

ANALYSIS OF THE TOP 100 CITED PUBLICATIONS IN EARTHQUAKE RESEARCH DURING 1991 TO 2021

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ABSTRACT

Earthquake research has expanded over the past few decades. Also, over the past 30 years, earthquakes have become a major study because earthquakes occur every year in each region. The aims of this research is to analyze the top 100 cited articles in the earthquake field from 1991 to 2021. Research give an idea of citation, author, year, journal and country characteristics of these articles using literature review, bibliometric analysis and VOSViewer which the data from Scopus database. The research found that articles is most document type of top 100 cited papers which 2005 was the most published year for the article. The average number of citations per article was calculated as 727 citations per paper. The journal Nature is the primary source of the Nature Publishing Group, which governs the publication of the most influential earthquake studies. Kanamori is recognized as the most productive author who received the highest number of quotes and the most incredible link strength. The United States dominates the production of highly cited articles. The research areas in these papers are mainly emphasized on earthquake, states, geological, sciences, earth, and japan. Further research related to earthquakes can also be directed to the relevance of the tsunami. The results of the Scopus database show 2,098 document results [January 17, 2022] with the title “earthquake tsunami.”

Keywords: *Bibliometric, Earthquakes, Top 100 cited, Tsunami, VOSViewer.*

1. INTRODUCTION

Indonesia has volcanic paths from Sumatera to Papua so probability to occur earthquake and tsunami disasters is very high (Deta et al, 2020). This can be seen from the large number of earthquakes and tsunamis that occurred in Indonesia. In addition, research about earthquake has grown over in the past few decades. Besides, earthquake become a top study in the last thirty years because every year, in each region in the world was current earthquake (Pakiser and Shedlock, 2014). Several studies have been conducted on the characteristics of prevention and mitigation such as tsunamis and their impacts, displacement of most vulnerable areas, vertical evacuation, seismic hazard and coastal resilience to tsunamis (Toulkeridis et al, 2018; Mato and Toulkeridis, 2018; Toulkeridis et al, 2019). Research could help scientists better track dangerous earthquakes for future (Rusydy et al, 2020). For example, the Earthquake Engineering and Structural Dynamics Journal have publication of papers on several aspects about engineering related to earthquakes since 1970 until now. The other example, Geoenvironmental Disasters have publications from 2014 to 2022. The number of papers in this both journal has steadily growing since its inception.

During the pandemic, the use of secondary data in research is helpful for researchers. Currently, there are studies of bibliometric analysis in various disciplines. One way to conduct a bibliometric analysis study is to use the VOSViewer software, making it easier to interpret the data visually. In addition, the advantage of this analysis is that it analyzes many scientific publications written on any subject. In bibliometric research, researchers can use citation analysis to consideration a systematic metric degree and use to discover the maxim impactful studies in a field (Suprpto et al, 2021). Papers that receive more citations are expected to have good research quality and to influence specializations in a particular field (Suprpto et al, 2021).

Research Objective

This research reviewed the trends of earthquake research in terms of top one hundred cited papers to identify the status of earthquake research and help researchers in future studies. The research's main objective is to explore the top one hundred cited papers on earthquake from 1991 to 2021. The specific objectives that will be discussed in this research because they are essential as a reference for future research on earthquake:

- 1) To know the types of publications of the top one hundred cited papers in earthquake.
- 2) To study the year-wise distribution of the top one hundred cited papers in earthquake.
- 3) To identify the sources publishing of the top one hundred cited papers in earthquake.
- 4) To study the authorship pattern and prolific author of the top one hundred cited papers in earthquake.
- 5) To know the country of origin of the papers and collaboration among them
- 6) To study the period of references of the top one hundred cited papers in earthquake.

2. METHODS

Research use qualitative descriptive using bibliometric analysis (Suprpto et al., 2021; Kulakki and Osmanaj, 2020, Yang et al, 2017). The database sources are from Scopus and searched for the subject category “earthquake” using the string given below. There are five steps in conducting bibliometric analysis such as keyword determination, initial search results, search refinement, initial data statistics and data analysis creation (Schmeisser, 2013; Setyaningsih, 2018).

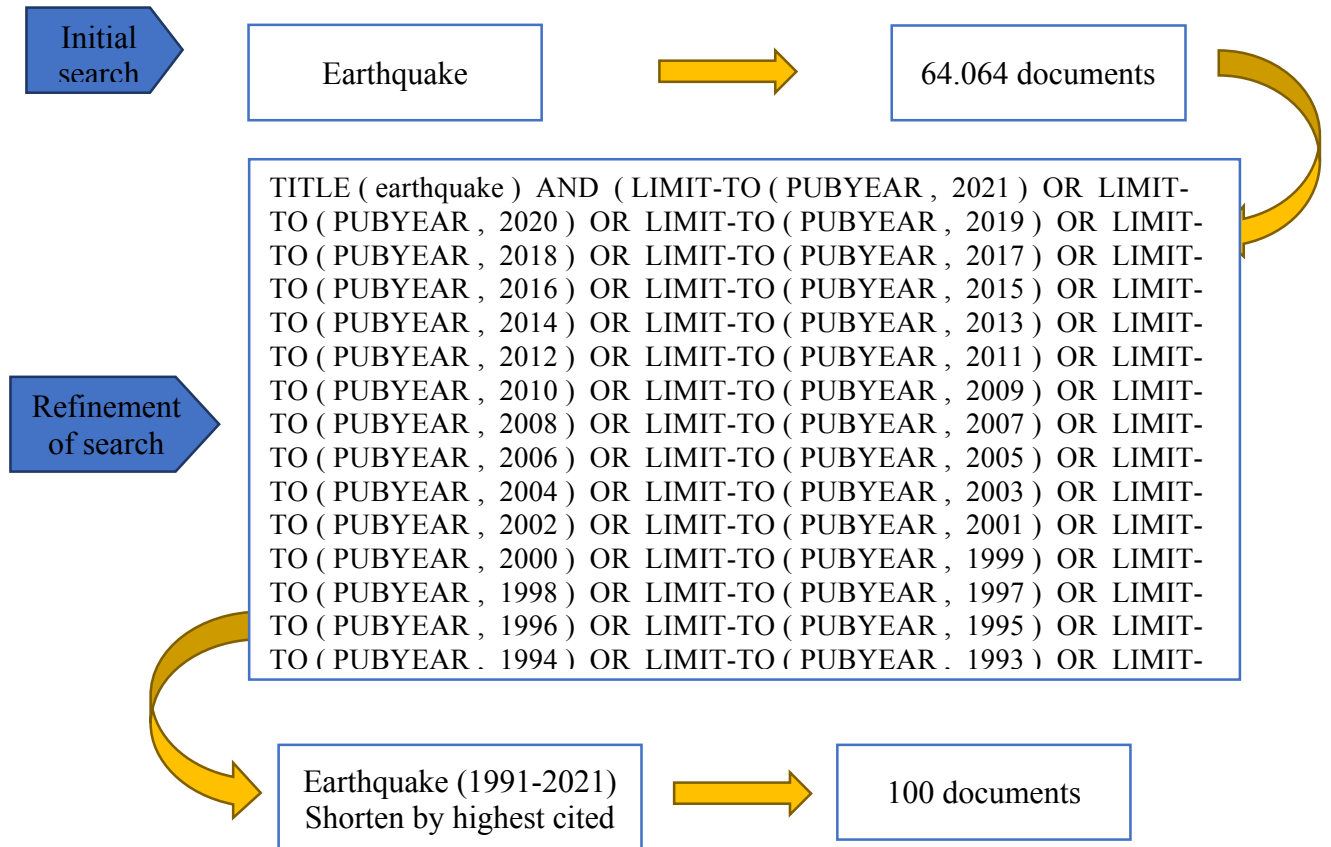


Figure 1. Flowchart research

The data were collected on January 10, 2022. The obtained result does not limit to type of language and publication type then sorted according to “times cited” from highest cited to lowest cited. Then the data of top one hundred cited papers downloaded in *.ris* or *.csv* file format which will then be uploaded to the VOSViewer software. In this study, two analytical techniques were used to perform bibliometric analysis. The first analysis technique uses VOSViewer to reveal the network visualization of the keywords used obtained from the *.ris* file metadata. The second analytical technique, descriptive analysis, analyzes the year of publication, country, affiliation, language, and others obtained from the analyzed *.csv* metadata using *Microsoft Excel* and word cloud generator for visualization (Suprpto et al., 2021).

3. RESULTS AND DISCUSSION

3A. Publication Type

Table 1. Document Type of Top Cited Papers

Document Type	Frequency	Total Cited	Mean	Median	S.D.
Article	82	56275	686,28	533,5	435,50
Book	2	1035	517,50	517,5	55,86
Conference paper	3	3929	1309,66	627	1254,98
Review	12	8856	738,00	524	388,28
Short Survey	1	511	511,00	511	-
Total	100	70606	752,49	-	-

Table 1 shows the document types of the top one hundred cited papers about earthquake from 1991 to 2021. Of these 100 papers, 82 papers were in the form of articles, 2 were in the form of a book, 3 papers were in conferences, 12 were review papers, and 1 were in the form of a short survey. The average number of citations per paper in each category varied on average 752. However, the standard deviations of conference papers were high is 1254,98. At the same time, the average citations rate of the conference papers was the highest at 1309,66. In contrast, book and short surveys were secondary with an average of citations. The majority of the language used in the top one hundred cited papers related to the earthquake in 1991-2021 was English.

3B. Year-wise distribution of top 100 cited papers

The top one hundred cited papers of earthquake research have been published during 1991 to 2021, which 2021 is the year with the highest number of papers (3,953). Thus, 2005 with ten papers was the largest published year, followed by 2011 (8 papers), 1997 and 1998 (7 articles each). These top 100 papers received an average of 727,68 citations for a total of 70606 citations. The mean citations per paper was the highest at 1666 in 1991 and the mean citations per paper per year was the highest at 105 for 2013.

Table 2. Year wise distribution of papers

Year	Papers	Citations	ACPP	ACPPY	Citable Years
1991	3	5000	1666,66*	53,76	31
1992	5	3062	612,40	20,41	30
1993	5	4462	892,40	30,77	29
1994	5	4779	955,80	34,14	28
1995	2	1065	532,50	19,72	27
1996	4	2007	501,75	19,29	26
1997	7	4619	659,86	26,39	25
1998	7	5702*	814,57	33,94	24
1999	3	2309	769,66	33,46	23
2000	4	4398	1099,50	49,97	22
2001	2	953	476,50	22,69	21
2002	3	1533	511,00	25,55	20
2003	3	1281	427,00	22,47	19
2004	3	1538	512,67	28,48	18
2005	10*	5672	567,20	33,36	17
2006	4	2430	607,50	37,96	16
2007	3	1706	568,67	37,91	15
2008	5	2414	482,80	34,48	14
2009	5	2707	541,40	41,65	13
2010	3	3734	1244,66	103,72	12
2011	8	4189	523,62	47,60	11
2012	3	2395	798,33	79,83	10
2013	2	1906	953,00	105,88*	9
2014	1	745	745,00	93,12	8
Total	100	70606	727,68	1036,63	
<i>ACPP=Average Citation per Paper, ACPPY=Average Citation Per Paper Per Year, *the highest number</i>					

3C. Sources of Publication

The lists of sources of top 100 cited papers shown in Table 3. 41 sources either journal or conference proceedings have published the top 100 papers. The journal “Nature” is the main source publishing thirteen papers, followed by “Bulletin of the Seismological Society of America” publishing ten papers, and “Science” publishing eleven papers. The top three sources that have published the top cited papers are “Nature” were 11711 citations, “Bulletin of the Seismological Society of America” were 9439 citations, and “Science” were 7132 citations. The largest publisher is the Seismological Society of America with 16 papers and total of citations is 13,274, followed by Nature Publishing Group with 13 papers and total of citations is 17111.

Table 3. Sources of top cited papers

Sources	Publisher	Papers	Citations	ACPP
Nature	Nature Publishing Group	13*	11711*	900,85*
Bulletin of the Seismological Society of America	Seismological Society of America	10	9439	943,9
Science	American Association for the Advancement of Science	11	7132	648,36
Journal of Geophysical Research: Solid Earth	Blackwell Publishing Ltd	9	4977	553
Geophysical Journal International	Oxford University Press	3	3965	1321,66
Seismological Research Letters	Seismological Society of America	6	3835	639,16
Journal of Geophysical Research	Wiley-Blackwell	6	3819	636,5
Journal of Personality and Social Psychology	APA	2	3676	1838
Geology	Geological Society of America	2	1201	600,5
Nature Geoscience	Springer Nature	2	993	496,5
Physical Review Letters	American Institute of Physics Inc. American Physical Society	3	1756	585,33
Proceedings of the 19th International Conference on World Wide Web, WWW '10	The Association for Computing Machinery	1	2758	2758
Physics of the Earth and Planetary Interiors	Elsevier	1	1471	1471
Geotechnique	ICE Publishing Ltd.	1	1280	1280
GSA Today	Geological Society of America	1	670	670
Annals of the Institute of Statistical Mathematics	Springer Netherlands	1	642	642
New England Journal of Medicine	Massachusetts Medical Society	1	634	634
International Journal of Information Management	Elsevier Ltd	1	627	627
Tectonophysics	Elsevier	1	580	580
Ionospheric Precursors of Earthquakes	Springer Berlin Heidelberg	1	557	557
Safety Science	Elsevier Sci Ltd, Exeter, United Kingdom	1	544	544

Sources	Publisher	Papers	Citations	ACPP
Annual Review of Earth and Planetary Sciences	Annual Reviews Inc.	1	533	533
Journal of Structural Engineering	ASCE	1	524	524
Earthquake protection	Wiley	1	518	518
Landslides	Springer Verlag	1	517	517
Proceedings of the National Academy of Sciences of the United States of America	National Academy of Sciences	1	503	503
Earthquake and Volcano Deformation	Princeton University Press	1	478	478
Reports on Progress in Physics	Institute of Physics Publishing	1	463	463
Engineering Geology	Elsevier	1	461	461
Dizhen Dizhi	Guojia Dizhen-ju	1	460	460
Surveys in Geophysics	Springer Nature	1	454	454
Reviews of Geophysics	Blackwell Publishing Ltd	1	449	449
Geophysical Research Letters	Blackwell Publishing Ltd	1	445	445
Tunneling and Underground Space Technology	Elsevier	1	442	442
Environment and Behavior	SAGE	1	427	427
Journal of Asian Earth Sciences	Elsevier	1	424	424
British Journal of Psychiatry	Royal College of Psychiatrists	1	423	423
Science in China, Series D: Earth Sciences	Zhongguo Kexue Zazhishe/Science in China Press	1	418	418
Journal of Earthquake Engineering	Taylor & Francis	1	417	417
Acta Geophysica Sinica	Science Press	1	410	410
Total		100	73452	28297,53
<i>ACPP=Average Citation per Paper, *the highest number</i>				

3D. Top 10 Authors of Top 100 Cited Papers and Top Papers

328 authors have actively pony up to the top one hundred cited papers on the keyword "earthquake". Table 4 describes the top 10 authors, the number of most cited papers, and the best papers authored. There are top ten authors who have published two or more of the top cited papers. Kanamori as the most author that has published many papers, received the most number of paper citations and the highest link strength (11). But, Kanamori's papers do not include the top three cited papers.

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Table 4. Top 10 Authors

Top 100 Cited Papers			Top Papers	
Authors	Total Papers	Total Link Strength	Authors	Total Papers
Kanamori	5*	11*	Kanamori	185*
Stein, r. s.	7	9	Hayakawa	170
Ammon, c. j.	2	8	Satake, K.	147
Lay, t.	2	8	Liu, J.	136
Beroza, g.c.	4	7	Burgman, R.	133
Ide, s.	4	7	Lay, T.	132
Shelly, d.r.	3	6	Wu, Y. M.	117
Ekstroom, g.	2	5	Xu, C.	116
Ji, c.	2	5	Yamazaki, F.	112
Nettles, m.	2	5	Rundle, J. B.	101

*the highest number

Top authors clusters and number of authors over time are shown in Figure 2. Thus, in the earthquake paper, there are 16 author clusters such as Wen, Beroza, Okai, Wiemer, Zhang, Abrahamson, Kanamori, Shearer, Cornell, Stein, Segall, Bilham, Ellsworth, Hubbard, Boore, Christensen. Kanamori and Stein clusters are the biggest author clusters that have top cited papers.

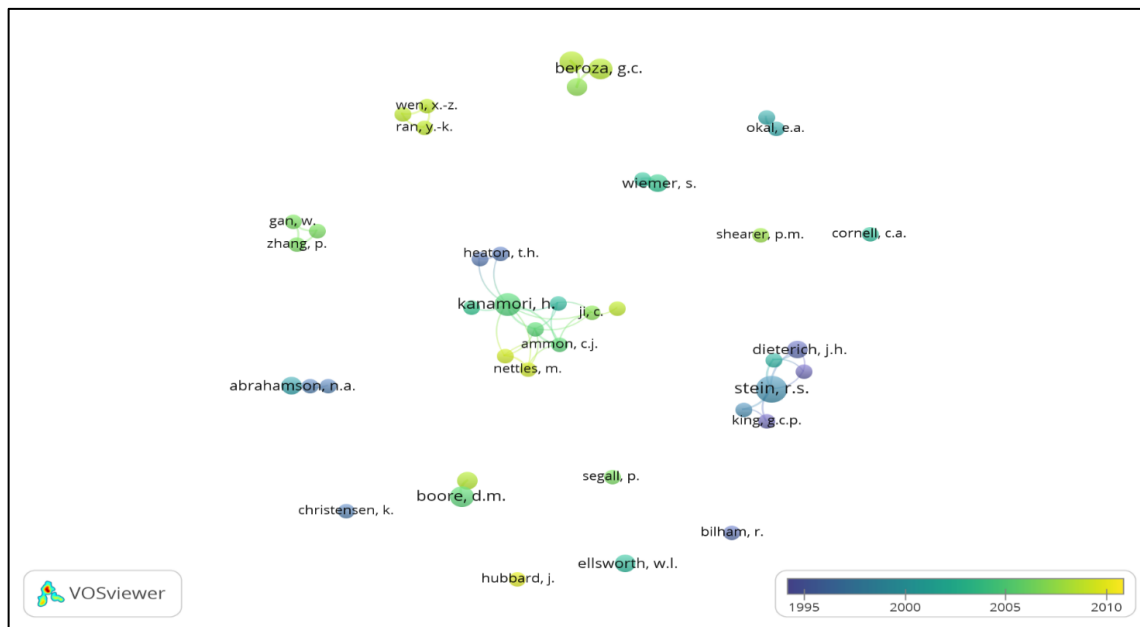


Figure 2. Top authors over time.

3E. Publication Countries in Top 100 Cited Papers and Top Papers

The data obtained from Scopus were then sorted by author affiliation and country. Only the first author was considered when calculating the country of publications. Based on graph and table 5, most of the countries in the earthquake research were dominated by the United States that have published 56 papers and total citations were 38915, followed by Japan that have published 16 papers and total citations were 9366. Despites, China dominates with 15.825 papers, followed by United States (12.875 papers), Japan (9.621 papers).

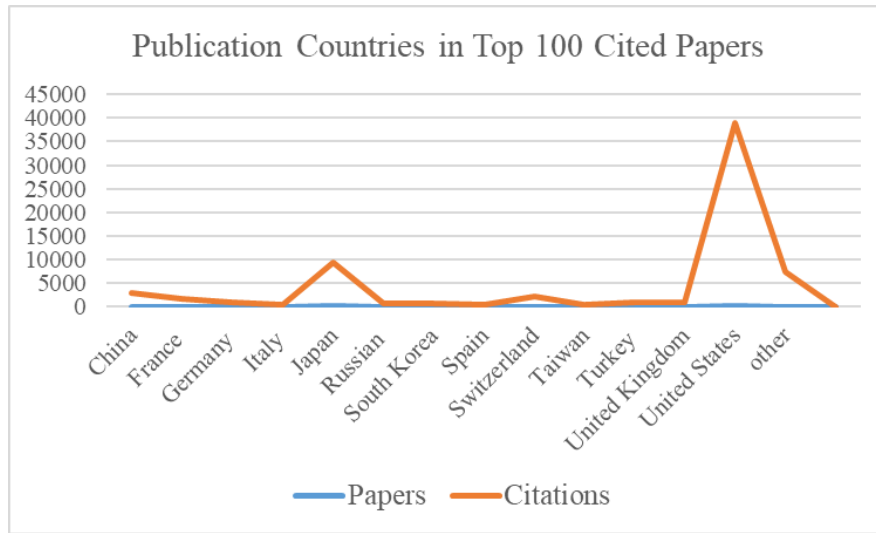


Figure 3. Publication Countries in Top 100 Cited Papers

Table 5. Top 5 of Country of Publications

Top 100 Cited Papers			Top Papers	
Country	Papers	Citations	Country	Papers
United States	56*	38.915*	China	15.825*
Japan	12	9.366	United States	12.875
China	6	2.932	Japan	9.621
Switzerland	3	2.196	Italy	4.356
Australia	2	2986	India	2.474
*the highest number				

The first red clusters contain 28 items such as accuracy, application, catalog, comparison, database, difference, distance, equation, factor, function, order, paper, parameter, peak acceleration, peak ground acceleration, period, prediction, procedure, relationship, respect, response, scaling, shallow crustal earthquake, shallow earthquake, solution, term, uncertainly, and use. The second green clusters contain 17 items such as case, china, crust, faulting, form, landslide, longmen shan, may, occurrence, person, slow slip event, strong earthquake, surface, thousand, tibetan plateau, wall, wenchuan earthquake. The third blue clusters contain 15 items such as basis, century, coseismic slip, displacement, estimate, frequency, large earthquake, map, moment magnitude, observation, rupture, second, seismic wave, tohoku oki earthquake, and tsunami. While the fourth cluster consists of 11 items such as aftershock, bar, change, decade, earthquake occurrence, field, from author, landers earthquake, sequence, space, and stress change represents by yellow.

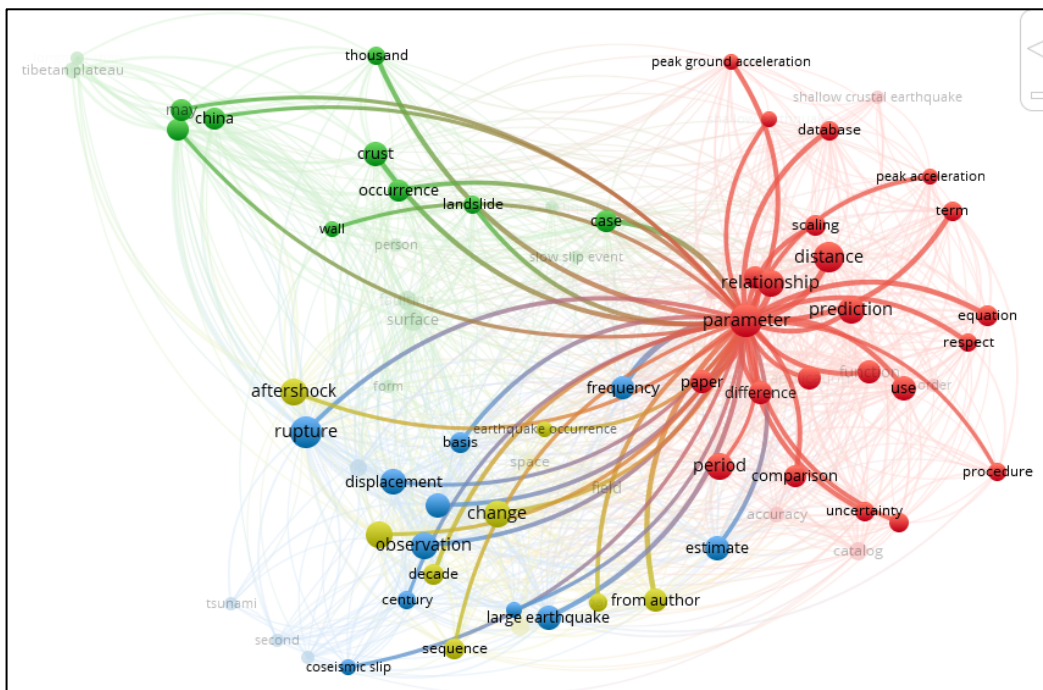


Figure 6. Visualization red clusters

Figure 6 explains that the earthquake is related to parameter and relationship. According to Madlazim (2021), when measuring the resulting amplification, a relationship between the number of tsunamis and the destruction rate of earthquakes can be found as the failure rate parameter plays an important role in run-up amplification. In addition, to calculate acceleration, researchers measure the distance and magnitude of earthquake sources from the point location (Sari et al., 2021).

Figure 8 explains that the keywords “surface” and “landslides” have a relationship with earthquake. Landslides is one of areas is at risk of an earthquake or the seismic hazard zone and its generally close to the seismic zone location (Sari et al, 2021). One of the methods to predict the seismic hazard on the earth surface is the wave propagation method. Spectral velocity in earth surface gives information for earthquake resistant design as application in infrastructure engineering (Mikhail et al, 2019).

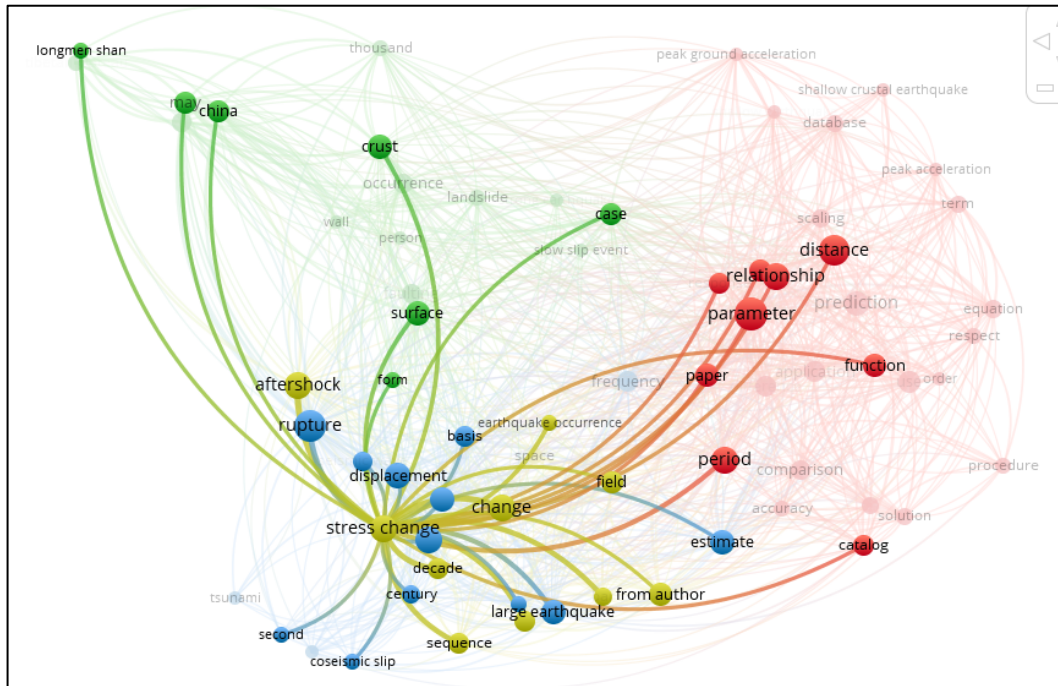


Figure 9. Visualization yellow clusters

Figure 9 describes keywords “stress change” in an earthquake that has a relationship with other clusters such as displacement in blue cluster, parameter in red cluster, and surface in green cluster. According research by Hardebeck and Okada (2018), earthquakes can extrude the stress field withinside the lithosphere as they relieve and redistribute strain. Earthquake-precipitated strain modifications were located as temporal rotations of the predominant strain axes following fundamental earthquakes in plenty of tectonic settings. In earthquake, there are term aftershocks, common effects of earthquakes of normal hypocentral depths that occur in the fragile crust (Ammon et al, 2020).

3G. Study Literature Top Cited Paper

Table 6. Top Cited Paper about Earthquake During 1991-2021

Title	Authors	Source	Cited by	Finding	Recommendation/ Limitations
Earthquake Shakes Twitter Users: Real Time Event Detection by Social Sensors	Sakaki, T., Okazaki M., and Matsuo, Y. (2010)	Proceedings of the 19 th International Conference on World Wide Web'10	2758	The authors specifically explored the real-time nature of Twitter for event detection. Each Twitter user acts as a sensor and sets up actions to detect events based on sensory observations.	This study provides insights into semantic analysis and future integration of microblogging data.
Traveltimes for Global Earthquake Location and Phase Identification	Kennett, B. L. N., and Engdahl, E. R. (1991)	Geophysical Journal International	2554	Although the computational cost is not higher than that of a traditional lookup table, the accuracy of constructing the travel time for the source at any depth is improved. Thus, for a given epicenter depth, it is possible to very quickly compile the complete list of transit times and associated derivatives for the major seismic phases observable at a given epicenter distance.	-
A Double-Difference Earthquake Location Algorithm: Method and Application to the Northern Hayward Fault California	Waldhauser, F., and Ellsworth, W. L. (2000)	Bulletin of the Seismological Society of America	2472	An effective method of finding the hypocenter with high resolution over long distances is a positioning method that includes traditional absolute transit time measurements and/or cross-correlation measurements of P and S wave differential transit times.	It is recommended that in the future researchers can use this method to finding the hypocenter
A	Nolen-	Journal of	2014	Students uncovered to	This research

Title	Authors	Source	Cited by	Finding	Recommendation/ Limitations
Prospective Study of Depression and Posttraumatic Stress Symptoms After a Natural Disaster: The 1989 Loma Prieta Earthquake	Hoeksema S., and Morrow J. (1991)	Personality and Social Psychology		greater risky or hard conditions because of the earthquake additionally had accelerated symptom ranges 10 days after the earthquake.	cannot explain the causal relationship between variables
Static stress changes and the triggering of earthquakes	King, G. C. P., Stein, R. S., and Jian Lin (1994)	Bulletin- Seismological Society of America	1799	Movement during an earthquake causes a change in stress. An increase in voltage causes additional earthquakes. Raising the voltage to less than half a bar is enough to cause an earthquake and lowering the voltage by a similar amount is enough to subdue	This research can be a reference to development the earthquake's research

3I. Research Implication

Visualization of each cluster can be used as an alternative for future researchers to obtain ideas and initial explanations in studies related to earthquake topics. This research provides new insights to librarians, researchers, and policy makers around the world to advance earthquake research and build a full Scopus document. The study also provides librarians, researchers, and policy makers insight and information into research trend profiles in Scopus documents. Librarians and researchers can conduct more in depth research development and collaboration between other universities as an effort to increase publications and more references/information for continuous research about earthquake. Besides, the policy makers can pre-plan for earthquake disaster, policy makers can implement disaster mitigation policies that include design and manufacture, urban planning, financial planning, policy direction and public reaction (Heidari et al, 2020). Further research related to earthquakes can also be directed to the relevance of the tsunami. The results of the Scopus database show 2,098 document results [January 17, 2022] with the keyword earthquake tsunami.

3. CONCLUSIONS

This paper is the first bibliographic study of its kind among 100 cited papers in the field of "earthquakes". Research data covering the top 100 earthquake publications from 1991 to 2021 were obtained from the Scopus database. It is found that the top one hundred papers and article is most publication document type, followed by reviews and a few as lectures and books. The majority of these top-cited papers were published in 2005. The average number of citations per article was calculated as 727 citations per paper. The journal Nature is the primary source of the Nature Publishing Group, which governs the publication of the most influential earthquake studies. Most research articles have multiple authors. Kanamori is recognized as the most productive author. At the same time, Kanamori received the highest number of quotes and the most incredible link strength. The United States dominates the production of highly cited articles, followed by Japan and China. The research areas in these papers are mainly emphasized on earthquake, states, geological, sciences, earth, japan. In this study, we only used the Scopus database to search for relevant publications using the keyword "earthquake". Bibliometric data, such as index or citation times, indicate the scope and impact of the work, respectively. However, due to the way research is conducted and how scientific publications work, it is not necessarily accurate and exhaustive. Future research should focus on other disasters, use one or more keywords, and collaborate with Google Scholar, the Web of Science data, for in-depth analysis.

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