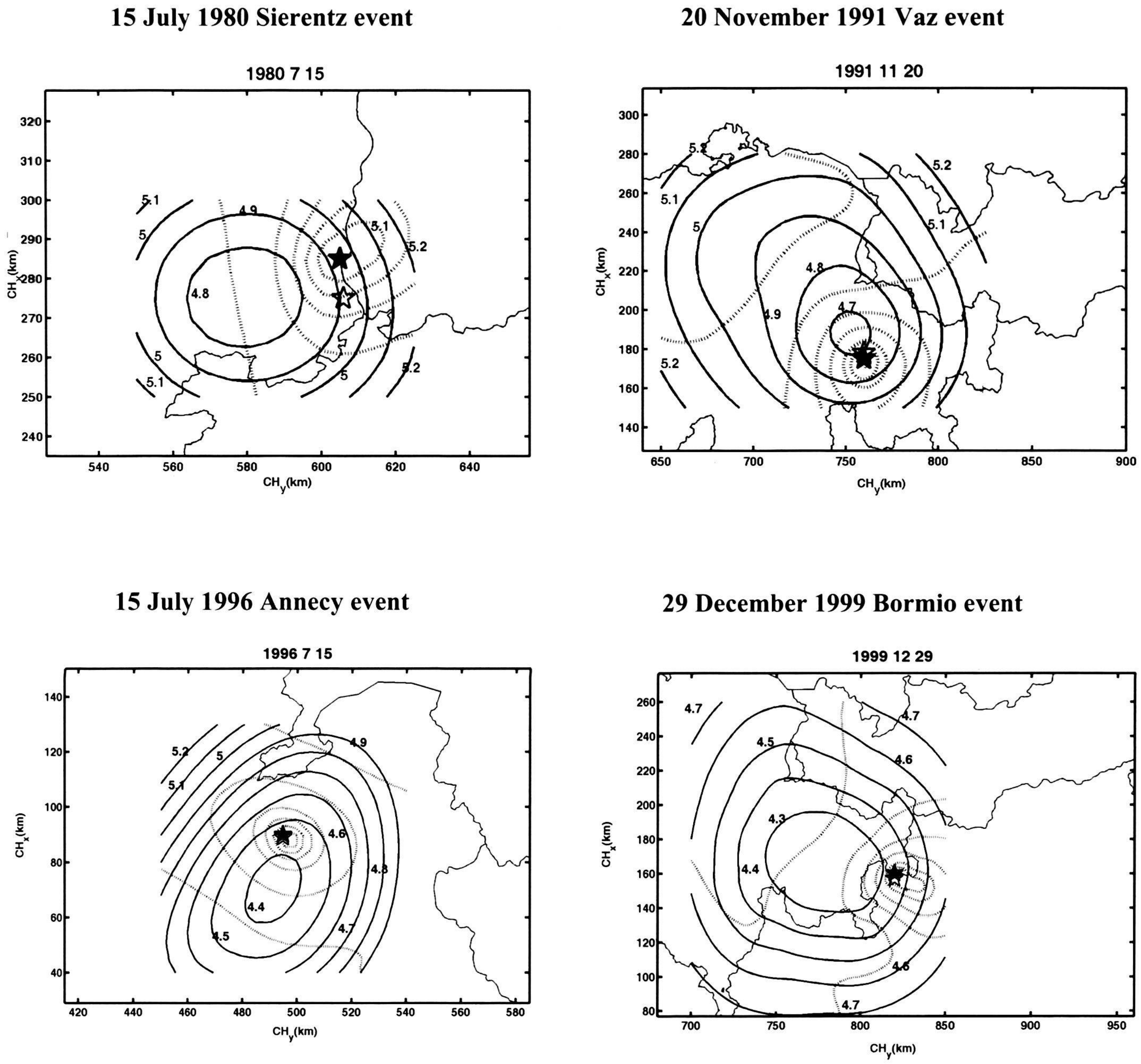


Fig. 8. Maps of contours of Mm as solid lines and contours of rms[Mm] as dotted lines, and instrumental and macroseismic epicenter as open and solid stars respectively. Magnitude contours show the best fitting magnitude at each point while the rms[Mm] contours show for the same point the misfit to the macroseismic field.

The parameter w_i is a distance weighting function, with observations at near distances preferentially weighted to improve the resolution of the epicentral region.

Results of the application of the method for some of the strongest instrumentally recorded events in the last 25 years are given in the Figure 8. The maps provide magnitude and rms[Mm] contours (solid and dotted lines respectively). Magnitude contours show the best fitting magnitude at each point while the rms[Mm] contours show for the same point the misfit to the macroseismic field. The instrumental epicenter (open star) and the intensity center (filled star) are also shown.

15 July 1980 event

The Sierentz event with moment magnitude Mw=4.9 is located in France close to the German and Swiss borders. Macroseismic information is available for locations in France and Switzerland. The earthquake reached maximum intensities of

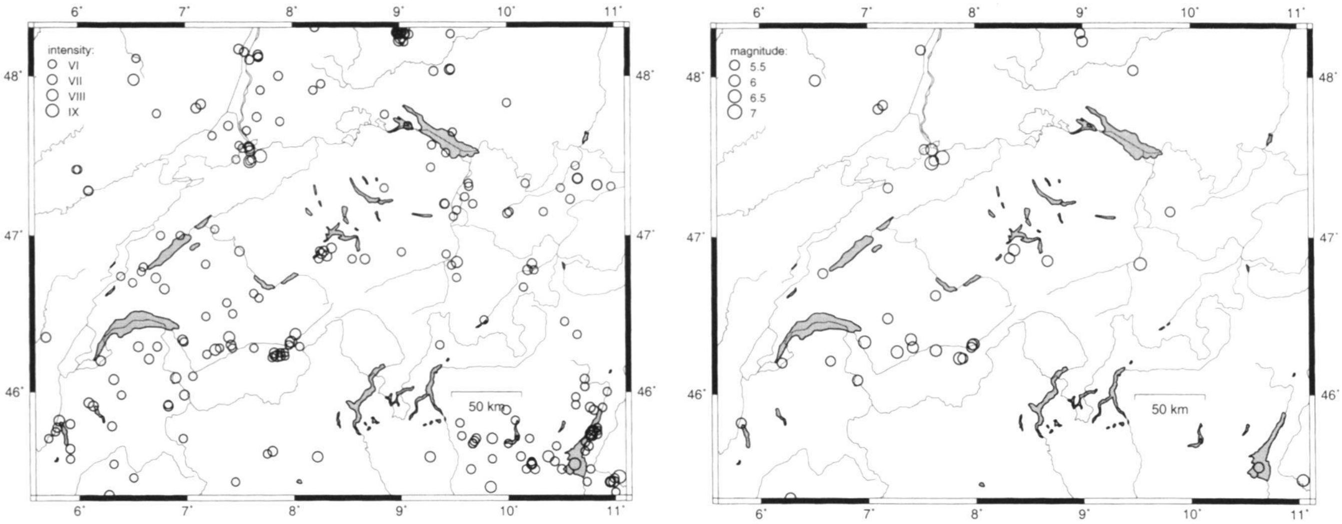


Fig. 9. a) Events in ECOS that caused damage and therefore reach intensity VI. b) Earthquakes with magnitude Mw larger or equal to 5.5. More information on these earthquakes is given in Table 5.

VI-VII. The epicenter determined from Intensities (filled star) is located 10 km north of the instrumentally determined epicenter. The macroseismic magnitude Mm is 5.0.

20 November 1991 event
The Vaz Mw=4.8 event in Eastern Switzerland was felt at distances of 150 km and the macroseismic field contains 342 Intensity points over the Swiss territory. Macroseismic information is not available in neighboring countries (Italy, Austria, Germany). The best fit (shown in the map) is obtained for the deep event class. The epicenter determined from Intensities (filled star) is 3 km apart from the instrumentally determined one, and the macroseismic magnitude is Mm = 4.7.

15 July 1996 event
The Mw=4.6 Annecy event in France was felt all over Switzerland. Macroseismic information is available for locations in France and Switzerland. The best fit (shown in the map) is obtained for the shallow event class (the instrumentally determined depth is 2 km). The Mm determined from Intensities at the epicenter (filled star) is 4.5, and the macroseismic epicenter coincides very well with the instrumentally determined epicenter (open star).

29 December 1999 event
The Mw=4.9 Bormio event at the Swiss border reached maximum intensities of IV-V in the Swiss territory. Macroseismic information is very scarce in the epicentral region (not available for Italy and Austria). The best fit is obtained for a deep class event as shown in the map. The macroseismic epicenter (filled star) is 2 km away from the instrumentally determined one. The macroseismic magnitude Mm of 4.4 is most probably underestimated due to the lack of IDPs in the epicentral region.

For each historical event with a sufficient number of IDPs the grid search approach is applied to determine depth class of the event, location, macroseismic magnitude Mm, and associated uncertainties. The results on the set of validation earthquakes show that our empirically derived approach provides reliable and robust source parameter estimates for earthquakes in Switzerland. We find that associated uncertainties in source parameters are controlled by the number and azimuth distribution of available IDP's, by the degree to which IDP's are available at near distance and by the internal consistency of the IDP's.

Of special interest is the 1356 Basel earthquake, the largest known historical earthquake in Central-Northern Europe. This event had been assigned epicentral intensity IX-X in past investigations, and magnitudes in the range of 6.2-6.5. From paleoseismic investigations on the Rheinach fault south of Basel a moment magnitude of 6.4 to 6.5 was estimated (Meghraoui et al. 2001). The macroseismic field for the Basel earthquake has points with intensity IX as well as VIII; epicentral intensity is certainly IX, and the intercept intensity of the magnitude-intensity calibration curve at distance zero is VIII-IX. This event is the only one with such high intercept intensity and the magnitude required to produce an event with this intercept intensity and such a large area of strong intensity (VII and higher) is 7.1 in our relation. However, we are not confident that we can extend the linear magnitude-intensity relation to such high magnitudes and we believe that the upper bound of 7.6 obtained from the error estimate for the 1356 Basel earthquake is unrealistic. We therefore make an exception for the Basel event and reduce the magnitude to M_W=6.9. Recent strong earthquakes such as the 1995 Kobe event (M_W 6.9) and the 1999 Izmit event (M_W 7.6) also did not produce an intercept intensity higher than IX. On the other hand, we do not expect to

year	month	day	hour	minute	Latitude	longitude	Mw	Io	Ix	Place
250					47.50	7.70	6.9	9	9	Augusta Raurica
1295	9	4			46.83	9.53	6.5	8	8	Chur/GR
1356	10	18	17		47.55	7.60	6.2	7-8	8	Basel
1356	10	18	21		47.46	7.60	6.9	9	9	Basel/BS
1363	6	24			47.80	7.10	5.5	7	7	Thann,Haut-Rhin/F
1372	6	1			47.82	7.14	5.5	7	7	Mühlhausen/F
1524	4				46.27	7.27	6.4	8	8	Ardon/VS
1574	5	3			46.20	6.20	5.5	7	7	Geneve/GE
1577	9	22	1	0	47.31	7.19	5.5	5	6	Bassecourt
1584	3	11	11		46.33	6.96	6.4	7	8	Aigle/VD
1601	9	18	1		46.92	8.36	6.2	7	8	Unterwalden
1650	9	21	3		47.55	7.53	5.6	6	7	Basel
1682	5	12	2	30	47.97	6.51	6	8	8	Hautes-Vosges
1685	3	8	19	0	46.28	7.63	6.1	6	7	Ober-Wallis
1729	1	13	21		46.63	7.63	5.6	6	6	Frutigen/BE
1736	6	12			47.48	7.62	5.5	6	6	Aesch, Basel
1755	12	9	13	30	46.32	7.98	6.1	8	8	Brig, Naters/VS
1770	3	20	15	35	46.48	7.18	5.7	6	6	Chateau-d'Oex/VD
1774	9	10	15	30	46.85	8.67	5.9	7	8	Altdorf/UR
1787	8	27			47.16	9.81	5.5	5	5	Bludenz, Vorarlberg/A
1822	2	19	8	45	45.81	5.81	5.6	7-8		Bugey (Belley)
1837	1	24	1	0	46.31	7.96	5.7	7	7	Birgisch VS
1846	8	17	6	15	46.77	6.58	5.5	6	6	Yverdon-les-Bains VD
1855	7	25	11	50	46.23	7.85	6.4	8	8	Törbel VS
1855	7	26	9	15	46.23	7.88	5.6	7	8	Stalden,Visp/VS
1879	12	30	12	27	46.21	6.65	5.5	7-8		Chablais
1905	4	29	1	59	46.09	6.9	5.7	7-8		Massif du Mont Blanc
1924	4	15	12	49	46.30	7.96	5.5	6	7	Brig/VS
1946	1	25	17	32	46.35	7.40	6.1	8	8	Ayent VS
1946	5	30	3	41	46.30	7.41	6	7	7	Ayent VS
1964	3	14	2	39	46.86	8.31	5.7	7	7	Alpnach/OW

Tab. 5. Events in or near Switzerland with Mw ≥ 5.5.

reach an intercept intensity VIII-IX from a magnitude 6 earthquake.

Results

The earthquakes that produced damage (Intensity larger or equal to VI) in Switzerland are shown in Figure 9a. The strongest events with magnitude larger than or equal to Mw=5.5 are given in Figure 9b and Table 5. The strong events are mostly located in the Rhinegraben rift system, the Alpine front, and the Valais region.

Statistical analysis of the ECOS catalog

While one aim of the catalog recompilation is to provide a homogeneous coverage over an extended period, inevitably some degree of heterogeneity remains. The first order of heterogeneity in the catalog is introduced through the temporally and spatially varying completeness of reporting, documented already from a historical point of view (Table 1). These changes in completeness can also be seen clearly by plotting magnitudes as a function of time (Figure 10). In addition, Figure 10 shows that magnitudes are binned in 0.4 magnitude steps during the period 1300 to about 1970 for magnitudes below 4.5. This effect is an immediate consequence of the fact that during this period and magnitude range, magnitudes are converted from one or only few intensity site points, which are generally given in discrete steps. For events with moment magnitude larger than 4.5, however, magnitude was estimated from macroseismic fields, which allows binning in 0.1 units.

In Figure 11 we plot the cumulative number of events as a function of time for two different magnitude thresholds (M>=3 and M>=4). The most noticeable rate changes are again caused by the changing completeness of reporting, generally increasing the rate of events in later times. A drop in rate by about 50% around 1970 of the magnitude M>=3.0 events, however, cannot be explained by changes in completeness. An analysis of this rate change revealed that it is partly caused by the aforementioned change around 1975 to computing true instrumental magnitudes instead of reporting epicentral intensities. Nevertheless, that the number of M>4 events also dropped in the last 30 years seems to be real and reflects natural fluctuations in the rate of earthquakes, as can be seen during earlier periods.

The cumulative moment as a function of time (Fig. 11, solid black curve) shows an approximately constant energy release with time. Moment is computed from moment magnitude following Kanamori and Anderson (1975). Of course the largest event, the 1356 Basel M6.9 mainshock, dominates this record, and provides about 40% of the total moment released. Such jumps are common for regions of moderate seismicity, because the recurrence time of the largest earthquakes is on the order of, or longer than the observation period of the catalog. From 1500 onward, moment release shows a generally constant slope, with an average annual moment of 7.5 10^{23} Nm, which corresponds to an Mw5.2 event.

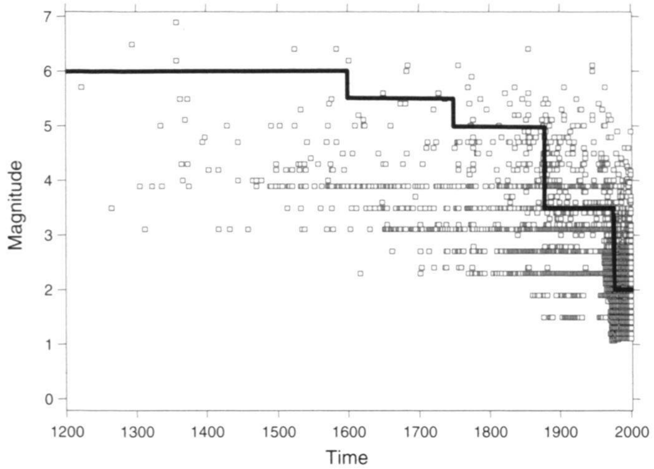


Fig. 10. Magnitudes of earthquakes as a function of time; each event in the catalogue is plotted as a small square. The approximate magnitude of completeness threshold obtained from the historical record (Table 1) is marked as a solid line. Note the discrete binning of magnitudes in 0.4 magnitude units before 1975 for magnitudes < 4.5, due to the adopted intensity-magnitude conversion.

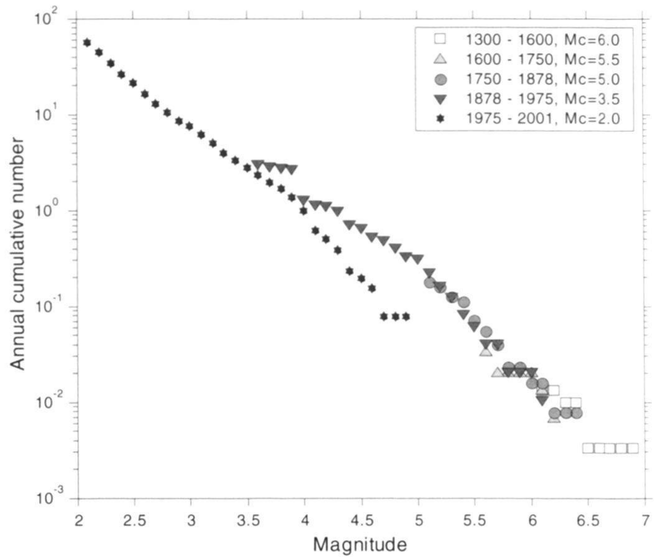


Fig. 12. Annual cumulative frequency of earthquakes as a function of magnitude for five periods.

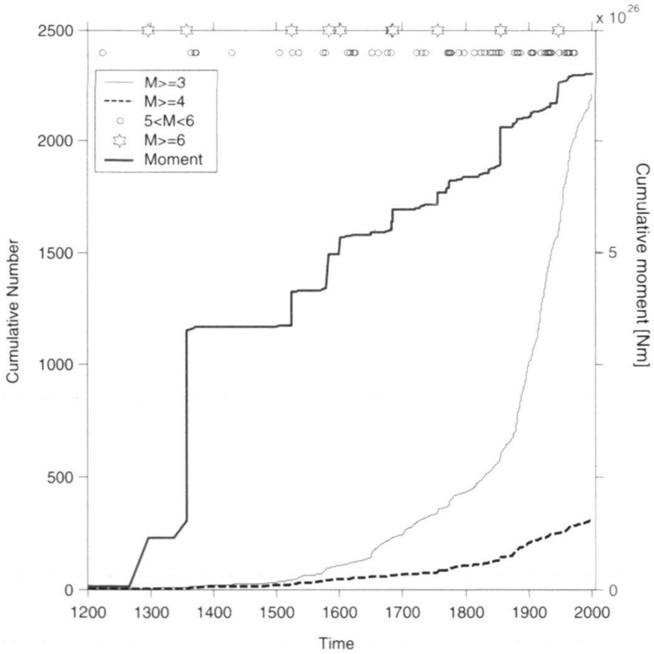


Fig. 11. Cumulative number of events as a function of time for different magnitude cutoffs: M >= 3.0 (thin gray line); M >= 4 (dashed line). Events with M >= 6 are marked by a star, and with 5 =< M < 6 by a small circle. The cumulative moment, computed from moment magnitude, is plotted as a thick black line.

Figure 12 plots the annual cumulative frequency-magnitude distribution (FMD) of earthquakes for different periods of completeness. The periods are extracted from the historically observed record (Table 1) and also marked in Figure 10. The slope (*b*-value) and intercept (*a*-value) of the FMD's shown in Figure 12 are constant to a first order approximation, suggesting a stationary seismicity. From these results, one might expect, on average, about one M=4 event every year, one M=5 event every 10 years, and an M=6 event every 100 years. It is beyond the scope of this study to compute average recurrence rates for hazard purposes, because this would require a more rigorous analysis of magnitude completeness and of possible dependence between individual events.

Conclusions

To improve the seismic hazard assessment for Switzerland, the SED substantially revised the macroseismic database and the Swiss earthquake catalogue. The highlights of the resulting catalogue ECOS and the related database can be summarized as follows:

- ECOS is the new unified earthquake catalogue for Switzerland and neighboring regions, covering all seismogenic areas which produce significant seismic hazard for Switzerland.
- The core of ECOS is the revised Macroseismic Earthquake Catalogue of Switzerland (MECOS-02), which includes a comprehensive, homogeneous database of historical and macroseismic information built by collecting and analyzing primary sources and compilers of historical information and merging all available macroseismic information and earthquake studies.
- ECOS is characterized by a homogeneous assessment of earthquake parameters, which includes a common magnitude M_W for all events and the assessment of error bounds for all source parameters.

Acknowledgements

ECOS has been supported by internal funds of the Swiss Federal Institute of Technology (ETHZ), from grants by the Swiss National Science Foundation and the Swiss Federal Nuclear Safety Inspectorate (HSK) and through an Agreement of Cooperation with NAGRA for compiling the catalogue and database. We thank all agencies for their support.

ECOS is generated by the fusion of 15 catalogues covering Switzerland and parts of France, Germany, Austria and Italy. Responsible agencies and experts from these countries have helped by supplying catalogues and data. We thank national agencies, research institutes and colleagues for contributing data and catalogues: W. Brüstle, LED Baden-Württemberg; M. Henger and G. Leydecker, BGR; K. Bonjer, IFG Karlsruhe; G. Grünthal, GFZ Potsdam; F. Scherbaum, Potsdam; M. Stucchi and P. Albini, IRRS/INGV; W. Lenhardt, ZAMG; M. Nicolas and Y. Menechal, LDG; A. Levret, IPSN, J. Lambert, BGRM; M. Di Bona and A. Amato, INGV.

We thank all colleagues who assisted with historical data and interpretation: G. Grünthal, GFZ, G. Leydecker, BGR, G. Schneider, Stuttgart, P. Alexandre, Bruxelles, P. Albini and M. Stucchi, IRRS/INGV, J. Vogt, Strasbourg, A. Levret, IPSN. In addition, M. Baer, U. Kradolfer and D. Mayer-Rosa have given us extensive advice on magnitude calibration and catalogue completeness.

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Manuscript received July 30, 2002
Revision accepted March 16, 2003