

Review

The Scientific Landscape of November 23rd, 1980 Irpinia-Basilicata Earthquake: Taking Stock of (Almost) 40 Years of Studies

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Abstract: The November 23rd, 1980 Irpinia-Basilicata (Southern Italy) earthquake is one of the strongest earthquakes ever occurred in Italy. The earthquake was a natural laboratory for the scientific community, which was engaged highly and promptly in investigating the event, thus publishing a flood of papers in different research areas over time. Just these research outputs are the focus of the article, which examines, with a tailored methodological approach, the international and national (Italian) studies started and advanced since the occurrence of the earthquake. First, we built and analyzed statistically two bibliographic databanks regarding the earthquake studies: (a) the international version of IRpinia Bibliographic databASE (IR_BASE_ENG), selecting and standardizing the pertinent scientific documents extracted from Scopus, Web of Science, and other databases and (b) the national version of the database (IR_BASE_IT) using the Google Scholar search engine to search for the most relevant papers in Italian. Second, IR_BASE_ENG was analyzed in a bibliometric perspective through the data mining VOSviewer software (Waltman et al., 2010) that builds co-occurrence term maps useful in perspective of investigating the wide-ranging studies on the earthquake. Third, taking a cue from this network analysis, we recognized the main research topics and performed a minireview of the related international studies, integrating in it a quick reference to the literature in Italian. Finally, we associated the scientific outputs to each cluster/topic, also performing the frequency analysis of the published documents for each subject, thus gaining information on the temporal trends of studies and getting a more exhaustive evidence of the scientific landscape on the earthquake over the last 40 years.

Keywords: 1980 Irpinia-Basilicata earthquake; earthquake effects; environmental effects; disaster epidemiology; disaster response

1. Introduction

The November 23rd, 1980 Irpinia-Basilicata (Southern Italy) earthquake is one of the strongest earthquakes ever occurred in Italy (Me 6.7, [1]). The event caused over 2700 casualties while felt effects occurred in a very wide area, from south to north, from Sicily to Liguria. Among the 687 municipalities affected, 37 were declared devastated, 314 seriously damaged, and 336 damaged [2]. Out of around 1,850,000 houses, 75,000 were destroyed, 275,000 seriously damaged, and 480,000 slightly damaged. In particular, the villages of Castelnuovo di Conza, Conza della Campania, Laviano, Lioni, Sant'Angelo dei Lombardi, and Santomenna, in the Avellino province, were almost razed to the ground. The damage to cultural heritage was also significant, with several hundreds of churches, bell towers, castles, palaces, and archaeological remains damaged with different degrees of severity. Furthermore, the event caused primary effects consisting of surface faulting extended for about 40 km

in length [3] and secondary effects with the triggering or the reactivation of numerous landslides such as those in Senerchia, Caposele, and Calitri in the Avellino province, San Giorgio La Molara in the Benevento province, and Grassano in the Matera province [4–6].

Due to the broad-spectrum of effects, the area most involved in the earthquake was considered a sort of natural and open-air laboratory to perform in-depth studies covering multidisciplinary and interdisciplinary areas. Research activities by the scientific community promptly started in the aftermath of the earthquake so that the first papers were published in the weeks and months immediately following the earthquake.

That being stated, in order to shed light on these studies in qualitative and quantitative way, the article aims to illustrate and discuss the international and national scientific publications. To do that, we built two databanks: (1) the international version of the IRpinia Bibliographic database (IR_BASE_ENG), making use mainly of Scopus and Web of Science citation indexes. Furthermore, BIOSIS, Data Citation Index, and MEDLINE were also considered to extract and analyze the pertinent papers published over a period of about 40 years, since 1980. Additionally, in order to increase the database completeness, we made some manual additions of bibliographic records, (2) the national version of the database (IR_BASE_IT) using the Google Scholar search engine to search for papers in Italian. The combined use of the databases allowed to widely tracing the typology, amount, and evolution of the most typologies of studies regarding the earthquake.

Once IR_BASE_ENG was built, we examined it to focus particularly on the hot issues and research lines covered by the papers. To do that, we made use of the VOSviewer data mining bibliometric software that builds distance-based maps (www.vosviewer.com [7]). The software is widely used to perform analysis in different fields such as information and communication technologies, medicine, agriculture, earth sciences, and applied geophysics [8–12].

Taking a cue from the network analysis, we identified the main research branches. We also carried out a minireview of some relevant international studies, also including a quick look at the 1980 literature in Italian.

The article is divided into four main parts: (1) the criteria followed to build the two 1980 IR_BASE and analyze the IR_BASE_ENG through the bibliometric software, (2) the statistical result analysis related to the two databases, (3) the VOSviewer map analysis by identifying the main clusters/topics and performing a minireview about each of them, and (4) the statistical analysis of the research outputs for each topic over time.

2. Materials and Methods

As Figure 1 shows, the approaches followed to build the two 1980 literature databases were quite different.

As regards to IR_BASE_ENG, we considered four main steps: (1) selection of the international bibliographic databases from which the pertinent data is extracted; (2) identification of the proper queries to interrogate the archives and extract the data; (3) checking, homogenization, and fusion of the bibliographic data extracted by the different digital repositories; and (4) manual adding of both missing records and incomplete bibliographic information.

Concerning the first point, we considered Scopus and Web of Science, which are the most considered databases commonly used to search for the literature [13]. In addition, in order to expand our searches to as many research branches as possible, these two databases were supplemented by BIOSIS, Data Citation Index, and MEDLINE.

Scopus was launched in November 2004, and it includes over 25,000 active serial titles from more than 5000 international publishers. Scopus delivers the most comprehensive overview of the world's research output in the field of science, technology, medicine, social science, and arts and humanities. Scopus also includes "Secondary Documents" (SDs) that are documents, which have been extracted from a Scopus, document reference list, but are not available directly in the Scopus database since they are not indexed. In order to increase our findings for the 1980s and 1990s especially, SDs were

also considered in building the 1980 international database. This choice implied to manually adding some missing information to the SD records, as they are not indexed by Scopus. This aspect will be discussed in a deeper way later.

The Web of Science Core Collection (1965 to present) consists of 10 indexes containing information gathered from thousands of scholarly journals, books, book series, reports, conferences, and more. Citation databases are Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (A&HCI), Conference Proceedings Citation Index-Science (CPCI-S), Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH), Book Citation Index-Science (BKCI-S), Book Citation Index-Social Sciences & Humanities (BKCI-SSH), Emerging Sources Citation Index (ESCI), Current Chemical Reactions (CCR-EXPANDED), and Index Chemicus (IC). Web of Science includes over 12,000 highly acclaimed impact journal worldwide.

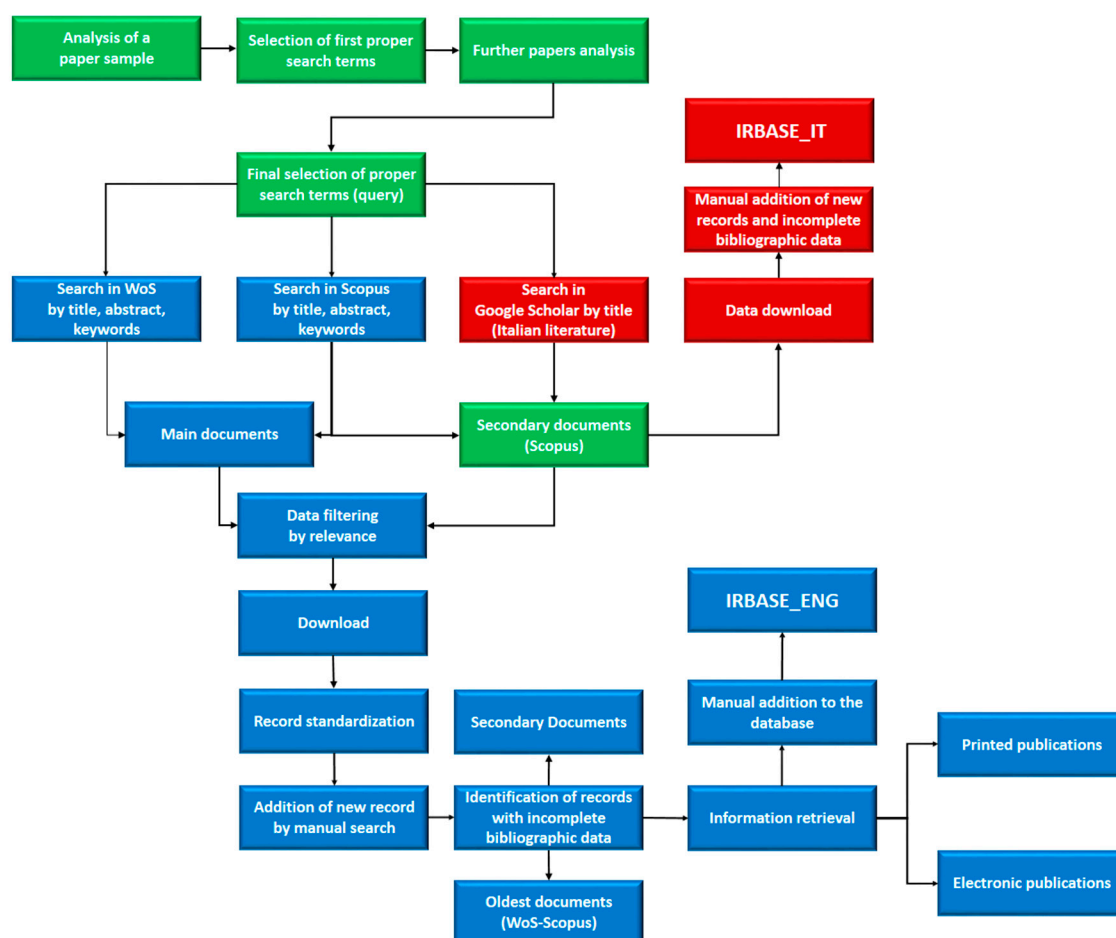


Figure 1. Flow chart summarizing the methodology used to build the two databases. In green, the methodological path common for the two databases. In blue, the path followed only for assembling IR_BASE_ENG. In red, the path for the building of IR_BASE_IT.

As said before, other databases were used to search for the 1980 earthquake documents: BIOSIS, Data Citation Index, and MEDLINE. BIOSIS Citation Index, with coverage from 1926 to present, is the world's most comprehensive reference database for life science research. It also includes cited references to primary journal literature on medical research findings. In addition, it covers original research reports and reviews in traditional biological and biomedical areas. The Data Citation Index contains source records relating to research data available in Web-based data repositories and covers all scholarly disciplines. MEDLINE, with coverage from 1950 to present, is the premier database of the US National Library of Medicine (NLM). It contains over 12 million records of journal articles in all

areas of the life sciences, with particular emphasis on biomedicine. Web of Science Core Collection, BIOSIS, Data Citation Index, and MEDLINE databases were accessed by the option “All Databases” of the Web of Science platform.

Looking at the second point of the methodology, in order to identify the search terms and queries useful to extract as many records as possible by the above mentioned international databases indexes, we performed a preliminary quick reading of a few dozen of papers, taking into account the overall time period under investigation here (1980–2020). After that, we fixed the first query to be used to pull records from the citation indexes. From these preliminary records, we identified and selected further search terms. This approach was followed until no new search terms were found (for the search terms used see Appendix A). Joining all the key terms, we execute the final query to interrogate Scopus and Web of Science by title, abstract, and keywords, both author and indexed ones. The choice to include all keywords implies that selected documents include both direct studies on 1980 earthquake that research where the 1980 events are not the main target of the investigations.

We executed the query considering all document typologies coming from the repositories taken as a reference. Furthermore, we considered the search results without restriction for specific research areas. Once executed the query, the results were saved for the two searches (Scopus and Web of Science) separately.

The third point of the approach refers to the preprocessing of data. Due to their differences in the format, we homogenized the data deriving from Scopus and Web of Science and fused them in an Excel sheet, deleting duplicate records and manually checked the pertinence of each item with our search aim, analyzing the abstract and/or the full texts.

The fourth step concerns the manual adding of information, in both Secondary Documents of Scopus and oldest documents retrieved in Web of Science as well as in Scopus. As said before, Secondary Documents are not indexed. Therefore, the bibliographic records are only partial and they do not include, e.g., the abstracts and source information as they are frequently incomplete, at least for the items published in the 1980s and early 1990s. Furthermore, such records are frequently duplicate reflecting the different way in which the documents were cited. These limitations required a deep and time-consuming manual check of the records, with corrections and/or adding of missing information (authors, year of publication, abstracts, and publication source) by consulting the original scientific works retrieved on the web and libraries. However, also the indexed documents required to be made complete in the bibliographic data. Indeed, the documents of Web of Science and Scopus published in the 1980s frequently did not have abstracts. Therefore, we performed the manual addition of them, in perspective to be analyzed by the VOSviewer software (version 1.6.8).

However, the use of Scopus as well as Web of Science alone did not allow finding some documents. We refer, e.g., to some papers published in the Special Issue of *Annali di Geofisica* edited in 1993 dedicated to the Irpinia-Basilicata earthquake [14]. To overcome this drawback and increase the completeness of the IR_BASE_ENG database as much as possible, we added manually in it some missing records and the related abstracts, by analyzing the references of some relevant papers on the 1980 earthquake published in the 1980s and 1990s, with particular attention to the works reported in Valensise (1993) [15]. After these steps, we built the final version of the Irpinia Bibliographic databASE (IR_BASE_EN). Later on, the data were read in and explored by the VOSviewer software (see next sections).

As regards the construction of IR_BASE_IT, we used Google Scholar (GS). GS is not a bibliographic database, but a specialized search engine that looks for scholarly materials that may be available online. GS was accessed by the Publish & Perish software (<https://harzing.com/resources/publish-or-perish>). However, unlike of Scopus and Web of Science, in GS, it is not possible to perform search also in abstracts and keywords [16]. In addition, the search analysis in GS performed through the “Keywords” field of Publish & Perish provided too much irrelevant data. Therefore, we oriented our analysis of Italian literature to find only the most relevant documents, interrogating GS only by the title field. Anyway, with the aim to increase the corpus of IR_BASE_IT records, the GS data were supplemented by searches performed in the Secondary Documents of Scopus. Furthermore, also for IR_BASE_IT,

manual additions of records coming from Valensise (1993) [15] were performed. We used the following search terms: *terremoto/i 1980* (earthquake/s 1980), *sisma 1980* (earthquake/s 1980), *terremoto/i irpinia* (earthquake/s irpinia), and *faglia irpina* (fault irpinia). Then, we extracted the bibliographic data and saved them as *.csv file to be analyzed statistically joined with the other databank (IR_BASE_ENG). The analysis of IR_BASE_IT by the VOSviewer software was not done, but a quick discussion of the related research items was fused within the minireview based on the international Scopus-Web of Science derived papers, as we have discussed better later. Data for both IR_BASE_ENG and IR_BASE_IT databases were searched and downloaded between 25th July 2020 and 3rd August 2020.

As said before, IR_BASE_ENG was analyzed by the VOSviewer software. This builds co-occurrence networks, suitable to give an idea of relationships between words. Indeed, word co-occurrence networks, among the most common linguistic networks studied in the past due to their topological features [17], are used to detect semantic similarity between terms [18]. The software uses the text mining technique to identify the noun phrases from titles or title and abstracts. The noun phrases are classified based on a relevance score: high relevance score is assigned when terms co-occur mainly with a limited set of other noun phrases so showing a more precise connotation in the field considered. This means that noun phrases with low relevance score are those that tend to be too general and meaningless for the domain of interest: they are omitted from the data processing. The software grouped the high relevance noun phrases (referred as terms) together into clusters to identify possible subfield or research topics. The default option of the software is to select the 60% most relevant terms among the noun phrase that occurred 10 times at least [19,20].

In our analysis on the 1980 earthquake, we selected the titles and abstracts option to extract noun phrases. Furthermore, in order to have a picture as more representative as possible of the research activity, we lowered considerably the threshold values of noun phrase, fixing the occurrence at 3 times at least. Conversely, regarding the percentage of most relevant terms, we considered a percentage of 70%. Furthermore, the option to insert a thesaurus text file was considered. This option is helpful in order to merge different spellings of the same term (e.g., *hypocenter* and *hypocentre*; *isnet* and *irpinia seismic network*). In addition, the option was considered also for merging different terms referring to the same concept (e.g., *earthquake sequence* and *seismic sequence*). After that, the resulting terms were cleaned by deleting the irrelevant words (e.g., *March*, *introduction*, *paper*, *review*).

The software builds three typologies of maps: network visualization, overlay visualization, and density visualization. The first map shows the items by their label and by a circle. For each term, the size of the term's label and the size of the term's circle depends on the weight of the term. Furthermore, the color of an item is determined by the cluster to which the item belongs. The overlay visualization is the same as the network visualization except that items are colored in a different way depending on the user choice. Lastly, density visualization shows the density of an item at a certain point. In our analysis, we built and analyzed comparatively the network and the density visualizations.

3. Results

The Two Databases

Overall, the two databases, made up mainly of journal articles and conference proceedings, include 636 bibliographic records, 512 of which related to IR_BASE_ENG and 124 to IR_BASE_IT.

Figure 2 shows the yearly pattern of number of bibliographic records for both the databanks over the period of almost 40 years. On the one hand, IR_BASE_ENG covers all the time window; on the other hand, IR_BASE_IT shows an intermittent lacking of data for 11 years, since the early 1990s. However, over the entire period, at least one international or national document was published yearly, including the remaining period of just over a month after the earthquake occurrence. The average annual number of documents is equal to 16, the maximum number of documents published in one year (1981) is 64.

Analyzing Figure 3, which shows the cumulative yearly percentage of documents published in the two databases taken alone and as a whole, we can see that in the 1980s, about 50% of the total documents was published. Considering the two databases separately, we can also realize that approximately the same percentage (50%) of documents in Italian was reached only after 6 years since the event occurrence, while the equivalent percentage for the Scopus and Web of Science derived documents was reached in a double period.

Figure 4 shows the number of total authors involved in the authoring the documents yearly (researchers that authored more papers were counted more times according to the number of papers they signed or cosigned). Overall, 2035 authors were involved in the studies, with a yearly mean of about 51. The maximum yearly of 197 was in 1981 and the minimum of 16 in 2001 and 2006. However, for the most of the period, the number of authors was less than 60.

The term map obtained by analyzing the IR_BASE_ENG database with the VOSviewer software shows three main clusters made up of about 330 words (Figure 5). However, the green and red clusters, in turn, can be divided into a series of subclusters that identify different research areas. We will discuss of these in the following sections. An interesting data about the mutual relationship between the three clusters can be provided by Figure 6, where we can see the density view map. In the visualization, the connection between the red and green clusters (171 and 131 items, respectively) appears to be slightly stronger than of either these subfields with the blue cluster (27 terms). What is more, we can also see that relationship within the red and green clusters are quite relevant, thus showing that subclusters/research topics cannot be considered as independent to each other, with special attention to the closest group of terms.

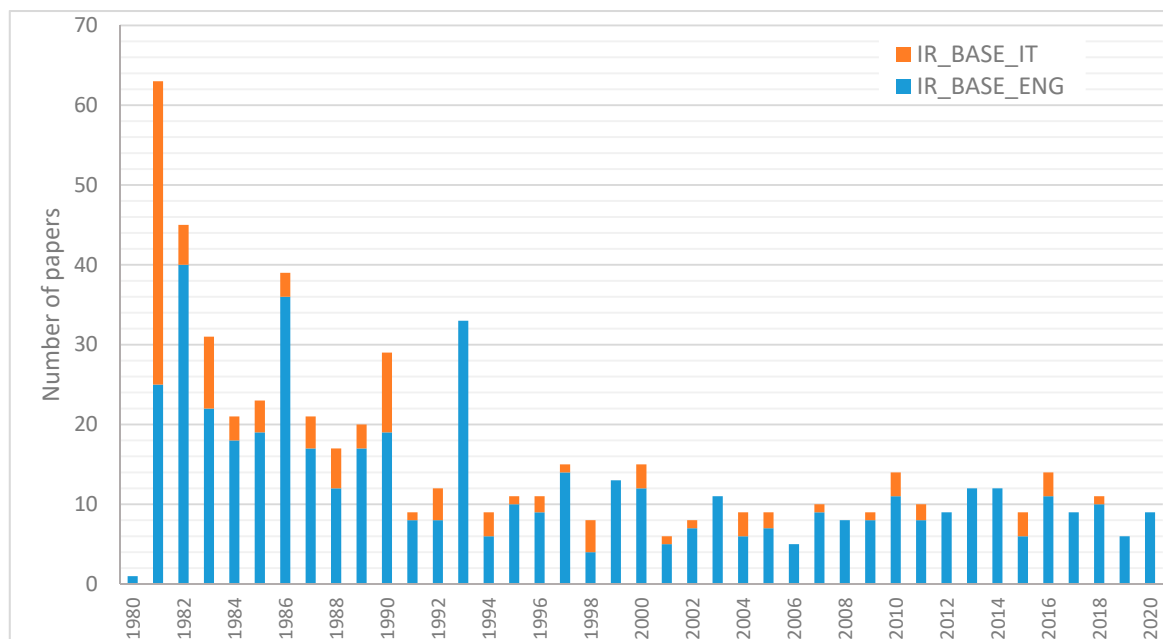


Figure 2. Yearly number of documents in the two 1980 Irpinia earthquake databases.

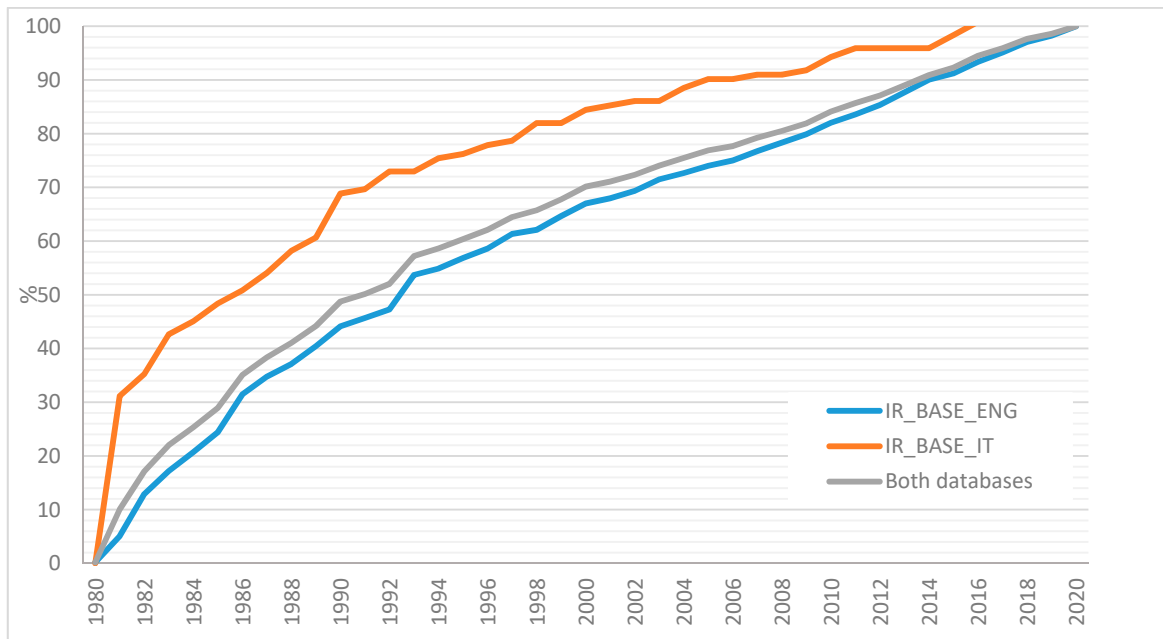


Figure 3. Cumulative percentage of yearly documents in the two databases taken both separately and as a whole.

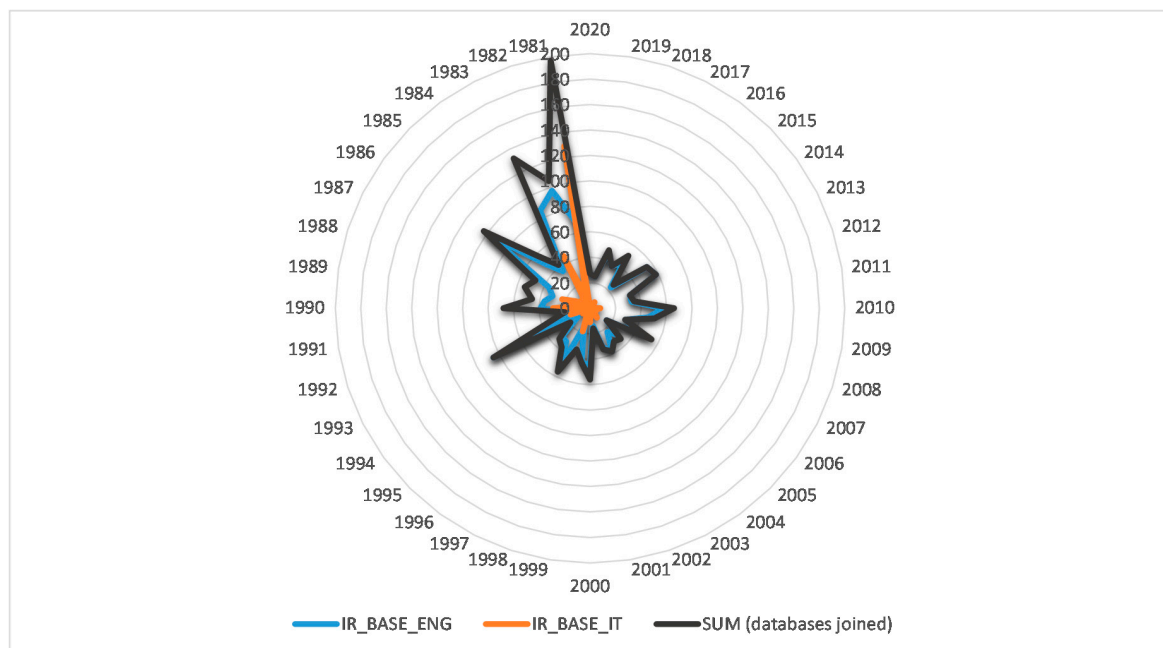


Figure 4. Number of authors involved in the research on 1980 since the earthquake occurrence. The data are represented both for each database taken individually and through the sum of the data contained therein. In the counting, the works published as “Working Group” are considered as published by one author.

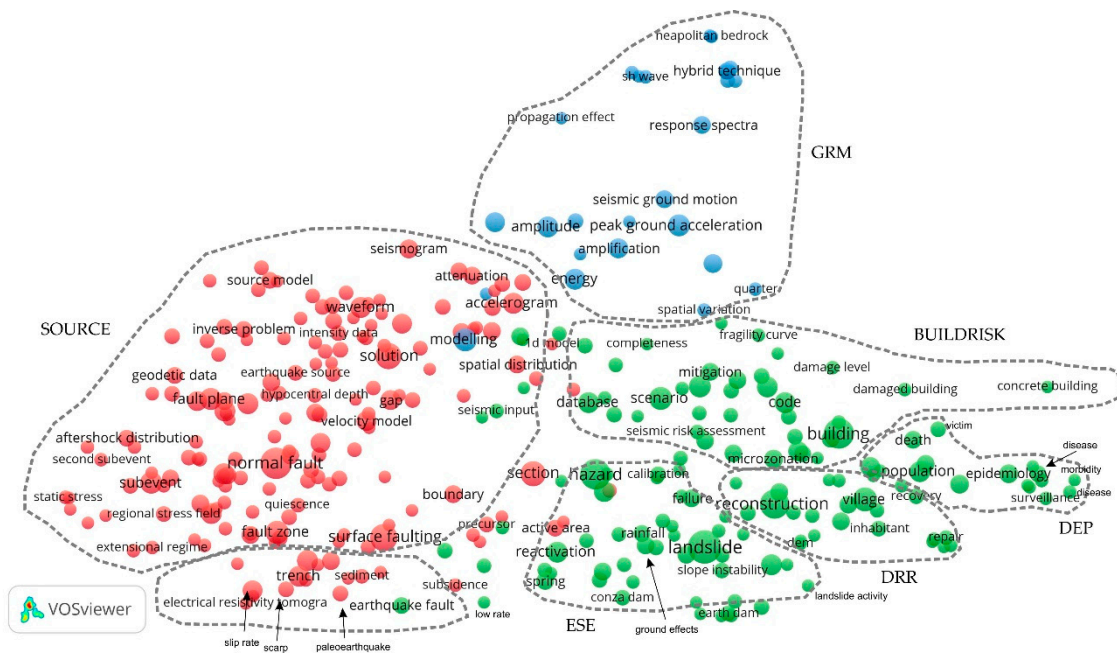


Figure 5. Network visualization by VOSviewer of IR_BASE_ENG database. For each term, the size of the term’s label and the size of the term’s circle depend on the number of occurrences. The map shows the three main clusters. The first two wider clusters may be divided into some subclusters. For example, the green cluster can, in turn, be divided into four main subclusters whose terms and “boundaries” are roughly drawn manually in the map. Taken overall, the map identifies seven main research fields on the 1980 earthquake. To improve the readability of the map, we added manually some names of terms.

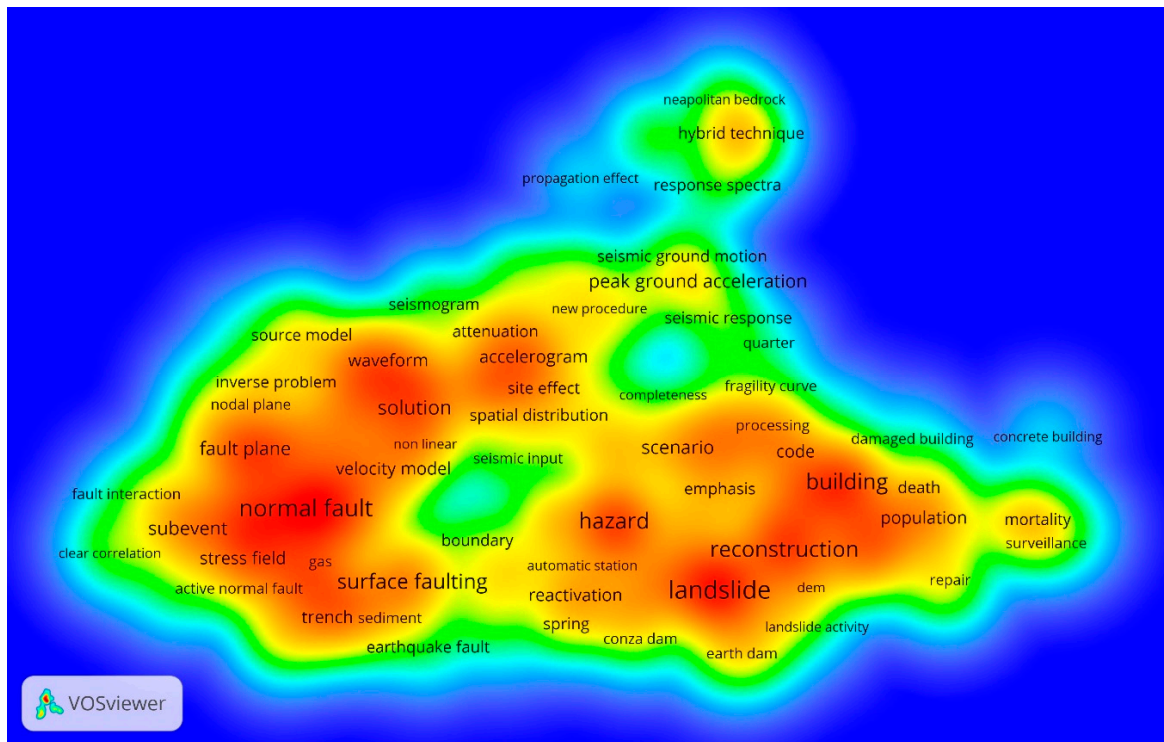


Figure 6. Density visualization by VOSviewer of IR_BASE_ENG database. The map shows the main terms leading the clusters and the connection between them.

4. Discussion

4.1. Cluster 1 (Red) (SOURCE)

The red cluster (Figure 5), led by the word *normal fault* (45 occurrences), may be roughly split into two larger subclusters, which call back on studies concerning the seismic sources through: (1) (mainly) seismological data (the upper and central-lower portion) and (2) (direct) paleoseismological and (indirect) geophysical investigations on the Irpinia fault (lower portion).

4.1.1. Studies Concerning the Seismic Source through Mainly Seismological Data

This subcluster can be identified in the upper and central-lower portion of the red group of terms. The richness of the words, their recurrence, and the mutual relationship of the terms well label both the complexity and high degree of maturity of the studies. These involved also the use of multidisciplinary approaches by integrating seismological, geodetic, and geological data, so showing the great efforts made by the scientific community to fuse multiple data thus building a proper source model.

One of the first works on the seismic source regarded the processing of seismograms recorded at teleseismic distance [21]. The authors gained information on the origin time, location, magnitudes, both mb (6.1) and Ms (6.8), and the geometry of the causative (normal) fault, whose strike direction was found to follow closely the axis of the Apennines in accordance with both the *stress pattern* (4) indicated for this area by focal mechanism analysis of previous earthquakes and neotectonic evidence. The authors also found an anomalous shift in the origin time for the earthquake, so assuming that it might have been caused by a multiple event, which, however, was regarded as not having caused fault breaking at the surface.

In the same year, the *Gruppo di Lavoro Sismometria del Terremoto del 1980* published an important dataset that will then be used in the following years to both constrain the location and extent of the seismogenic source [22]. In addition, the data contained in Berardi et al. [23], which published the accelerometric recordings of the 1980 earthquake, were subsequently the subject of in-depth analyzes to investigate the complexity of the earthquake rupture mechanism.

As it had already emerged immediately after the event, other studies performed in the early 1980s confirmed the normal faulting mechanism of the earthquake, supplying information about the fault features. For example, Del Pezzo et al. [24], analyzed the seismograms from permanent and temporary stations, located the *hypocenter* (13) of the event, confirming the normal faulting fault-plane solution. Furthermore, analyzing more than 600 aftershocks, the authors found an alignment of events over an area having a length of about 70 km. Arca et al. [25], examining the *waveforms* and the *aftershock distribution* (7), confirmed the normal faulting mechanism suggesting an inhomogeneity of the slip. In addition, the same authors proposed the vertical movements as to be modeled by a normal fault segmented in various branches, with an abrupt stop of the rupture in the NW tip, where the *vertical displacement(s)* (6) reached its maximum values. Deschamps and King [26], starting from far field and local data, performed the *waveform modelling* (8), the fault plane and aftershocks analysis also finding that the 1980 earthquake was a normal event with a large component of left-lateral strike slip.

The year later, the same authors [27], performed detailed analysis of over a thousand of aftershocks founding a reverse faulting in the same area that created a large component of normal faulting in the main event, proposing a speculative model to interpret the unusual findings. The same year, Westaway and Jackson (1984) [28], based on a field survey in the epicentral region, recognized as primary effects environmental evidence that had been interpreted in previous years as gravitational phenomena. Indeed, the authors described for the first time, the 1980 *surface faulting* (28), so starting a new leading research line of the following years (see below) aimed at exploring in depth the location as well as the geometry of the surface rupture caused by the 1980 occurrence. The more than 10 km long faulting was considered as consistent with the focal mechanisms of the event, so concluding that deformation associated with earthquakes in the southern Apennines took place in the upper 10–15 km of the Earth's crust on steep planar normal faults.

In order to gain information on the source model, next studies paid more attention to the fusion of different datasets. For example, Westaway (1985) [29] stressed the importance of different data to both study the complex earthquakes and constraint the sources, combined long-period teleseismic and short-period strong motion *waveform modelling* with field survey of *surface faulting* and other data, and pointed out that the faulting had a segmented geometry in which motion occurred on planar normal faults which broke the surface. Crosson et al. (1986) [30] analyzed the aftershocks, the pattern of strong ground motion, the focal mechanism of the mainshock, and two critically placed leveling profiles, arguing that the 1980 faulting resulted in a complex and uncommon pattern of two high-angle subperpendicular direct faults. The work spurred a scientific discussion the year later [31,32]. On the same year, Westaway and Jackson (1984) [33] correlating teleseismic waveforms, local ground acceleration, elevation changes, surface faulting, and aftershocks investigated the three-dimensional *fault geometry* (11) and the timing of the faulting, which caused about 12 km of surface faulting, so updating the data of Westaway and Jackson [28]. The modelling of long-period teleseismic body waves also allowed to question about the hypocenter and focal mechanism, finding a seismogenic normal fault structure to be approximately planar, with a dip of 60° . Moreover, the authors reported a total of six *subevent(s)*: i) within 10 s of the origin time of the seismic event, the motion happened on three discrete fault segments extending for 30 km along the strike, ii) a fourth subevent occurred about 13 s after the first motion, and iii) two later fault ruptures also arose about 20 and 40 s after the first motion. Some years later, Bernard and Zollo (1989) [34] using strong motion, leveling data, teleseismic waveform modeling and aftershock studies, analyzed the kinematics of the 1980 normal fault confirming the three main rupture episodes at 0, 20, and 40 s.

The use and fusion of *levelling data* (4) with field observations, the last useful to recognize three main strands forming a 38-km-long northwest trending *fault scarp* (9), were envisaged by Pantosti and Valensise (1990) to delineate the faulting model. The fault scarp, with an average strike of 308° , extended between the north-facing slope of Mt. Cervialto (near Lioni, Avellino) and the Pantano di San Gregorio Magno (Salerno). The scarp was 40–100 cm height [35]. Later on, Blumetti et al. (2002) [6] contributed to identify a set of open fractures and south-southwest-dipping normal fault scarps around Castelgrande, Muro Lucano, and Bella, for a total length of about 8 km. These were interpreted by the authors as possibly primary tectonic effect, probably related to the 40 s event.

In 1992 and 1993, Westaway (1992, 1993) [36,37], relocated the *nucleation* (5) point of the fault, also suggesting an updated sequence of rupture subevents. According to the author, the main shock was characterized by seven rupture subevents, among which were the 20 and 40 s ones. The initial fault rupture nucleated at or near the SE end of the Carpineta fault and propagated NW.

In the same years, Amato et al. (1992) [38], based on the velocity distribution at depth, argued that 40 s rupture was the result of reactivation of an old thrust as a normal fault. Further investigations using the inversion of strong motion *waveform(s)* (13) shed light on the spatiotemporal pattern of rupture process, which propagated northwestward [39,40].

Furthermore, 1993 was the year in which many studies regarding the 1980 earthquake were published as results of the Meeting held in Sorrento in 1990 on the 10th anniversary of the earthquake. The works, already published in a preliminary form in the meeting Proceedings, flowed in the final draft form in the Special Issue of “Annali di Geofisica” [14]. Therefore, several articles were published beyond the two already cited just above [39,40].

Amato and Selvaggi (1993) [41], starting from the relocation of about 600 aftershocks, computed a *velocity model* (12) highlighting that the complexity of the Irpinia mainshock was due to the rupture of the highly heterogeneous medium. Giardini (1993) [42], making use of data recorded at teleseismic distance, determined the main seismological parameters, including a focal mechanism with an almost pure dip-slip mechanism. Pingue et al. (1993) [43] modeled the Irpinia source using geodetic data, but integrating and constraining the results with different data sets useful to overcome some limitations of geodetic data alone. The model described three fault segments each of which related to one of the three main rupture episodes of the main shock. Other studies dealt with the investigation on both

0 s subevent to analyze the propagation rupture [44] and second and third ones to constraint their location and mechanism [45]. In the same year, Vaccari et al. (1993) [46] studied the rupture model by the inversion of accelerometric waveform and the comparison between the model-derived synthetic isoseismal and the observed damage patterns.

In the central-lower portion of the red cluster (Figure 5), we can identify some terms related to studies on the stress change caused by the 1980 earthquake. Nostro et al. (1997) [47] assessed the *static stress change* (4) induced by the normal-faulting 1980 earthquake on nearby seismogenic faults, concluding that the Irpinia earthquake caused an increase on both the fault zone active during the 1990 and 1991 events and faults responsible of 1732 (Irpinia) and 1857 (Basilicata) earthquakes. Belardinelli et al. (1999) [48] computed the dynamic spatiotemporal stress changes caused by the rupture of the first subevent (0 s). The modelling showed that after a transient phase, the stress time history evolved to the final static stress value. In particular, the dynamic stress peaked on the *second subevent* (4) fault plane and it was reached between 7 and 8 s after the rupture initiation on the main fault, with the static stress level on the *second subevent* (20 s) fault plane to be reached nearly after 14s.

Other studies in 2000s, continued to investigate the source and the faulting mechanism using inversion of coseismic *vertical displacement* (6) data [49], *relocation* (4) of the main event, P-wave velocity *inversion (procedure)* (5), and analysis of postseismic *ground deformation* (6) [50].

4.1.1.1. Studies of the Seismic Source by Paleoseismological and Geophysical Investigations

In the lower part of the cluster, we can trace some terms identifying both direct (paleoseismological) and indirect (geophysical) investigations on the Irpinia fault.

The paleoseismological studies started in the late 1980s following the identification of 1980 surface faulting by Westaway and Jackson (1984) [28].

Pantosti et al. (1989) [51] built a thorough mapping of the 35 km-long sector of NW trending NE-facing *scarp(s)* (6) related to the earthquake. In the central part of the surface rupture (Piano di Pecore), the *trench(es)* (14) dug showed a surface displacement of 85 cm, also identifying other three previous paleoearthquakes, beyond the 1980 event.

Two new trenches were excavated in 1990 at Pantano di San Gregorio Magno, an elongated depression located close to the southern end of the Irpinia fault. Four pre-1980 paleoearthquakes were identified, so suggesting the first data on both earthquake recurrence intervals and slip per event, as well as the *slip rate* (12) on the fault (e.g., [52–54]).

In the 2000s, some studies were also oriented to the geophysical investigations of the structure of the Irpinia fault. For example, Improta et al. (2003) [55] performed a high-resolution multifold wide-angle seismic survey carried out across the scarp to investigate the shallow structure of the fault. Bruno et al. (2010) [56] carried out a two-step imaging method to dense wide-aperture data with the goal of imaging the Irpinia fault in its complex geologic setting. Galli et al. (2014a) [57] performed integrated and complex geophysical investigation (electrical resistivity tomography, ground penetrating radar measurements, and horizontal-to-vertical spectral ratio microtremor analysis) along the fault, so supplying a subsurface image of the near-surface fault architecture. Geophysical survey jointly with previous paleoseismological studies allowed the assessment of some fault parameters and the precise locating of the fault trace. Galli et al. (2014b) [58] identified, across the active Mount Marzano Fault System, several clusters of inflection points that, once compared with *historical seismicity* (5) of the area, gathered paleoseismological data along some significant segments of the fault, and previous geophysical investigation (Galli et al., 2014a) [57] allowed to make new considerations about the present *slip rate* and recurrence time for high-magnitude earthquakes.

Vassallo et al. (2016) [59] correlating the ambient noise recorded at broadband stations, found a *low-velocity* anomaly in the area bounded by the two main faults that caused the 1980 earthquake. Furthermore, Lo Re et al. (2016) [60] performed a microgravity survey to precisely locate and better characterize the near-surface geometry of a segment of the Irpinia Fault.

4.2. Cluster 2 (Green)

The green cluster may be subdivided in at least four main subclusters related to research on: (1) Earthquake Secondary Effects (ESE); (2) Disaster Response and Recovery (DRR), (3) Disaster EPidemiology (DEP); and (4) BUILDing and infrastructure damage, vulnerability, seismic RISK assessment and mitigation (including seismic microzonation studies) (BUILDRISK).

4.2.1. Earthquake Secondary Effects (ESE)

The subcluster, in the lower-left portion, includes studies on slope movements, ground cracks, hydrological anomalies, and liquefaction phenomena.

The studies dealing in some way with the *landslide(s)* (52) triggered by the 1980 earthquake cover almost the entire study period analyzed in this article. First works on the subject were those examining the *reactivation* (13) of old landslides in Senerchia, in the Sele River valley [61–63]. The early 1980s also saw studies on liquefaction phenomena [64].

Further research looked at the landslide phenomena in many other localities or areas. We refer to the Sauro torrent, near the village of Stigliano, in the basin of the Agri River [61] Calitri [65–67], an area close to Atella [68], the Upper Valley of Sele River [69], the Valley of Tammaro River [70], and in the Mounts Cervialto and Terminio-Tuoro [71].

While these works, as well as most of the papers published over the following decades, looked at the earthquake-induced landslides in specific areas or towns, Alexander (1981) [72] examined the *hazard(s)* (40), mechanisms and the effects of landsliding provoked by the 1980 earthquake at a wider territorial scale, both in Basilicata and Campania regions. The effects of the induced mass-movement were considered with respect to the slope instability and damage to both settlements and infrastructures. Furthermore, the author also framed the landslide problem within the historical, social, political, and economic factors. As regards the latter, the author underlined as poor conservation of soil in Italy determined that 46% of soil was vulnerable to landslides after flooding, erosion and earthquakes.

About two decades after, Porfido et al. (2002) [73], in line with a wide-ranging analysis of earthquake-induced landslides, performed a systematic overview of the territorial spreading of *ground effect(s)* (9) induced by two strong earthquakes in the southern Italian Apennines, among which just the 1980 event. The authors also shown a likely correlation between maximum distance of effects and length of the reactivated fault zone. Five years later, Porfido et al. (2007) [74] discussed the seismically induced environmental effects extending the study to three strong earthquakes occurred in the Southern Italian Apennines.

In the term map (Figure 5), we can observe a certain closeness between the “landslide” and “spring” terms. This link recalls, e.g., the studies relating to the change in spring flows due to the sliding process triggered by the earthquake [75] or the influence of spring flow increase on the slope failures in the Sele valley [76].

Other terms in the map, such as hazard, indicate the complexity and importance of the landslide studies. Del Prete (1993) [77] discussed two examples of mudslide hazards in the Upper Sele Valley concluding, among other things, that this type of landslide is prone to be reactivated especially due to the seismic shaking. Some years later, Parise and Wasowski (1999) [78] dealt with the assessment of landslide hazard in some areas of the Southern Apennines hit by the 1980 earthquake. The aim was reached by the preliminary building of the landslide activity maps integrating different source of information. The authors, estimating the areal frequency of active landsliding for the last 40 years, argued the significant impact that the 1980 earthquake had on the stability of slopes located close to epicenter. The Upper Sele Valley was also considered by investigations of Capolongo et al. (2002) [79]. The authors evaluated the earthquake-triggered landslide hazard integrating different data into a typical earthquake stability model of slope to assess the landslide potential during the 1980 earthquake in the Valley.

As regards the proximity between *landslide* and *database* (14) this can be justified, e.g., by the building of the list of earthquake-induced ground failures in Italy (Italian acronym CEDIT), which collects data

regarding landslides, liquefactions, ground cracks, surface faulting, and ground changes triggered by strong earthquakes (e.g., [80]).

4.2.2. Disaster Response and Recovery (DRR)

The issue of reconstruction was already considered in the early 1980s jointly with the analysis of the emergency phase (e.g., [81–83]).

D'Souza (1982) [84] dealt with the recovery and rebuilding in two communities of Southern Italy, showing that the combination of appropriate aid and effective leadership affect strongly the efficacy for recovery. The same author in 1984 (D'Souza, 1984) [85], analyzing one community living in a village of Salerno province (Campania region), debated that outside aid to the affected area should encourage and sustain indigenous solutions as well as the use of community's own skills and resources. The same year, Alexander (1984) [86] considered the policies implemented by the institutions in two phases, the first involving the relocation of the survivors in temporary prefabricated homes and the second concerning the reconstruction of permanent housings. The author sustained that the financial aids for the rebuilding process was reduced in efficacy due to bureaucratic delays, legal complexities, and inequality in the distribution of economic resources. The author also argued that the occurrence of other natural hazards in the aftermath of the 1980 earthquake had an increasing effect in the formation, in 1982, of a Ministry for Civil Protection with the consequent strengthening of both disaster relief and prevention actions.

Caporale et al. (1985) [87] sustained that there were highly differentiated patterns of recovery in the different villages affected by the earthquake. Therefore, the authors examined the social, economic, and political factors responsible for the differences to draw policy implications for emergency management, reconstruction strategies, and intervention policies.

Some years later Alexander (1989) [88], discussing on how preserving the identity of small settlements during the large-scale phase of reconstruction, analyzed the impact on the urban landscape of temporary shelter and reconstruction. Furthermore, the author argued that inconsistencies in government reconstruction funding were the cause for much of the variability of postdisaster recovery in Italy, concluding that the existing theoretical models were inadequate to predict the development of the rebuilding phase.

Many years later, Chubb (2002) [89] analyzed comparatively the government response to three earthquakes such as the Belice 1968, Friuli 1976, and 1980 one.

Other studies were performed on the reconstruction over the following years. For example, Forino et al. (2015) [90] reflected on the relationship between state-driven developmental policies and postwar territorial transformations in southern Italy. To do this, they also analyzed to what extent the measures for industrial recovery and settlement reconstruction put into the field after the 1980 earthquake in Campania and Basilicata affected soil resource depletion and land degradation. The authors found manifold links between the post-war economic policy and the downward environmental spiral observed in southern Italy.

Recently, Porfido et al. (2017) [91] scrutinized the in situ reconstruction of two villages as well as the rebuilding of another village that was rebuilt far from its original place. Downstream of their analyses, the authors stressed the key role of technical experts both in the built environment and in social as well as ethical context for the proper rebuilding of villages, having particularly the people resilience in mind.

4.2.3. Disaster Epidemiology (DEP)

Looking at the right-terminal portion of the green cluster, close and correlated to the disaster response/recovery subcluster, we can notice a group of terms headed by the word *epidemiology* (10).

These terms and the related ones, reflect empirical studies carried out mainly in the 1980s on the epidemiological consequences of the 1980 earthquake. For example, Greco et al. (1981) [92] performed three typologies of surveys aimed at the: (1) surveillance of hospital admissions of the *survivor(s)*,

(2) surveillance of infectious *disease(s)* (4) among the survivors, and (3) statistical analysis of mortality and traumatic injury in the survivor(s). The authors concluded that earthquakes do not necessarily cause epidemics nor make the epidemiology of infectious illness worse as respect the predisaster situation. Alexander (1982) [93], analyzing the disease epidemiology of the earthquake and the health service response in the *emergency phase* (4), concluded that there were no serious epidemics and the hospital system was able to cope with the aftermath needs. The author also underlined as the national plan of vaccination of both survivors and rescue volunteers was probably an overreaction of institutions with respect to the dominant epidemiological condition.

Three years later, Bruycker et al. (1985) [94] analyzed the *morbidity* (number of injured) (3) and *mortality* (7) after the 1980 earthquake based on a sample of over 3600 people of near-epicenter *village(s)*. They found that *injury* (6) rates were more than five times higher in trapped than in nontrapped victims and chance for escape was vital for *survival* (3) and interconnected with the seismic vulnerability of buildings. The disaster response analysis performed by the authors, also indicated that the emergency phase for medical care was limited to the 3–4 days after the earthquake occurrence.

4.2.4. Building and Infrastructure Damage, Vulnerability, Risk Assessment, and Mitigation (BUILDRISK)

One of the first works regarded the analysis of the damage on different structures, such as *building(s)* (38) and *bridge(s)*, was performed by a Swiss reconnaissance team who surveyed the most affected area about 3 weeks later the earthquake occurrence [95]. In addition, Guepinar et al. (1981) [96] performed a 7-day field trip at the end of January 1981, paying special attention to the damage caused by soil failures or soil–structure interaction.

Postpischl together with other authors published some progress reports on the macroseismic surveys in the affected area starting from 1981 (e.g., [97,98]) until the work of Postpischl et al. (1985) [99] in which the isoseismal maps of the 1980 earthquake were published in an Atlas.

Coburn et al. (1982) [100] described the typical forms of local buildings classifying them. Furthermore, the type and *damage level* (4) analyzed in relation to building type, location, and ground movement were also considered. The researchers found that local damage level correlated well with both instrumental and spectral acceleration. Further analyses on both building damage and behavior of (reinforced) *concrete building* (3) (e.g., [101–103]) were also performed in the following years.

Braga et al. (1982) [104] in order to define the damage probability matrices (DPMs) for the most common types of buildings, performed a statistical study on damaged buildings in 41 municipalities affected by the earthquake. The vulnerability assessment through the DPMs was tested for the first time just after the 1980 earthquake, using the MSK-1976 as reference macroseismic scale. Moreover, the same authors [105], based on their experience on damage survey after the 1980 event discussed a quick method for damage assessment of dwelling buildings. The approach was aimed to setup well-grounded policy for *reconstruction*.

More recently, other studies analyzed statistically large data set of damaged buildings allowing deriving empirical *fragility curve(s)* (4) to define seismic vulnerability of classes of buildings. For example, Rota et al. (2008) [106] derived typological fragility curves starting from a reanalysis of a set of about 150,000 survey building records related to postearthquake data on *damaged building(s)* (4) for the Italian earthquakes of the last three decades. Recently, Del Gaudio et al. (2020) [107], in order to define fragility curves, investigated a set of about 25,000 residential (reinforced) *concrete building(s)* derived from a sample originating from the Web-GIS platform named “Da.D.O.” (Observed Damage Database) [108].

Within the subcluster, we find also research related to the microzonation studies of some towns heavily affected by the 1980 earthquake (e.g., [109–112]). After the 1980 event, the new rules imposed that general development urban plans had to be prearranged according to site conditions [109]. However, the first studies on microzonation came back to the early 1980s when the study on seismic microzonation in the emergency phase were performed within the framework of the Italian Geodynamics Project [113,114].

4.3. Cluster 3 (Blue) (GRM)

The third cluster, in the topmost portion of the VOSviewer map, refers mainly to studies concerning the estimations of seismic ground motion of 1980 earthquake and site effect analysis in localities hit by the 1980 earthquake also using in situ geophysical surveys.

For example, Rovelli et al. (1988) [115], analyzing horizontal components of many accelerogram related to moderate and strong normal faulting earthquakes happened in the Italian Central and Southern Apennines, proposed a numerical simulation of *seismic ground motion* (9) peak values as a function of the earthquake size, for seismic risk purpose. Bosco et al. (1992) [116] presented a possible procedure to build artificial acceleration time histories (peak acceleration, response spectra, and envelope curves of the acceleration time history) of bedrock motion consistent with records of past events such as the 1980 Irpinia earthquake. Convertito et al. (2010) [117], using the Irpinia Seismic Network and the 1980 earthquake data, developed a fast procedure to get ground-shaking maps in view of damages and loss assessment for seismic emergency management in high seismic risk areas, such as Campania and Basilicata. They found the approach useful to predict peak ground-motion parameters of high-magnitude events regarding the attenuation relationship. Cultrera et al. (2013) [118] computed hybrid shakemaps for the 1980 earthquake integrating recorded data with deterministic-stochastic method, finding results different from the standard analysis, in the near-fault area, especially. They also found an agreement between peak ground velocity (PGV)-derived Mercalli–Cancani–Sieberg (MCS) intensities and the observed damage.

Nunziata et al. (2000) [119] simulated the *seismic ground motion* generated by the 1980 earthquake in Naples adopting the *hybrid technique* based on the *mode summation* (7) and the *finite difference method*(s) (6). The numerical approach was validated with the 1980 earthquake data recorded at a 10 km-away site. The application to a sample area located in the eastern district of Naples, for which the basic data were well known, allowed modeling the seismic response. Data showed the surficial cover as responsible of an increase in the amplitudes of the signal as respect to the bedrock. Di Giulio et al. (2008) [120] studied the variations of local seismic response for the entire urban area of Benevento (Southern Italy), making a large use of ambient noise recordings, seismic, geological, and geotechnical data. The authors also generated synthetic seismograms of moderate to strong earthquakes among which was the 1980 Irpinia earthquake, finding large amplification at soft soils. Maresca et al. (2012) and Maresca et al. (2018) [121,122] analyzed the effects of surface geology on *seismic ground motion* in Avellino using HVSR (horizontal-to-vertical spectral ratio) free-field peak frequency analysis, also correlating the data with the 1980 urban damage pattern.

5. Statistic of Documents by Topics

A cross-correlated analysis of VOSviewer outputs with the two databases allowed analyzing the total number of documents for each topic (Figure 7) as well as its trend over time (Figure 8). The analysis was also made for the IR_BASE_IT database, consulting the records and manually associating them to each of the cluster(s) identified by the IR_BASE_ENG analysis. Each figure reports data both for the two databases taken separately and fused (SUM).

Figure 7 shows the total number of records for each topic(s), the last including also the records for which an attribution was performed for more than one category. The highest number of documents in IR_BASE_ENG is related to the study of the seismic source (SOURCE) for which 153 (29.9% of 512 documents) documents were published. This follows the groups of documents relating to earthquake secondary effects (ESE) with 88 papers (17.2%), BUILDRISK (84, 16.4%), DRR (52, 10.2%), and GRM (34, 6.6%). Regarding IR_BASE_IT, the largest amount of records in the database is relating to the BUILDRISK topic (32, 25.8% of 124 documents). Next, the documents relating to secondary seismic effects (ESE), with 30 (24.2%) papers are present, followed by those concerning the study of the seismic source (SOURCE, 25, 20.2%). What is more, the database includes only one document related to the disaster epidemiology cluster (DEP).

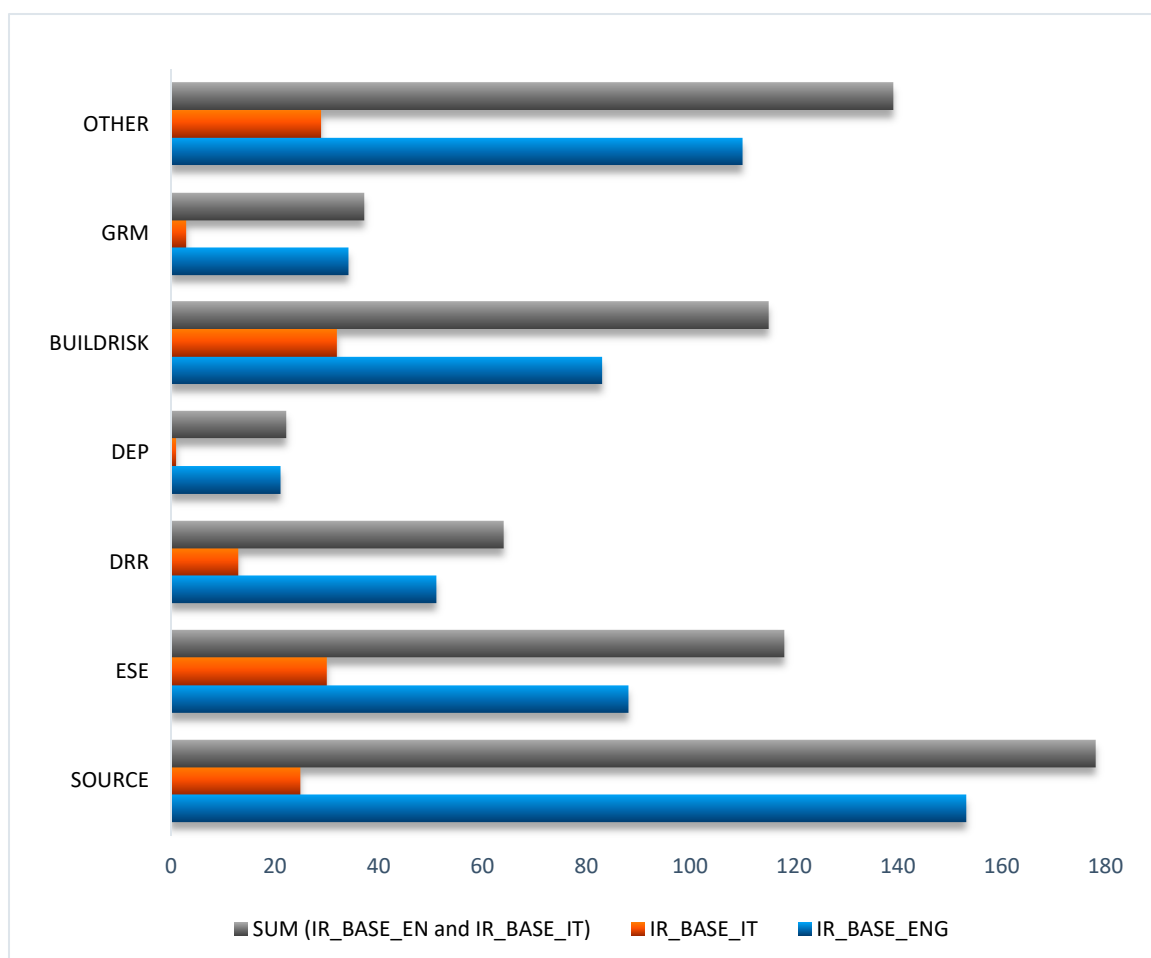


Figure 7. Total number of documents for each database and topic/(sub)cluster.

Looking at the SUM of the two databases, we can see that the relative frequencies of documents in the topics reflect those of IR_BASE_ENG, so confirming that the scientific community addressed efforts mainly in learning about the source mechanism, as discussed in the minireview of the previous sections. Obviously, the two databases also include records that do not mirror the belonging to the (sub)clusters/topics discussed in the previous sections. This is due to the thresholds used to build the term map. These records amount at about 140 (OTHER). They can be referred to different studies such as those on the geological and seismotectonic aspects of the epicentral area of the earthquake, research relating to the study of precursors of the seismic events, papers concerning geotechnical phenomena as well as those dealing with the social and demographic long-term impact of the natural extreme event. However, in order to shed light on details of these research outcomes, further investigations are required.

Figure 8, which should be read in conjunction with Figure 7, represents the temporal trend of documents published yearly by each topic in both the databases (IR_BASE_ENG and IR_BASE_IT) as well as in their joint one (SUM). For clarity, the SUM section also reports the number of documents published yearly, which is directly proportional to the bar heights.

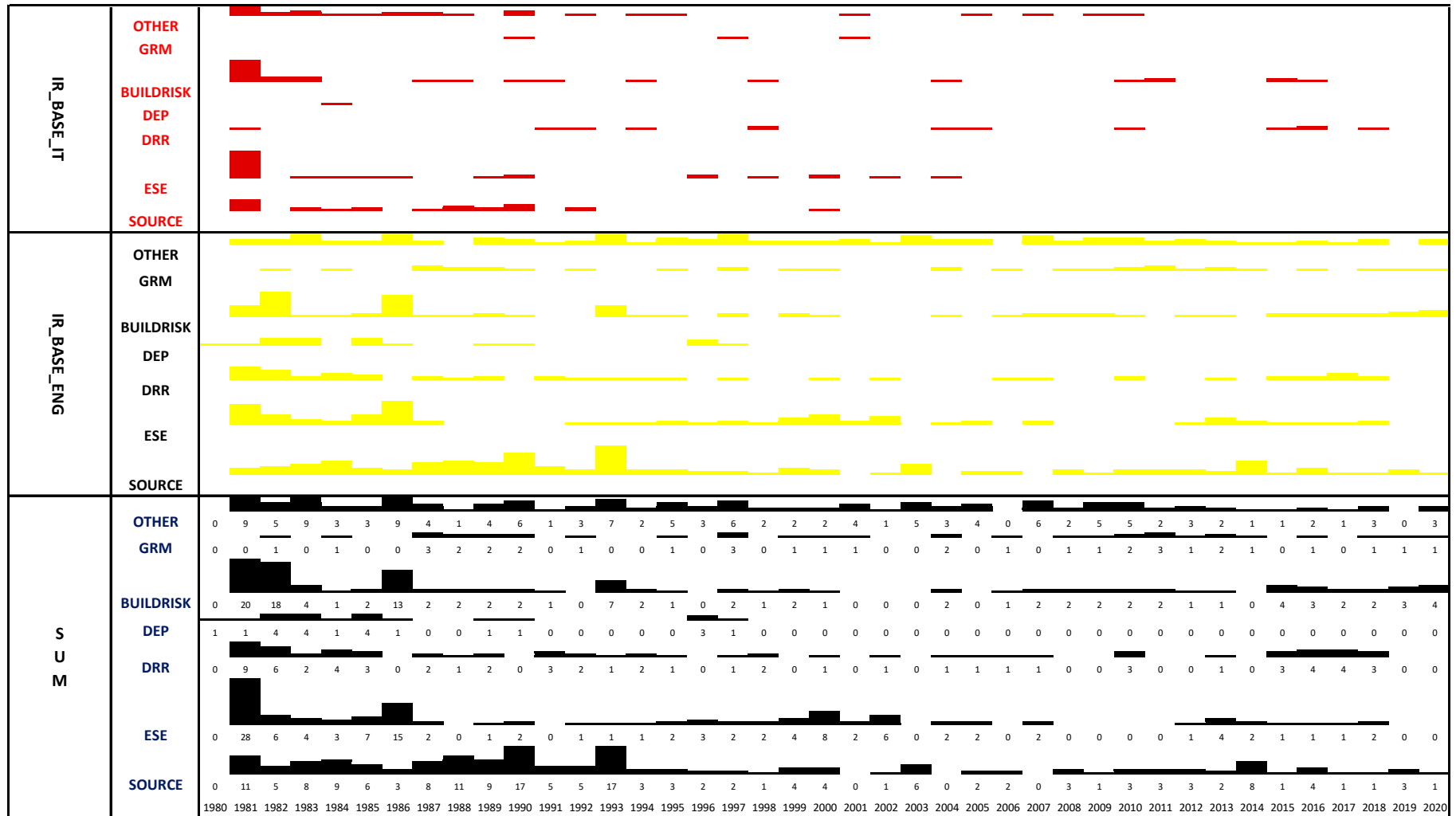


Figure 8. Number of records for each topic over time.

From the three sections of the graph, one can see that for almost all the topics, the documents are mainly distributed by the mid-1990s. In particular, the analysis of the SUM data for the SOURCE field shows a temporal continuity over the entire 40-year long period, even if the number of documents is decreasing over time, with as many as 64.0% of items published by 1993. There are two main peaks, at 1990 and 1993. These can be explained by the works published for the meeting held in Sorrento and the publication of the *Annali di Geofisica* Special Issue (see previous minireview sections, SOURCE). There is less temporal continuity for studies relating to secondary seismic effects (ESE), which show higher concentration in the first half of the 1980s (53.4% of documents published by the year 1986), with special attention to 1981 (28 items, 23.7%). Studies relating to DRR display higher frequency in the first half of the 1980s, but research also continued in the following decades, albeit in a discontinuous way. Epidemiological studies (DEP) almost exclusively characterize the 1980s, because of the predominantly empirical nature of the research. The BUILDRISK topic also shows a higher frequency in the first half of the 1980s, with continuity throughout the following decades. The OTHER studies cover the whole period under examination here, thus confirming that the 1980 earthquake was a full-scale laboratory for investigating several and different aspects.

Due to the high statistical weight of the IR_BASE_ENG records (~80%) compared to the two databases taken cumulatively, the temporal pattern of IR_BASE_ENG can be roughly overlapped on that of SUM. Conversely, the documents of IR_BASE_IT are mainly distributed in the 1980s and concern chiefly papers in the SOURCE (72.0%), ESE (70.0%), BUILDRISK (65.6%), and OTHER (62.1%) topics. Furthermore, the publication of documents is markedly irregular and decreasing for the other three decades. This can be explained by a greater propensity on the part of scientists to publish in international journals for higher visibility of the research.

6. Conclusions

The paper has shed light on the scientific landscape related to the 1980 Irpinia-Basilicata earthquake ($M_e=6.7$ [1]; $M_w=6.9$ [123]) from its occurrence until now. In order to reach the aim, the authors performed a tailored procedure to build two databases of both international and national (Italian) studies.

Overall, in the almost 40-year period, about 640 documents were published, which cover each year of the time window analyzed. Furthermore, research involved a high number of authors over the years, confirming the high complexity of the natural event that involved many different competencies by researchers.

Publications include studies on the seismic source, environmental effects, earthquake damage, seismic microzonation, disaster response and recovery, disaster epidemiology, ground motion estimations, and other research. Except for the epidemiological studies, which only cover part of the 1980s and mid-1990s, the scientific outputs are concentrated especially in the 1980s and early 1990s. However, investigations characterized also other decades, the studies of seismic source especially, which will probably be a leading research area in the coming years as well.

The study confirms that the earthquake was a significant occasion for the scientific community to grow the knowledge on the seismic phenomena, as well as to learn lessons in view of setting up preventive actions to mitigate the seismic risk.

Limitations

Three main limitations can be referred to this study. First, the unfeasibility to prepare all-inclusive search queries to search for documents might have left out some relevant items. Second, the number of oldest documents may be underestimated, for the 1980s, especially, due to the lower coverage of the citation indexes as well as the frequent lack of abstracts that we found both in Scopus and in Web of Science. This prevents the query from properly interrogating the mother databases from which we extracted the 1980 bibliographic data. Third, the search for the building of IR_BASE_IT database was performed only considering the document titles. However, overall, the documents retrieved and

analyzed here can be considered as a reliable cross-section of the main research activities performed on the Irpinia-Basilicata earthquake over time.

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Appendix A

Search terms considered to interrogate Scopus and WoS. “November 1980” earthquake*; “1980 november 23”; “23 november 1980”; “november 23 1980”; “23rd November 1980”; “november 23rd, 1980”; “23-11-1980”; Irpinia* 1980; “1980 earthquake*”; 1980 earthquake* Italy; 1980 “South* Ital* earthquake*”; 1980 Basilicata earthquake*; “Irpinia* earthquake*”; “Campania-lucania” earthquake*; “Campania earthquake*”; “campania-basilicata” earthquake*; “irpinia* fault”; “strong earthquake*” Italy; “large earthquake*” Italy; “large earthquake*” South* Apennine; Ital* 1980 “seismic event*”; earthquake* “South* Apennine.”

References

1. Guidoboni, E.; Ferrari, G.; Mariotti, D.; Comastri, A.; Tarabusi, G.; Sgattoni, G.; Valensise, G. *CFTI5Med, Catalogo dei Forti Terremoti in Italia (461 a.C.-1997) e Nell’area Mediterranea (760 a.C.-1500)*; Istituto Nazionale di Geofisica e Vulcanologia (INGV): Rome, Italy, 2018. [CrossRef]
2. Commissione Parlamentare D’Inchiesta. 1991—Commissione Parlamentare D’inchiesta Sulla Attuazione Degli Interventi per la Ricostruzione e lo Sviluppo dei Territori Della Basilicata e Della Campania Colpiti dai Terremoti del Novembre 1980 e Febbraio 1981, Relazione Conclusiva e Propositiva, Vol. I, Tomo I. 1991. Available online: <http://www.senato.it/leg/10/BGT/Schede/docnonleg/30412.htm> (accessed on 20 June 2020). (In Italian)
3. Pantosti, D.; Valensise, G. Faulting mechanism and complexity of the November 23, 1980, Campania- Lucania earthquake, inferred from surface observations. *J. Geophys. Res.* **1990**, *95*, 15319–15341. [CrossRef]
4. Cotecchia, V. Ground deformations and slope instability produced by the earthquake of 23 November 1980 in Campania and Basilicata. *Geol. Appl. Idrogeol.* **1986**, *21*, 31–100.
5. Esposito, E.; Gargiulo, A.; Iaccarino, G.M.; Porfido, S. Distribuzione dei Fenomeni Franosi Riattivati dai Terremoti dell’Appennino Meridionale. In Proceedings of the Censimento Delle Frane del Terremoto del 1980. Proc. Intern. Convention on Prevention of Hydrogeological Hazards, CNR(IRPI), Torino, I, Alba, Torino, Italy, 5–7 November 1996; pp. 409–429. (In Italian)
6. Blumetti, A.M.; Esposito, E.; Ferrel, L.; Michetti, A.M.; Porfido, S.; Serva, L.; Vittori, E. New Data and Reinterpretation of the November 23, 1980, M 6.9, Irpinia-Lucania Earthquake (Southern Apennine) Coseismic Surface Effects. In Proceedings of the International Workshop “Large-Scale Vertical Movements and Related Gravitational Processes” Special Issue, Studi Geologici Camerti, Siena, Italy, 20–21 September 2002; pp. 19–27.
7. Waltman, L.; Van Eck, N.J.; Noyons, E. A unified approach to mapping and clustering of bibliometric networks. *J. Infometr.* **2010**, *4*, 629–635. [CrossRef]
8. Liu, X.; Zhan, F.B.; Hong, S.; Niu, B.; Liu, Y. A bibliometric study of earthquake research: 1900–2010. *Scientometrics* **2012**, *92*, 747–765. [CrossRef]
9. Stahl, B.C.; Heersmink, R.; Goujon, P.; Flick, C.; van den Hoven, J.; Wakunuma, K.; Ikonen, V.; Rader, M. Identifying the ethics of emerging information and communication technologies: An essay on issues, concepts and method. In *Ethical Impact of Technological Advancements and Applications in Society*; Luppincini, R., Ed.; Information Science Reference: Hershey, PA, USA, 2012; pp. 61–79.

10. Gizzi, F.T.; Leucci, G. Global Research Patterns on Ground Penetrating Radar (GPR). *Surv. Geophys.* **2018**, *39*, 1039–1068. [[CrossRef](#)]
11. Knapczyk, A.; Francik, S.; Pedryc, N.; Hebda, T. Bibliometric analysis of research trends in engineering for rural development. In Proceedings of the 17th International Scientific Conference Engineering for Rural Development, Jelgava, Latvia, 23–25 May 2018; pp. 700–707. [[CrossRef](#)]
12. Krauskopf, E. A bibliometric analysis of the Journal of Infection and Public Health: 2008–2016. *J. Infect. Public Health* **2018**, *11*, 224–229. [[CrossRef](#)]
13. Guz, A.N.; Rushchitsky, J.J. Scopus: A system for the evaluation of scientific journals. *Int. Appl. Mech.* **2009**, *45*, 351–362. [[CrossRef](#)]
14. Boschi, E.; Pantosti, D.; Slejko, D.; Stucchi, M.; Valensise, G. Special Issue on the meeting “Irpinia Dieci Anni Dopo”. *Ann. Geofis.* **1993**, *36*, 351.
15. Valensise, G. Summary of Contributions on the 23 November 1980, Irpinia earthquake. *Ann. Geofis.* **1993**, *XXXVI*, 345–351.
16. Bartol, T.; Mackiewicz-Talarczyk, M. Bibliometric analysis of publishing trends in fiber crops in Google Scholar, Scopus, and Web of Science. *J. Nat. Fibers* **2015**, *12*, 531–541. [[CrossRef](#)]
17. Choudhury, M.; Chatterjee, D.; Mukherjee, A. Global topology of word co-occurrence networks: Beyond the two-regime power-law. In Proceedings of the International Conference on Computational Linguistics, Beijing, China, 23–27 August 2010; pp. 162–170.
18. Van Rijsbergen, C.J. A theoretical basis for the use of co-occurrence data in information retrieval. *J. Doc.* **1977**, *33*, 106–119. [[CrossRef](#)]
19. Van Eck, N.J.; Waltman, L. Text mining and visualization using VOSviewer. *ISSI Newsl.* **2011**, *7*, 50–54.
20. Van Eck, N.J.; Waltman, L. Visualizing bibliometric networks. In *Measuring Scholarly Impact: Methods and Practice*; Ding, Y., Rousseau, R., Wolfram, D., Eds.; Springer: Berlin/Heidelberg, Germany, 2014; pp. 285–320.
21. Boschi, E.; Mulargia, F.; Mantovani, E.; Bonafede, M.; Dziewonski, A.M.; Woodhouse, J.H. The Irpinia earthquake of November 23, 1980. *EOS* **1981**, *62*, 330.
22. Scarpa, R.; RAPP, S.R. Sismometria del Terremoto del 23/11/1980. Il terremoto campano-lucano del 23.11. 1980: Elaborazione dati sismometrici. *Rend. Soc. Geol. Ital.* **1981**, *4*, 427–450.
23. Berardi, R.; Berenzi, A.; Capozza, F. *Campania-Lucania Earthquake on 23 November 1980: Accelerometric Recordings of the Main Quake and Relating Processing*; Technical Report, Ente Nazionale per l’Energia Elettrica (ENEL); Contribution to the Annual Convention of the Italian National Research Project on Italian Seismicity: Udine, Italy, 1981; pp. 1–103.
24. Del Pezzo, E.; Iannaccone, G.; Martini, M.; Scarpa, R. The 23 november 1980 Southern Italy Earthquake. *Bull. Seismol. Soc. Am.* **1983**, *73*, 187–200.
25. Arca, S.; Marchioni, A. I movimenti verticali del suolo nelle zone della Campania et della Basilicata interessate dal sisma del novembre 1980. *Boll. Geod. Sci. Affin.* **1983**, *42*, 125–135.
26. Deschamps, A.; King, G.C.P. The Campania-Lucania (southern Italy) earthquake of 23 November 1980. *Earth planet. Sci. Lett.* **1983**, *62*, 296–304.
27. Deschamps, A.; King, G.C.P. Aftershocks of the Campania-Lucania (Italy) earthquake of 23 November 1980. *Bull. Seismol. Soc. Am.* **1984**, *74*, 2483–2517.
28. Westaway, R.; Jackson, J. Surface faulting in the southern Italian Campania-Basilicata earthquake of 23 November 1980. *Nature* **1984**, *312*, 436–438. [[CrossRef](#)]
29. Westaway, R. Geometry of faulting in the Campania-Basilicata (Southern Italy) earthquake of 23rd November 1980. *Geophys. J. R. Astron. Soc.* **1985**, *81*, 335.
30. Crosson, R.S.; Martini, M.; Scarpa, R.; Key, S.C. The southern Italy earthquake of 23 November 1980: An unusual pattern of faulting. *Bull. Seismol. Soc. Am.* **1986**, *76*, 381–394.
31. Crosson, R.S.; Martini, M.; Scarpa, R.; Key, S.C. The southern Italy earthquake of 23 November 1980: An unusual pattern of faulting. Reply. *Bull. Seismol. Soc. Am.* **1987**, *77*, 1075–1077.
32. Westaway, R. The Southern Italy earthquake of 23 November 1980—An unusual pattern of faulting—Comment. *Bull. Seismol. Soc. Am.* **1987**, *77*, 1071–1074.
33. Westaway, R.; Jackson, J. The earthquake of 1980 November 23 in Campania–Basilicata (southern Italy). *Geophys. J. R. Astron. Soc.* **1987**, *90*, 375–443. [[CrossRef](#)]
34. Bernard, P.; Zollo, A. The Irpinia (Italy) 1980 earthquake: Detailed analysis of a complex normal faulting. *J. Geophys. Res.* **1989**, *94*, 1631–1647. [[CrossRef](#)]

35. Pantosti, D.; Valensise, G. Source geometry and long-term behavior of the 1980, Irpinia earthquake fault based on field geologic observations. *Ann. Geofis.* **1993**, *36*, 41–43.
36. Westaway, R. Revised hypocentre and fault rupture geometry for the 1980 November 23 Campania-Basilicata earthquake in southern Italy. *Geophys. J. Int.* **1992**, *109*, 376–390. [[CrossRef](#)]
37. Westaway, R. Fault rupture geometry for the 1980 Irpinia earthquake: A working hypothesis. *Ann. Geofis.* **1993**, *36*, 51–69.
38. Amato, A.; Chiarabba, C.; Malagnini, L.; Selvaggi, G. Three-dimensional P-velocity structure in the region of the MS = 6.9 Irpinia, Italy, normal faulting earthquake. *Phys. Earth Planet. Inter.* **1992**, *75*, 111–119. [[CrossRef](#)]
39. Cocco, M.; Pacor, F. The rupture process of the 1980 Irpinia, Italy, earthquake from the inversion of strong motion waveforms. *Tectonophysics* **1993**, *218*, 157–177. [[CrossRef](#)]
40. Cocco, M.; Pacor, F. Space-time evolution of the rupture process from the inversion of strong-motion waveforms. *Ann. Geofis.* **1993**, *36*, 109–130.
41. Amato, A.; Selvaggi, G. Aftershock location and P-velocity structure in the epicentral region of the 1980 Irpinia earthquake. *Ann. Geofis.* **1993**, *1*, 3–15.
42. Giardini, D. Teleseismic observation of the November 23 1980, Irpinia earthquake. *Ann. Geofis.* **1993**, *36*, 17–25.
43. Pingue, F.; De Natale, G.; Briole, P. Modeling of the 1980 Irpinia earthquake source: Constraints from geodetic data. *Ann. Geofis.* **1993**, *1*, 27–40.
44. Sirovich, L.; Chiaruttini, C. The influence of source complexity on the polarization and azimuthal radiation of S-Waves, and a simplified synthesis of the macroseismic field. *Ann. Geofis.* **1993**, *1*, 81–91.
45. Bernard, P.; Zollo, A.; Trifu, C.I.; Herrero, A. Details of the rupture kinematics and mechanism of the 1980 Irpinia earthquake: New results and remaining questions. *Ann. Geofis.* **1993**, *1*, 71–80.
46. Vaccari, F.; Harabaglia, P.; Suhadolc, P.; Panza, G.F. The Irpinia (Italy) 1980 earthquake: Waveform modelling of accelerometric data and macroseismic considerations. *Ann. Geofis.* **1993**, *1*, 93–108.
47. Nostro, C.; Cocco, M.; Belardinelli, M.E. Static stress changes in extensional regimes: An application to southern Apennines (Italy). *Bull. Seismol. Soc. Am.* **1997**, *87*, 234–248.
48. Belardinelli, M.E.; Cocco, M.; Coutant, O.; Cotton, F. Redistribution of dynamic stress during coseismic ruptures: Evidence for fault interaction and earthquake triggering. *J. Geophys. Res. Solid Earth* **1999**, *104*, 14925–14945. [[CrossRef](#)]
49. Amoruso, A.; Crescentini, L.; Scarpa, R. Faulting geometry for the complex 1980 Campania-Lucania earthquake from levelling data. *Geophys. J. Int.* **2005**, *162*, 156–168. [[CrossRef](#)]
50. Amoruso, A.; Crescentini, L.; Di Lieto, B.; Scarpa, R. Faulting mechanism of the Campania-Lucania 1980 earthquake, Italy, from high-resolution, 3D velocity structure, aftershock relocation, fault-plane solutions, and post-seismic deformation modeling. *Ann. Geophys.* **2011**, *54*, 806–821.
51. Pantosti, D.; Schwartz, D.P.; Valensise, G. Paleoseismologic and geomorphic observations along the 1980 Irpinia surface fault rupture, southern Apennines (Italy). *EOS Trans. AGU* **1989**, *70*, 1349.
52. D’Addezio, G.; Pantosti, D.; Valensise, G. Paleoseismicity along the Irpinia fault at Pantano di San Gregorio Magno (Southern Italy). *Alp. Mediterr. Quat.* **1991**, *4*, 121–135.
53. Pantosti, D.; D’Addezio, G.; Cinti, F.R. Paleoseismological Evidence of Repeated Large Earthquakes along the 1980 Irpinia Earthquake Fault. *Ann. Geofis.* **1993**, *36*, 321–330.
54. Pantosti, D.; Schwartz, D.P.; Valensise, G. Paleoseismology along the 1980 surface rupture of the Irpinia fault: Implications for earthquake recurrence in the southern Apennines, Italy. *J. Geophys. Res. Solid Earth* **1993**, *98*, 6561–6577. [[CrossRef](#)]
55. Improta, L.; Zollo, A.; Bruno, P.P.; Herrero, A.; Villani, F. High-resolution seismic tomography across the 1980 (Ms 6.0) Southern Italy earthquake fault scarp. *Geophys. Res. Lett.* **2003**, *30*. [[CrossRef](#)]
56. Bruno, P.P.; Castiello, A.; Improta, L. Ultrashallow seismic imaging of the causative fault of the 1980, M6.9, southern Italy earthquake by pre-stack depth migration of dense wide-aperture data. *Geophys. Res. Lett.* **2010**, *37*, L19302. [[CrossRef](#)]
57. Galli, P.A.C.; Giocoli, A.; Peronace, E.; Piscitelli, S.; Quadrio, B.; Bellanova, J. Integrated near surface geophysics across the active Mount Marzano Fault System (southern Italy): Seismogenic hints. *Int. J. Earth Sci.* **2014**, *103*, 315–325. [[CrossRef](#)]
58. Galli, P.A.C.; Peronace, E.; Quadrio, B.; Esposito, G. Earthquake fingerprints along fault scarps: A case study of the Irpinia 1980 earthquake fault (southern Apennines). *Geomorphology* **2014**, *206*, 97–106. [[CrossRef](#)]

59. Vassallo, M.; Festa, G.; Bobbio, A.; Serra, M. Low shear velocity in a normal fault system imaged by ambient noise cross correlation: The case of the Irpinia fault zone, Southern Italy. *J. Geophys. Res. Solid Earth* **2016**, *121*, 4290–4305. [[CrossRef](#)]
60. Lo Re, D.; Florio, G.; Ferranti, L.; Ialongo, S.; Castiello, G. Self-constrained inversion of microgravity data along a segment of the Irpinia fault. *J. Appl. Geophys.* **2016**, *124*, 148–154. [[CrossRef](#)]
61. Guerricchio, A.; Melidoro, G. Pseudo-tectonic mass movements in the southern Apennines. [Movimenti di massa pseudo-tettonici nell'appennino dell'Italia meridionale]. *Geol. Appl. Idrogeol.* **1981**, *16*, 251–294.
62. Maugeri, M.; Motta, E.; Sorriso Valvo, M. Senerchia landslide triggered by the 23 November 1980 earthquake. In Proceedings of the 4th International Congress—International Association of Engineering Geology, New Delhi, India, 10–15 December 1982; Volume 8, pp. 139–149.
63. Bousquet, J.C.; Gars, G.; Lanzafame, G.; Philip, H. Surface breaks of gravitational origin at the time of the Irpinia earthquake-23/11/1980; southern Italy. *Geol. Appl. Idrogeol.* **1983**, *18*, 427–435.
64. Da Roit, R.; Fontanive, A.; Lojelo, L.; Muzzi, F.; Spat, G. Terremoto Campano-Lucano del 23 Novembre 1980: Evidenze di Liquefazione di Terreni non Coesivi Saturi. Comm. ENEA-ENEL per lo Studio dei Problemi Sismici Connessi con la Realizzazione di Impianti Nucleari. In Proceedings of the Conv. Ann. del CNR-PFG su Sismicità d'Italia, stato delle Conoscenze e Qualità della Normativa Sismica, 1981, Udine, Italy, 2–14 May 1982. (In Italian)
65. Del Prete, M.; Liuzzi, G.T. Results of a preliminary study of the Calitri (AV) landslide triggered by the 23 November 1980 earthquake. [Risultati dello studio preliminare della frana di Calitri (AV) mobilitata dal terremoto del 23 Novembre 1980]. *Geol. Appl. Idrogeol.* **1981**, *16*, 153–165.
66. Faccioli, E. Engineering Seismology Aspects of the M-6.5, Southern Italy Earthquake of Nov. 23, 1980: A Preliminary Review. International Conferences on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics. 1981, p. 16. Available online: <https://scholarsmine.mst.edu/icrageesd/01icrageesd/session08/16> (accessed on 20 May 2020).
67. Hutchinson, J.N.; Del Prete, M. Landslides at Calitri, southern Apennines, reactivated by the earthquake of 23rd November 1980. *Geol. Appl. Idrogeol.* **1985**, *20*, 9–38.
68. Baldassarre, G. Geological effects of the 23 November 1980 earthquake in Atella, outskirts of Basilicata. [Effetti geologici del sisma del 23 Novembre 1980 nella periferia dell'abitato di Atella (Basilicata)]. *Geol. Appl. Idrogeol.* **1981**, *16*, 227–238.
69. Agnesi, V.; Carrara, A.; Macaluso, T.; Monteleone, S.; Pipitone, G.; Sorriso-Valvo, M. Preliminary observations of slope instability phenomena induced by the earthquake of November 1980 on the upper valley of Sele river. [Osservazioni preliminari sui fenomeni di instabilità dei versanti indotti dal sisma del 1980 nell'alta valle del Sele]. *Geol. Appl. Idrogeol.* **1982**, *17*, 79–93.
70. Genevois, R.; Prestininzi, A. Deformations and mass movements induced by the November 23rd, 1980 earthquake in the middle valley of the Tammaro River-BN. [Deformazioni e movimenti di massa indotti dal sisma del 23-11-1980 nella media valle del F. Tammaro (BN)]. *Geol. Appl. Idrogeol.* **1982**, *17*, 305–318.
71. Salvemini, A. Basic aspects of phenomena of instability in the limestone massifs of Monti Cervialto and Terminio-Tuoro (southern Apennines) induced by the earthquake of 23 November 1980. [Aspetti fondamentali dei fenomeni di dissesto nei massicci carbonatici dei Monti Cervialto e Terminio-Tuoro (Appennino Meridionale) indotti dal sisma del 23 novembre 1980]. *Geol. Appl. Idrogeol.* **1982**, *17*, 209–218.
72. Alexander, D. Preliminary assessment of landslides resulting from the earthquake of 23rd November 1980 in Southern Italy. *Disasters* **1981**, *5*, 376–383. [[CrossRef](#)]
73. Porfido, S.; Esposito, E.; Vittori, E.; Tranfaglia, G.; Michetti, A.M.; Blumetti, M.; Ferreli, L.; Guerrieri, L.; Serva, L. Areal distribution of ground effects induced by strong earthquakes in the southern Apennines (Italy). *Surv. Geophys.* **2002**, *23*, 529–562. [[CrossRef](#)]
74. Porfido, S.; Esposito, E.; Guerrieri, L.; Vittori, E.; Tranfaglia, G.; Pece, R. Seismically induced ground effects of the 1805, 1930 and 1980 earthquakes in the Southern Apennines, Italy. *Boll. Soc. Geol. Ital.* **2007**, *126*, 333–346.
75. Cotecchia, V.; Salvemini, A. Correlation between seismic events and discharge variations at Caposele and Cassano Irpino springs, with particular reference to the 23 November 1980 earthquake. [Correlazione fra eventi sismici e variazione di portata alle sorgenti di Caposele e Cassano Irpino, con particolare riferimento al sisma del 23 Novembre 1980]. *Geol. Appl. Idrogeol.* **1981**, *16*, 167–192.
76. Wasowski, J.; Del Gaudio, V.; Pierri, P.; Capolongo, D. Factors controlling seismic susceptibility of the Sele valley slopes: The case of the 1980 Irpinia earthquake re-examined. *Surv. Geophys.* **2002**, *23*, 563–593. [[CrossRef](#)]

77. Del Prete, M. Example of mudslide hazard in the Southern Apennines (Italy). *Ann. Geofis.* **1993**, *36*, 271–276.
78. Parise, M.; Wasowski, J. Landslide activity maps for landslide hazard evaluation: Three case studies from Southern Italy. *Nat. Hazards* **1999**, *20*, 159–183. [[CrossRef](#)]
79. Capolongo, D.; Refice, A.; Mankelov, J. Evaluating earthquake-triggered landslide hazard at the basin scale through GIS in the Upper Sele river Valley. *Surv. Geophys.* **2002**, *23*, 595–625. [[CrossRef](#)]
80. Martino, S.; Prestininzi, A.; Romeo, R.W. Earthquake-induced ground failures in Italy from a reviewed database. *Nat. Hazards Earth Syst. Sci.* **2014**, *14*, 799–814. [[CrossRef](#)]
81. Cavazzani, A. *Social and Institutional Impact of the 1980 Earthquake in Southern Italy: Problems and Prospects of Civil Protection*; The Council of Yugoslav Association of Self-Managed Communities of Interest for Scientific Research: Ljubljana, Slovenia, 1982; pp. 425–436.
82. Ventura, F. The earthquake in Campania and Basilicata (Italy) of 23rd November 1980—The nature of the state’s emergency interventions and the future quality of reconstruction. In *Tenth World Conference of Sociology, Mexico*; ISIG Publication: Gorizia, Italy, 1982.
83. Ventura, F. The long-term effects of the 1980 earthquake on the villages of southern Italy. *Disasters* **1984**, *8*, 11. [[CrossRef](#)]
84. D’Souza, F. Recovery following the South Italian earthquake, November 1980: Two contrasting examples. *Disasters* **1982**, *6*, 101–109. [[CrossRef](#)]
85. D’Souza, F. Recovery following the south Italian earthquake, November 1980: Contrasting examples. *Ekistics* **1984**, *51*, 476–482. [[CrossRef](#)]
86. Alexander, D. Housing crisis after natural disaster: The aftermath of the November 1980 southern Italian earthquake. *Geoforum* **1984**, *15*, 489–516. [[CrossRef](#)]
87. Caporale, R.; Rossi, I.; Chaeretakis, A. *Reconstruction and Socio-Cultural Systems, A Long-Range Study of Reconstruction Processes Following the November 23, 1980 Earthquake in Southern Italy*; Institute for Italian-American Studies: New York, NY, USA, 1985; Unpublished report.
88. Alexander, D. Preserving the Identity of Small Settlements during Post-Disaster Reconstruction in Italy. *Disasters* **1989**, *13*, 228–236. [[CrossRef](#)] [[PubMed](#)]
89. Chubb, J. Three earthquakes: Political response, reconstruction, and the institutions: Belice (1968), Friuli (1976), Campania (1980). In *Disastro: Disasters in Italy Since 1860: Culture, Politics, Society*; Dickie, J., Foot, J., Snowden, F.M., Eds.; Palgrave: New York, NY, USA, 2002; pp. 186–210.
90. Forino, G.; Ciccarelli, S.; Bonamici, S.; Perini, L.; Salvati, L. Developmental Policies, Long-Term Land-Use Changes and the Way Towards Soil Degradation: Evidence from Southern Italy. *Scott. Geogr. J.* **2015**, *131*, 123–140. [[CrossRef](#)]
91. Porfido, S.; Alessio, G.; Gaudiosi, G.; Nappi, R.; Spiga, E. The resilience of some villages 36 years after the Irpinia-Basilicata (Southern Italy) 1980 earthquake. In *Proceedings of the Workshop on World Landslide Forum in Advancing Culture of Living with Landslides, Ljubljana, Slovenia, 29 May–2 June 2017*; Mikoš, M., Vilímek, V., Yin, Y., Sassa, K., Eds.; Springer: Cham, Switzerland, 2017; pp. 121–133. [[CrossRef](#)]
92. Greco, D.; Faustini, A.; Forastiere, F.; Galanti, M.R.; Magliola, M.E.; Moro, M.L.; Piergentili, P.; Rosmini, F.; Stazi, M.A.; Luzi, S.; et al. Epidemiological surveillance of diseases following the earthquake of 23rd November 1980 in Southern Italy. *Disasters* **1981**, *5*, 398–406. [[CrossRef](#)] [[PubMed](#)]
93. Alexander, D. Disease epidemiology and earthquake disaster. The example of Southern Italy after the 23 November 1980 earthquake. *Soc. Sci. Med.* **1982**, *16*, 1959–1969. [[CrossRef](#)]
94. Bruycker, M.D.; Greco, D.; Lechat, M.F. The 1980 earthquake in Southern Italy—Morbidity and mortality. *Int. J. Epidemiol.* **1985**, *14*, 113–117. [[CrossRef](#)] [[PubMed](#)]
95. Berger, E.; Studer, J. *Southern Italy Earthquake, November 23, 1980. Reconnaissance Summary*; Earthquake Engineering Research Institute: Oakland, CA, USA, 1981; pp. 88–94.
96. Guerpinar, A.; Vardanega, C.; Ries, E.R. November 23, 1980 Irpinia earthquake (terremoto campano lucano) observations of soil-structure interaction effects. In *Proceedings of the 6th International Conference on Structural Mechanics in Reactor Technology. Mechanical and Thermal Problems of Future Fusion Reactor Power Plants, Paris, France, 17–21 August 1981*; p. 20. Available online: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-0019708742&partnerID=40&md5=01c2a1d6484e65b7b3ecd86fa55993bd> (accessed on 13 June 2020).

97. Postpischl, D.; Ferrari, G.; Giovani, L.; Spadea, M.C.; Vecchi, M.; Stucchi, M.; Bottari, A.; Lo Giudice, E.; Baldassarre, R.; Branno, A.; et al. Il terremoto irpino del 23 Novembre 1980; rilievo macrosismico. Stato di avanzamento al 12-5-81. *Rend. Soc. Geol. Ital.* **1981**, *4*, 503–505.
98. Postpischl, D.; Perrone, V. *Il Terremoto del 23/11/1980 in Campania e Lucania: Rilievo Macrosismico*; C.N.R. Progetto Finalizzato Geodinamica: Pisa, Italy, 1981; p. 121.
99. Postpischl, D.; Brano, A.; Esposito, E.G.L.; Ferrari, G.; Marturano, A.; Porfido, S.; Rinaldis, V.; Stucchi, M. The Irpinia earthquake of November 23, 1980. *Atlas Iseismal Maps Ital. Earthq.* **1985**, *114*, 152–157.
100. Coburn, A.W.; Hughes, R.E.; Nash, D.F.T.; Spence, R.J.S. Damage assessment and ground motion in the Italian earthquake of 23.11.1980. In Proceedings of the 7th European conference on Earthquake Engineering, Athens, Greece, 20–25 September 1982; pp. 101–108.
101. Ammann, W.; Porro, B. Earthquake in southern Italy of 23 November 1980 engineering aspects and interpretation of building damage. In Proceedings of the 7th European Conference on Earthquake Engineering, Athens, Greece, 20–25 September 1982; Volume 1, pp. 151–158.
102. Hojjat, A. Behavior of reinforced concrete buildings during the southern Italy earthquake of November 23, 1980. In Proceedings of the 7th European Conference on Earthquake Engineering, Athens, Greece, 20–25 September 1982; Volume 1, pp. 143–150.
103. Cotecchia, V.; Nuzzo, G.; Salvemini, A.; Tafuni, N.; Pavoncelli, G. Tunnel and structural analysis of large underground structure damaged by the earthquake of November 23, 1980. In Proceedings of the International Symposium on Geology Problems in Seismic Areas, Bari, Italy, 13–19 April 1986; Volume 21, pp. 329–352.
104. Braga, F.; Dolce, M.; Liberatore, D. A Statistical Study on Damaged Buildings and Ensuing Review of MSK-76 Scale, Southern Italy November 23 1980 Earthquake. In *Progetto Finalizzato di Geodinamica*; CNR Italia, Pub. No. 503 (7ECEE, Athens): Athens, Greece, 1982; pp. 65–84.
105. Braga, F.; Liberatore, D.; Dolce, M. Fast and reliable damage estimation for optimal relief operations. In *Earthquake Relief in Less Industrialized Areas*; Schuppisser, S., Studer, J.A., Eds.; Balkema: Rotterdam, The Netherlands, 1984; pp. 145–151.
106. Rota, M.; Penna, A.; Strobba, C. Processing Italian damage data to derive typological fragility curve. *Soil Dyn. Earthq. Eng.* **2008**, *28*, 933–947. [[CrossRef](#)]
107. Del Gaudio, C.; Di Ludovico, M.; Polese, M.; Manfredi, G.; Prota, A.; Ricci, P.; Verderame, G.M. Seismic fragility for Italian RC buildings based on damage data of the last 50 years. *Bull. Earthq. Eng.* **2020**, *18*, 2023–2059. [[CrossRef](#)]
108. Dolce, M.; Speranza, E.; Giordano, F.; Borzi, B.; Bocchi, F.; Conte, C.; Di Meo, A.; Faravelli, M.; Pascale, V. Observed damage database of past Italian earthquakes: The Da. DO WebGIS. *Boll. Geofis. Teor. Appl.* **2019**, *60*, 141–164.
109. Scire, E.; Siro, L.; Stucchi, M.; Gaiazzi, M. Geo-seismic investigations and urban planning after the Irpinia-Basilicata 1980 earthquake: Part 2, the case of S. Angelo dei Lombardi (Italy). *Geol. Appl. Idrogeol.* **1986**, *21*, 387–397.
110. Scire, E.; Siro, L.; Stucchi, M.; Gaiazzi, M. Geo-seismic investigations and urban planning after the Irpinia-Basilicata 1980 earthquake: Part 1, the case of Caposele and Conza della Campania. *Geol. Appl. Idrogeol.* **1986**, *21*, 441–450.
111. Chiocchini, U.; Cherubini, C. Seismic microzoning of the Lioni village destroyed by the November 23rd 1980 earthquake (Irpinia, Campano-Lucano Apennine). *Geol. Appl. Idrogeol.* **1986**, *21*, 341–362.
112. Maugeri, M.; Carrubba, P. Microzonation for ground motion during the 1980 Irpinia earthquake at Calabritto, Italy. In Proceedings of the 14nd International Conference on Soil Mechanics and Foundation Engineering, Hamburg, Germany, 6–12 September 1997; pp. 81–96.
113. Siro, L. Microzonation in emergency: A short technical report. The Italian Geodynamics Project, Publication Number 503, National Research Council of Italy. Presented at the VII ECEE, Athens, Greece, 6–7 September 1982; pp. 53–63.
114. Siro, L. Emergency microzonations by Italian Geodynamics Project after November 23, 1980 earthquake. In Proceedings of the 3rd International Conference on Microzonation, Seattle, WA, USA, 28 June–1 July 1982; Volume 3, pp. 1417–1427.
115. Rovelli, A.; Bonamassa, O.; Cocco, M.; Di Bona, M.; Mazza, S. Scaling laws and spectral parameters of the ground motion in active extensional areas in Italy. *Bull. Seismol. Soc. Am.* **1988**, *78*, 530–560.

116. Bosco, G.; Dolce, M.; Marino, M. Artificial accelerograms consistent with the 1980 Irpinia earthquake. In Proceedings of the Tenth World Conference on Earthquake Engineering, Madrid, Spain, 24 July 1992; pp. 895–900.
117. Convertito, V.; De Matteis, R.; Cantore, L.; Zollo, A.; Iannaccone, G.; Caccavale, M. Rapid estimation of ground-shaking maps for seismic emergency management in the Campania Region of southern Italy. *Nat. Hazards* **2010**, *52*, 97–115. [[CrossRef](#)]
118. Cultrera, G.; Ameri, G.; Saraò, A.; Cirella, A.; Emolo, A. Ground-motion simulations within ShakeMap methodology: Application to the 2008 Iwate-Miyagi Nairiku (Japan) and 1980 Irpinia (Italy) earthquakes. *Geophys. J. Int.* **2013**, *193*, 220–237. [[CrossRef](#)]
119. Nunziata, C.; Costa, G.; Marrara, F.; Panza, G.F. Validated Estimation of Response Spectra for the 1980 Irpinia Earthquake in the Eastern Area of Naples. *Earthq. Spectra* **2000**, *16*, 643–660. [[CrossRef](#)]
120. Di Giulio, G.; Improta, L.; Calderoni, G.; Rovelli, A. A study of the seismic response of the city of Benevento (Southern Italy) through a combined analysis of seismological and geological data. *Eng. Geol.* **2008**, *97*, 146–170. [[CrossRef](#)]
121. Maresca, R.; Nardone, L.; Pasquale, G.; Pinto, F.; Bianco, F. Effects of surface geology on seismic ground motion deduced from ambient-noise measurements in the town of Avellino, Irpinia region (Italy). *Pure Appl. Geophys.* **2012**, *169*, 1173–1188. [[CrossRef](#)]
122. Maresca, R.; Nardone, L.; Gizzi, F.T.; Potenza, M.R. Ambient noise HVSR measurements in the Avellino historical centre and surrounding area (southern Italy). Correlation with surface geology and damage caused by the 1980 Irpinia-Basilicata earthquake. *Measurement* **2018**, *130*, 211–222. [[CrossRef](#)]
123. Rovida, A.; Camassi, R.; Gasperini, P.; Stucchi, M. (Eds.) *Catálogo Parametrico dei Terremoti Italiani (CPTI11)*; Istituto Nazionale di Geofisica e Vulcanologia (INGV): Milano, Bologna, 2011. [[CrossRef](#)]

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