ISCRAM turns 15: A Trend Analysis of Social Media Papers 2004-2017

Christian Reuter
TU Darmstadt, Science and Technology for Peace and Security (PEASEC), Germany

Gerhard Backfried
SAIL LABS Technology GmbH, Vienna, Austria

Marc-André Kaufhold
University of Siegen, Germany and TU Darmstadt, Science and Technology for Peace and Security (PEASEC), Germany

Fabian Spahr
University of Siegen, Germany

ABSTRACT

In 2004, Information Systems for Crisis Response and Management (ISCRAM) was a new area of research. Pioneering researchers from different continents and disciplines found fellowship at the first ISCRAM workshop. Around the same time, the use of social media in crises was first recognized in academia. In 2018, the 15th ISCRAM conference will take place, which gives us the possibility to look back on what has already been achieved with regard to IT support in crises using social media. With this article, we examine trends and developments with a specific focus on social media. We analyzed all papers published at previous ISCRAMs (*n*=1339). Our analysis shows that various platforms, the use of language and coverage of different types of disasters follow certain trends – most noticeably a dominance of Twitter, English and crises with large impacts such as hurricanes or earthquakes can be seen.

Keywords

ISCRAM, Social Media, Trend Analysis, Systematic Literature Review, Vocabulary Analysis

1. INTRODUCTION

While social media have recently become natural elements in many people's everyday lives, their origins date back further than one might tend to think. These networks emerged from knowledge management and collaboration ideas such as Memex by Vannevar Bush, a first hypothetical hypertext system from 1945, and the concept of Computer-Supported Cooperative Work (Allen, 2004). The so-called Web 2.0 was the interactive implementation of a specific type of platform where users could contribute and share content as well as interact with each other – in contrast to the business-focused Web 1.0, which primarily enabled one-sided communication. Such interaction can be subsumed under 'computer-mediated communication', as described in many examples in "The Network Nation" by Hiltz and Turoff (1978), a hypernym for what is today called 'social media'. Usage of these platforms has increased dramatically over the past ten years and made social media indispensable (Statista, 2017), with the social network Facebook having the largest world-wide group of users (over 2 billion), closely followed by the video-sharing platform YouTube (1.5 billion) and instant messenger WhatsApp (1.3 billion). The image-sharing platform Instagram is used by more than half a billion people, the business network LinkedIn by over 100 million, while the microblogging service Twitter has more than 328 million users[1].

Crisis scenarios have become an important field of application for social media, which, under the term of 'crisis informatics' (Palen & Anderson, 2016), has been an extensive area of research since 2006 (Palen & Hughes, 2018; Reuter & Kaufhold, 2018). During this time, crisis situations have been quite common: Between 2005 and 2015, an average of 631 disasters occurred worldwide each year, causing over 80,000 casualties and affecting almost 200,000 people, while causing monetary damage of the equivalent of over 160 billion US$ (IFRC, 2015). When talking about crises and disasters, we'd like to distinguish between natural and human-induced events. The related terms convey slightly diverse meanings: *crisis* generally implies a situation that cannot be overcome by an organization without taking particular measures, while *emergency* includes the characteristic of *unpreparedness*,

[1] It should be stated that these numbers are snapshots only. The social media realm is a very dynamic one where todays's hot platform might be out of operation within a short period of time.

and possible impact that has to be kept under control (DHA, 2000). For a thorough discussion of terminology involved also see Coombs and Holladay (2012).

While a lot of research has been carried out on crises, emergencies or disasters with regard to social media use, there are only a few studies systematically analyzing recent developments – particularly none with a special focus on ISCRAM. By examining related work (section 2) on the history of social media in crisis management and the history of ISCRAM, we point out existing research gaps. Based on these we describe our method (section 3), which includes a quantitative study on the development of the vocabulary used in all ISCRAM papers. Finally, we present the results of our investigation (section 4), draw conclusions and discuss our findings (section 5).

2. BACKGROUND AND RELATED WORK

2.1 History of Social Media in Crisis Management

The role of social media in emergencies is gaining relevance. First examples of the use of wikis (Palen & Liu, 2007), photo repository sites (Liu et al., 2008), the microblogging service Twitter (Hughes & Palen, 2009) and other platforms in emergency situations date back to the beginning of this millenium. Early cases are the terrorist attacks of September 11th, 2001, the Indian Ocean tsunami in 2004, and the Southern California wildfires in 2007. The first event provoked the development of emergency management as a research field, which had previously been marginally treated in unrelated disciplines. As an important tool for engagement and for unofficial citizen communication, social media have since been used to share and obtain information in crisis situations and make sense of an evolving dynamic environment (Bruns et al., 2012). Ever since their inception in the early 2000s, there exists almost no large emergency[2] where the use of social media has not been studied (Reuter & Kaufhold, 2018).

Reuter et al. (2018b) summarized cases of social media in emergencies between 2001 and 2017 and observed a wide range of events covered in scientific studies, which allows for the easier detection of patterns and trends in the different social behaviors. Moreover, Olteanu et al. (2015) identify types of content and information across crises. Several limitations in the research corpora and technologies can be discerned: Twitter, although only used by relatively few citizens compared to other sites like Facebook, has been analyzed by a majority of studies (Kaufhold & Reuter, 2016; Reuter et al., 2018b). One reason might be that Twitter's open API, terms of use and the simplicity of 140/280-character messages allow for a convenient way of gathering data and establishing substantial data samples (Imran et al., 2015). Further reasons for the focus on particular platforms might be related to the location of the researchers themselves, of funding bodies and programs, and to a host of socio-economic factors influencing the platform use and distribution within affected populations.

Another limitation concerns the location of events and language of social media content. While the analysis of social media in crises has become commonplace in the US since about 2006 (Palen & Hughes, 2018), there is still relatively little research on this topic in Europe (Backfried et al., 2015) and elsewhere as well as on non-English speaking communities (Reuter & Kaufhold, 2018). Related studies, mainly on automatic information extraction from social media that can help disaster prevention and management, have been conducted in Japan as a country prone to earthquakes (Sakaki et al., 2010), and similarly in Qatar (Imran et al., 2014).

Natural Language Processing (NLP) tools used to analyze data are generally much more advanced for English language content. This mirrors the situation in several related areas such as Automatic Speech Recognition (ASR), Named-Entity Recognition (NER) or Topic Detection (TD) which have all received a lot of attention in the US, driven by DARPA sponsored evaluations such as the HUB, TDT or MUC evaluations (Fiscus & Doddington, 2002; Grishman & Sundheim, 1996; Przybocki et al., 1999). Extensions to other languages and groups of languages - each one exhibiting particularities in structure and use on several linguistic levels - often require substantial amounts of time and up to this date remain a significant challenge. Languages with scarce resources, so-called *low-resource languages* more recently have also become the focus of attention at conferences such as LREC[3] and Interspeech[4], leading to gradual improvements on corpora and language specific technologies. Advances in deep-learning paired with the availability of data further aid in the extension to such languages.

As social media have become indispensable for the public and private sector in crisis situations, their scientific analysis in this context has been advancing, although still bound to limitations and bias in location, language and technology. The most influential venue for this research area is the international ISCRAM conference. Therefore, besides the trends mentioned above, we are interested in how the papers developed at this specific conference.

[2] *large* primarily in a humanitarian sense rather than from an economic point of view
[3] http://www.lrec-conf.org/
[4] http://www.isca-speech.org/iscaweb/index.php/conferences/interspeech

2.2 History and Topics of ISCRAM

The history of Information Systems for Crisis Response and Management (ISCRAM) began in 2004, when interdisciplinary researchers, who felt their work had not received appropriate acknowledgement, gathered in Brussels, Belgium, for the first ISCRAM workshop (Table 1). Their central research question was how information technologies, especially decision support systems, could help manage crises (Comes et al., 2013). This first, successful and well-visited meeting, already brought together experts from various fields to develop a framework of a 'dynamic emergency response management information system' for stakeholders from different areas (Turoff et al., 2004). Their diverse needs and desires should be addressed by using elements of computer-mediated communication, all directed towards a more efficient emergency management (Campbell et al., 2004).

Year	Location	Program and conference chairs	Social Media-related Track(s) and Track Chairs
2004, 2005	Brussels, Belgium	*Bartel Van de Walle and Benny Carlé*	-
2006	Newark, New Jersey	*Bartel Van de Walle and Murray Turoff*	Communication Challenges in Emergency Response / Workshop on Future Communication Requirements for Emergency Response *(B.S. Manoj and Alexandra Hubenko Baker)*
2007	Delft, the Netherlands	*Bartel Van de Walle, Paul Burghardt, and Kees Nieuwenhuis*	Virtual Teams and Virtual Communities in Emergency Preparedness and Response *(Starr Roxanne Hiltz and Leysia Palen)*
2008	Washington, D.C.	*Bartel Van de Walle, Frank Fiedrich, Jack Harrald, and Theresa Jefferson*	Social Networking, Web Collaboration and e Participation in Crisis and Risk Managements *(Simon French and Clare Bayley)*
2009	Gothenburg, Sweden	*Jonas Landgren, Bartel Van de Walle, and Susanne Jul*	Collaboration and Social Networking *(Linda Plotnick and Connie White)*
2010	Seattle, Washington	*Mark Haselkorn, Simon French, and Brian Tomaszewski*	Collaboration and/or Social Networking *(Starr Roxanne Hiltz, Leysia Palen, and Paloma Diaz)*
2011	Lisbon, Portugal	*Maria A. Santos, Julie Dugdale, and David Mendonça*	Social Media and Collaborative Systems *(Starr Roxanne Hiltz, Paloma Diaz and Linda Plotnick)*
2012	Vancouver, Canada	*Brian Fisher, Richard Arias-Hernandez, Leon Rothkrantz, Jozef Ristvej, and Zeno Franco*	Social Media and Collaborative Systems *(Starr Roxanne Hiltz, Paloma Diaz, Leysia Palen, and Linda Plotnick)*
2013	Baden-Baden, Germany	*Jürgen Beyerer, Thomas Usländer, and Tina Comes*	Social Media and Collaborative Systems *(Starr Roxanne Hiltz, Volkmar Pipek, Linda Plotnick, and Kate Starbird)*; Community Engagement in Crisis Informatics Research *(Christine Adler, Zeno Franco, Paul Bledzycki, Tracey O'Sullivan, and Syed Ahmed)*
2014	State College, Pennsylvania	*Andrea Tapia, Starr Roxanne Hiltz, Mark S. Pfaff, Linda Plotnick, and Patrick C. Shih*	Social Media in Crisis Response and Management *(Linda Plotnick, Starr Roxanne Hiltz, Volkmar Pipek, Kate Starbird, and Amanda Hughes)*
2015	Kristiansand, Norway	*Monika Buscher, Leysia Palen, Amanda Hughes, and Tina Comes*	Social Media Studies *(Starr Roxanne Hiltz, Amanda Hughes, Imran Muhammad, Linda Plotnick, Christian Reuter, Kate Starbird)*
2016	Rio de Janeiro, Brazil	*Marcos R. S. Borges, Paulo Victor de Carvalho, and Andrea Tapia*	Social Media Studies *(Amanda Lee Hughes, Muhammad Imran)*
2017	Albi, France	*Tina Comes, Frédérick Bénaben, Matthieu Lauras, Chihab Hanachi, and Aurélie Montarnal*	Social Media Studies *(Amanda Lee Hughes, Starr Roxanne Hiltz, Muhammad Imran, Linda Plotnick, Christian Reuter)*
2018	Rochester, USA	*Brian Tomaszewski and Kees Boersma*	Social Media Studies *(Starr Roxanne Hiltz, Amanda Lee Hughes, Imran Muhammad, Christian Reuter)*

Table 1. Locations and chairs of the past ISCRAM conferences from 2004 to 2017.

Five years later, in 2009, the field was still emerging, but already receiving more recognition (Jul, 2017). Three of the people responsible for the early creation of ISCRAM produced a very successful text book on Information Systems for emergency management (van de Walle et al., 2010). A Belgium-based non-profit ISCRAM Association was founded, whose goal is to promote community, research and knowledge exchange, as well as to develop systems for emergency management. The association, its activities, standards and legal matters are managed by the Board of Directors consisting of ten members, who are elected for a period of two years directly by its members at the annual conference.

The ISCRAM conference has been held at different institutions worldwide and monitored by changing program and conference chairs. A specific social media track was established as early as 2006. Prior to the major conferences, ISCRAM offers a meeting for PhD students. A standardized academic curriculum dedicated to the cooperation between emergency management and information systems has been proposed (Turoff, 2014). To date, ISCRAM has been established as a legitimate research area, where work is regularly published in influential

journals (Hiltz et al., 2011; Pipek et al., 2014; Reuter et al., 2018a) and presented at conferences, workshops and meetings dedicated to crisis topics.

2.3 ISCRAM and Social Media

Social media play a central role in ISCRAM research. As a general overview of topics dealt with by ISCRAM, we analyzed the ten best-cited papers published in the conference proceedings, based on the 2017 Google Scholar rating. Most of the studies deal with social media used in crisis situations, primarily Twitter, presenting the main subject of four of the ten works (Ashktorab et al., 2014; Caragea et al., 2014; Hiltz, Kushma, & Plotnick, 2014; Imran et al., 2013). Another remarkable commonality is that many studies adopt the example of natural disasters such as floods and hurricanes, as well as dealing with events and affected parties located in the US.

A number of limitations and problems with the analysis of social media in crises have been detected. In the vast number of messages on social media, a diversity of topics and levels of relevance were found (Imran et al., 2013) and low quality and trustworthiness identified (Tapia et al., 2013). The sheer number of posts makes efficient processing and timely reaction by humanitarian organizations and emergency managers difficult if not impossible. For three contributions, the goal was therefore to develop a system to automatically filter, classify and extract information in order to raise awareness and generate practical information for crisis managers and volunteers (Chowdhury et al., 2013; Hiltz et al., 2014a; Imran et al., 2013). However, automatic classification is not yet adapted to and reusable for short texts that are characteristic for microblogging services (Imran et al., 2014). Also, there is a lack of connection between the location of the disaster event and those tweeting about the disaster (Caragea et al., 2014; Hiltz et al., 2014b). Caragea et al. (2014) therefore carried out sentiment analysis and mapping of Twitter posts.

Some of the studies relied on quantitative data analysis, while others also conducted qualitative interviews with stakeholders like emergency managers and intervention teams, to investigate communication practices and how these could be enhanced by social media (St. Denis et al., 2014; Tapia et al., 2013). One paper took up a topic on the meta level, examining the interoperability of crisis-term-ontologies that support communication between different organizations during an emergency (Liu et al., 2013). Another work focused on enhancing communication, particularly between volunteers (Reuter et al., 2013). Here, the lack of a contact point between real and virtual volunteers and a decrease in active volunteering were targeted by using a variety of systems, enhancing collaborative resilience. The aims are to develop and enhance prototypes, frameworks and systems for stakeholders in various kinds of natural or human-induced crises. At the same time, they display a variety of methodological and technological approaches to this topic, as well as a diversity regarding their specific goal.

2.4 Research Gap

While we acknowledge the summarized research on social media in crisis management (section 2.1) and the history and topics of ISCRAM (section 2.2), emphasizing the central role of social media (section 2.3), we are aware that these data present just an excerpt of the reality. The social media landscape is a very dynamic and fluid one, with platforms appearing and disappearing continuously, morphing into new incarnations and online populations migrating along the way. What is still missing is a systematic analysis of all papers published before the 15th conference, taking place in 2018, which is precisely the research gap our contribution aims to address. Our research question is: **What are trends of ISCRAM research, especially with regard to the share of social media content, the distribution of social media platforms, the consideration of crisis events and the focus on crises in different regions?**

3. METHOD

In order to investigate how social media research developed over the years, which trends emerged and if there are any correlations between crisis events, the creation of platforms and the publishing of papers in ISCRAM, a quantitative study on the development of the vocabulary used in ISCRAM papers was performed. To achieve the best overview, a census of all papers was carried out. We downloaded the papers from the ISCRAM digital library and performed a systematic literature and vocabulary analysis. From the resulting 1339 papers, two were excluded from the statistics due to being full proceedings of the conferences in 2016 and in 2017 and thus providing redundant content already present in the digital library individually.

The texts of all papers were extracted automatically using Apache Tika[5] resulting in approximately 6.8 million words. Subsequently some basic cleaning (removal of sentence markers, punctuation, etc.) was performed, casing adjusted and some mappings for alternative spellings of words applied (e.g. Sg. tweet vs Pl. tweets). Moreover,

[5] https://tika.apache.org

the reference section of each paper was eliminated before further analysis. All papers were assigned to their respective year and all words counted on a per-paper and per-year basis. Stop words were excluded (resulting in approx. 3.9 million words) and a ranking based on frequency generated. For the actual analysis we extracted from this ranking the top 1000 (Top1k) words. As the papers had been grouped by year, we ensured that the overall top-ranking words were considered across all years, even if a particular word would not have been among the top-ranking words of a particular year. In addition, the top-ranking words were extended with a set of words, which had been selected to be of importance for our study. Those extensions take three important categories of ISCRAM and the survey's main pivot point into account:

(1) The main focus of this survey is social media. Therefore, the platform names are an immanent part of the word-set and needed to be included (such as Twitter, Facebook, etc.). Likewise, platform-specific terms like "tweet" or "retweet" were included.

(2) Since the conference covers a broad variety of topics concerning crisis situations, the different kinds of disasters had to be included as well. Man-made crises and disasters were not specifically addressed.

(3) Further word sets were required which enabled the authors to narrow down the socio-cultural and economic region mentioned by the papers. Hence, country names were also included in the word set variables.

These three additional sets enable us to identify past, current and upcoming trends in social media and allow us to link them to particular locations and events. By doing so, general distributions have been generated over the three main categories listed above. The platforms themselves provide the focus of identifying social media content and were hence chosen as the starting point of our analysis. A time-related analysis across platforms was performed with temporal comparisons across the different years. Each year was also analyzed separately to investigate potential links and correlations between the three categories.

In the visualizations, the lower 2.5 percent (lower quantile) of every figure were excluded in order to factor out papers with weak relations to the focus of the study. Papers with significant correlation are assumed to have a linear relationship and were checked.

4. RESULTS

Figure 1 below shows the years of creation of different social media platforms found to be of relevance within the scope of media coverage of disasters. Several platforms date back to the mid-2000s with Twitter, the most frequently referenced and researched platform, coming into existence in 2006. All statistics below concerning the use and reference of platforms should be viewed in the context of this timeline.

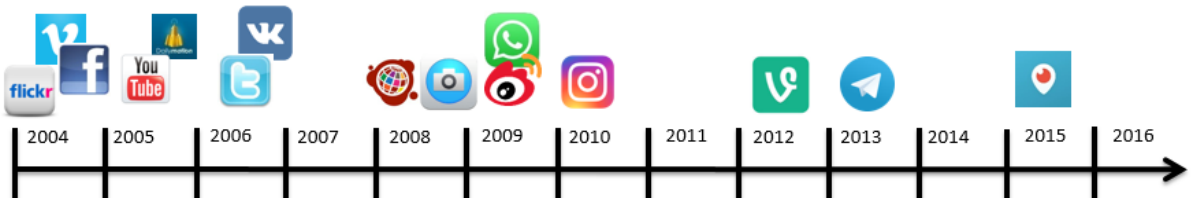

Figure 1. Year of Creation of Social Media Platforms (own illustration)

4.1 Share of Social Media Content – From 0% to 60%

A close look at the general statistic in Figure 2 shows that social media-related content was first published at ISCRAM in 2008 and then noticeably picked up momentum in 2012, passing the 20% line. Until 2014, this increase continued, whereas after this year, the overall number of published papers stagnated and even decreased considerably. While an increase in the total number of papers is observed from 2014 to 2015, this jump is not reflected in the number of contributions on social media. In the following years, the overall amount of papers started to decrease once more, but social media were not affected by this development. On the contrary, the percentage of social media-related research increased compared to the overall number of papers, reaching a peak of almost 60% in 2017.

From the numbers, we can conclude a general trend for the coverage of social media to get stronger over time. However, this trend is not straightforward and some of the years are worth taking a closer look: Those years are 2010, 2011, 2012, 2014, 2015 and 2017.

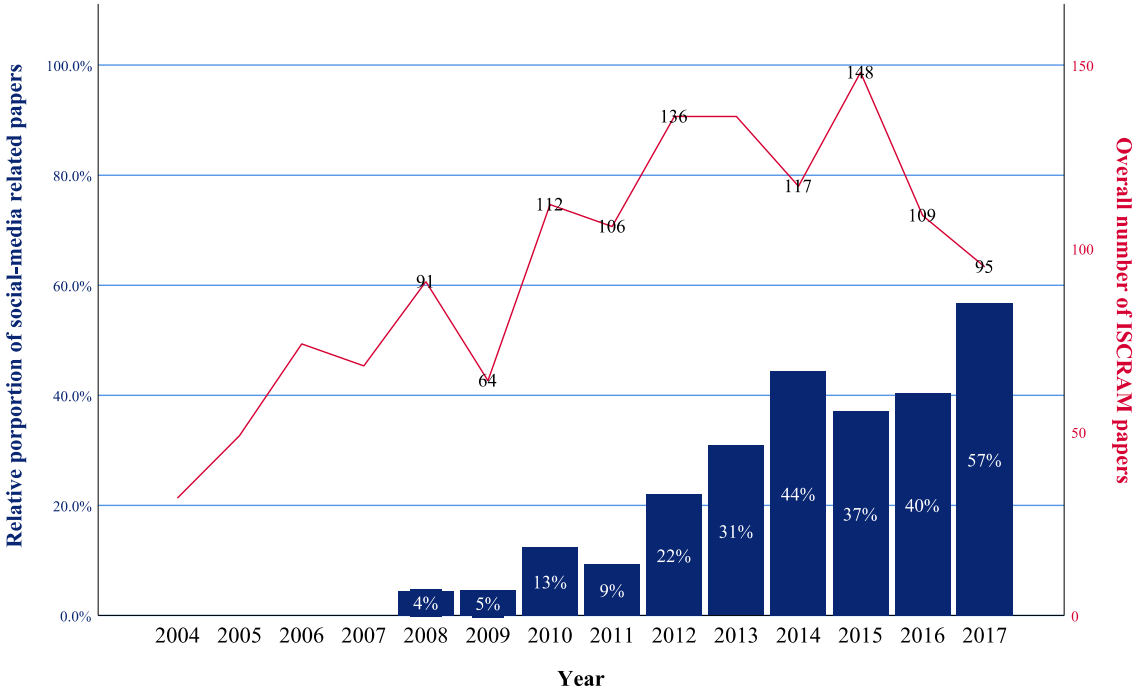

Figure 2. Percentage distribution of papers with social media content

4.2 Social Media Platforms – Twitter, Twitter and Twitter

The reference to particular platforms provides a central point of interest in our study. Therefore, we analyzed the distribution of the different social media platforms addressed over the years. From the beginning, Twitter was in the focus of the most research papers. In the first year of its coverage, it developed identically to Facebook. However, already one year later, in 2009, the coverage of Twitter significantly increased, with another increase from 2009 to 2010 (see Figure 3). In 2010, papers related to Twitter were published about twice as often as works on all other platforms. However, their numbers declined by nearly 50% in 2011, whereas other platforms did not exhibit a similar drop in coverage.

The year 2012 witnessed a comeback of Twitter increasing its share again by close to two thirds of the initial percentage of 2011. In the following years, the amounts of content related to Twitter constantly increased (see Figure 3), until it peaked in 2014. More recently, between 2014 and 2017, we can observe that contributions related to Twitter were no longer as frequent as in previous years.

During the same time-span, Facebook-related papers developed quite similarly to those covering Twitter, except for their absolute amount. In 2010, works mentioning Facebook also increased in absolute numbers. However, those papers only amounted to a lower 5% range. A significant increase can first be detected in 2012 and unlike the studies concerning Twitter, this increase continues up to 2015. In the following years, we can observe the same development as with Twitter-related research, only on a lower scale.

On an even lower scale, works related to Ushahidi show quite a similar distribution of the publishing numbers. Even though the first studies were published in 2009, they also had their first peak in 2010, declined in 2011 and then increased again until 2014. 2015, on the other hand, shows a significant decrease in the share of published papers covering Ushahidi. This trend did not continue in the following years when the amount of contributions in question constantly expanded.

Papers dealing with OpenStreetMap developed in a different way compared to the other platforms. With the appearance of contributions in 2010, the first peak took place in this year, while the numbers decreased in the following year and then constantly went up again until 2016. This behavior stands in contrast to Facebook- and Twitter-related papers which stagnated earlier. OpenStreetMap then could not keep up with the overall increase of works concerning social media topics. All further platforms seem to play only a marginal role, with the percentage of coverage never exceeding 4%.

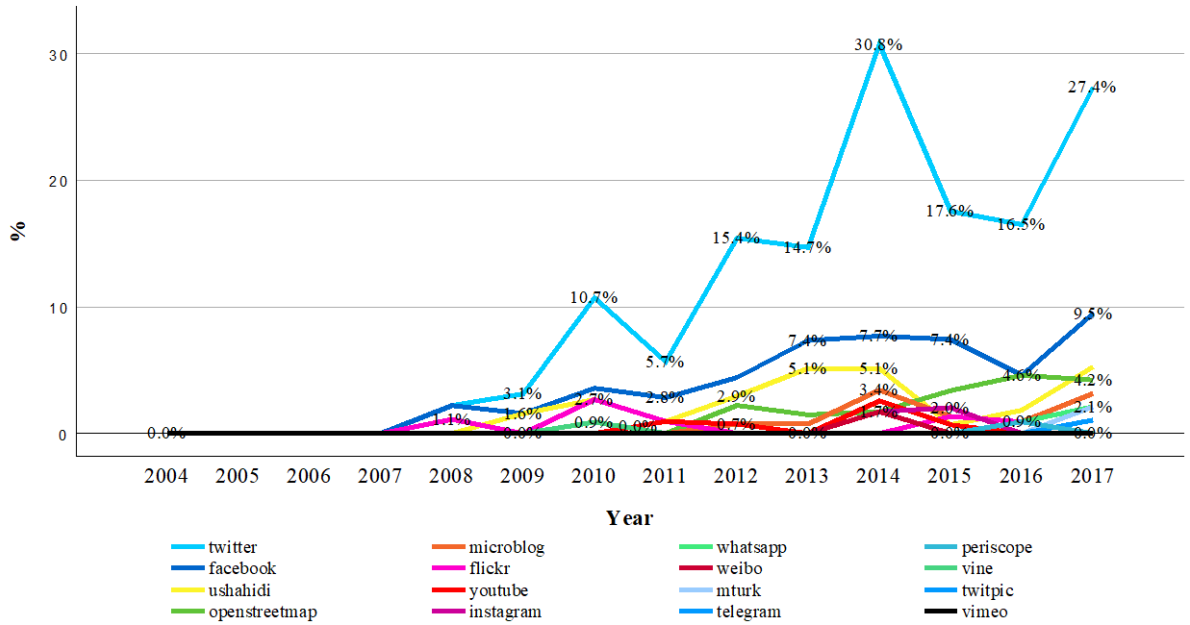

Figure 3. Distribution of the social media platforms across the years (Appendix 1)

4.3 Crisis Events in Social Media – Fire, Floods and Earthquakes

Next, we addressed the question of how those papers – or the social media platforms – are related to specific kinds of crisis events. A prominent topic in all the works (including those outside the social media track), is their relation to fires, earthquakes and floods (see Figure 4). Within the events and platforms, we can find a significant correlation between hurricane and Twitter (r= 0.267). However, the most significant correlations can be found with landand mudslides and the social media platform YouTube (r=0.524, r= 0.495). On average, the social media platforms and the event categories correlated significantly ($r_{(mean)}$ =0,237), even stronger than within the social media platform category ($r_{(mean)}$=0.213). A closer look at the individual years indicates that in 2010 (n=112), there were strong correlations between the publications dealing with the social media platform Ushahidi with earthquakes and hurricanes (r = 0.695, r= 0.648).

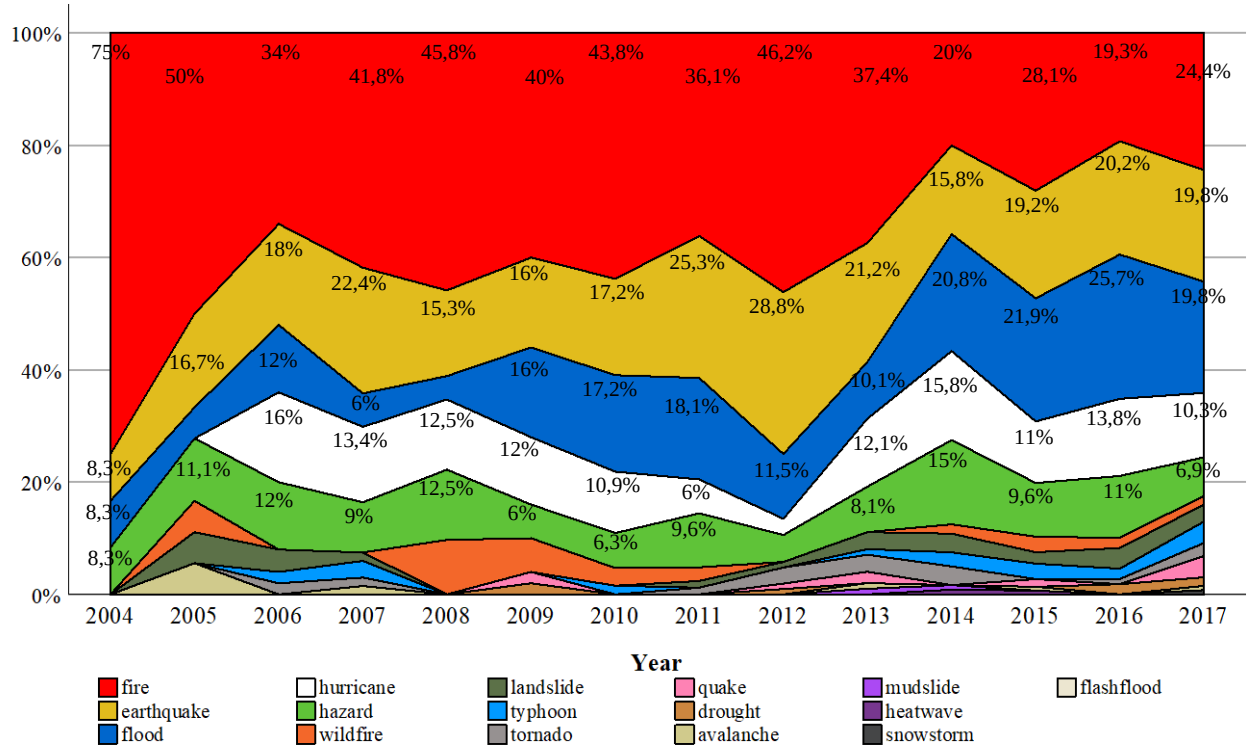

Figure 4: Distribution of crisis events in the papers (Appendix 2 numbers in total)

In the following year, 2011 (n=106), the trend towards correlations between social media platforms and types of disasters was prevalent. Especially the correlation between Flickr and YouTube (r = 0.998) proved to be very strong. In 2012 (n=136), this trend continued, less pronounced than before, but nevertheless showing a strong relation between events and platforms. In particular, the works on tornados and the social media platform Ushahidi (r = 0.482) indicated a significant correlation. Contributions in 2014 (n=117) extended this trend, however with a more intense focus on inter-social-media-platform relations, the correlation between Weibo (also a microblogging platform) and Microblog (r = 0.852) being the most significant one. It is also noticeable that the most significant correlations between events and the social media platforms are all related to either to hurricanes or floods. In 2015, the correlations were again more equally distributed. Therefore, there are no further interesting results from a correlation-based point of view in 2015. However, 2017 (n=95) again shows a strong trend towards a correlation of events and social-media-platforms. Extraordinary in this case is the correlation of typhoon-related papers to those working with OpenStreetMap (r = 0.541).

4.4 Regions – Dominance of European Studies

We will now switch our perspective to a regional point of view, to elaborate on the topic as to which geographical regions were most often referred to in social media-related papers. Overall, Europe has been the focus of most publications, with a rising tendency from the 2017 conference (see Figure 5). The amount of papers on North America has been approximately 20% after a peak in 2006, while South America stays low over the years. Asia increased from 0% to almost 20% over that time, with the tendency still rising. This trend corresponds well with the frequency and impact of disasters and the high social media usage in the region.

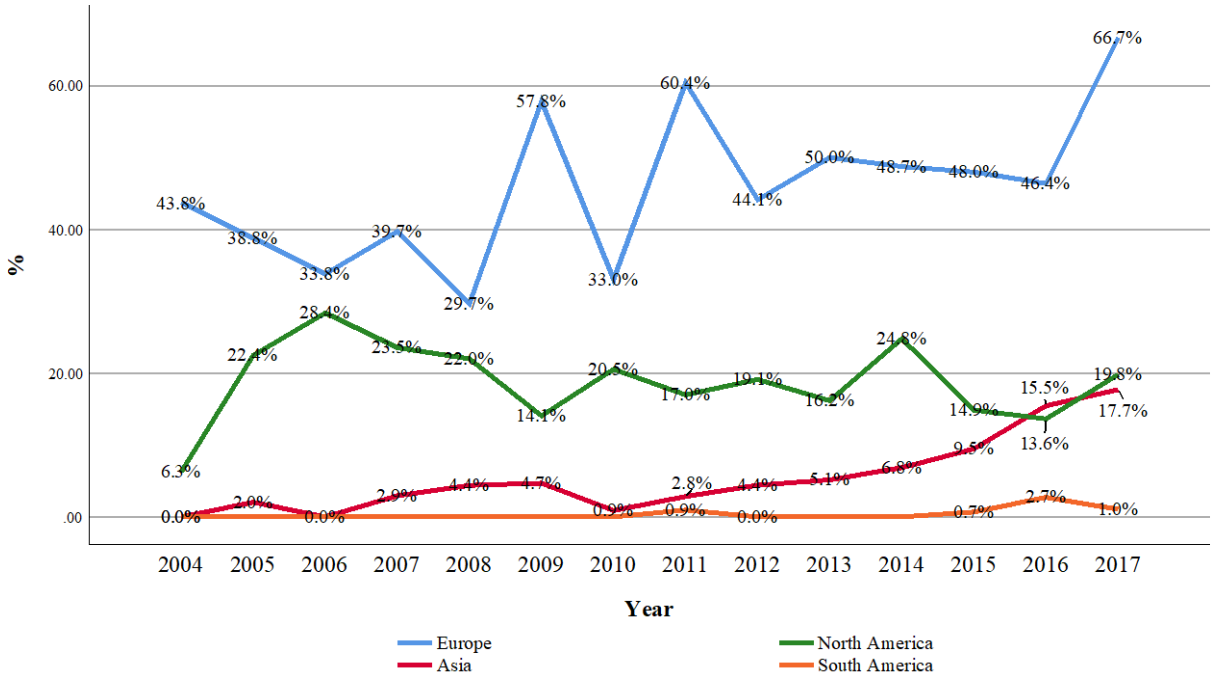

Figure 5: Distribution of continents

Overall (n=1337), if a paper concerns social media and at the same time correlates to certain continents or countries, most cases apply to North America: this is the case for Twitter (r =0.100) and Weibo (r = 0.073). However, the most significant correlations can be found for Asia and OpenStreetMap (r = 0.285) as well as Twitpic (r = 0.155). Hence, a closer look is required again. The results for 2010 (n=112) show that especially Flickr-related publications were of interest in terms of continent- and platform-related papers. Studies on events in North- and South America displayed strong correlations to Flickr (r = 0.416, r = 0.969), with South America being especially significant in this year. One year later, in 2011 (n=106), the trend towards Flickr-related works also followed for crises in Europe (r = 0.241), together with a similar trend for YouTube (r = 0.237). At the same time, Europe-related research dominates the output of ISCRAM in general (see Figure 5).

2012 (n=136) was the year when Twitter was most strongly connected to publications referring to South- and North America (r = 0.327, r = 0.245). South America was also significantly correlated to Ushahidi (r = 0.318). Meanwhile, North America was rather related to contributions concerning Microblogs (r = 0.172), and also to

Ushahidi (r = 0.173). In 2014 (n= 117), Asia could be found in a large number of papers addressing social media, particularly OpenStreetMap indicated strong correlations (r = 0.523). For South America, we could also observe correlations with works concerning Twitter (r = 0.375). The following year, 2015 (n=148), publications on disasters in North America tended to be more correlated to social media papers: Twitter and Facebook show significant dependencies to this continent (r = 0.256, r = 0.240), while Flickr-related research particularly correlated with Europe (r = 0.176). In 2017 (n=95), social media-related studies were less strongly related to specific countries. Only Asia showed correlations with OpenStreetMap (r = 0.231) and North America indicated dependencies to Twitter (r = 0.251).

5. DISCUSSION

What are the conclusions for the trends of research at the 15th ISCRAM conference? What has been researched in ISCRAM, especially in the area of social media? In order to answer our research question (**What are trends of ISCRAM research, especially with regard to the share of social media content, the distribution of social media platforms, the consideration of crisis events and the focus on crises in different regions?**) we collected and processed all research contributions (*n*=1339) from the past 15 years of ISCRAM and analyzed their quantitative development as well as their content with a focus on social media use in emergency situations. In particular, we investigated potential dependencies between platforms, types of crises and locations described in the papers, deriving tangible results.

- Our results indicate that the platforms named in most publications addressing social media generally correlate eaqually with each other as well as with events, such as fires, hurricanes and earthquakes.
- Concerning the correlation between and within platforms and crisis events in works related to social media, Twitter proved to be the most prominent among all social media platforms, therefore being of particular significance to the analysis. Over the entire time-span of 15 years, contributions related to Twitter present the vast majority – mostly over 30% – of all papers related to social media, underlining this platform's dominant position.
- However, the correlations between the platforms and the crisis events in a particular year suggest that the results need to be viewed in a more differentiated way. Ushahidi and OpenStreetMap, for example, correlate strongly in the years with earthquakes, hurricanes and tornados.
- With regard to a focus on the regions, the survey shows a significant amount of research concerning social media platforms is correlated to Europe, North- and South America as well as Asia.

Lifetime: The first social media platforms that gained the attention of works published at ISCRAM originated in 2004, and further ones have constantly been emerging since then. However, it was only in 2008 that papers explicitly examining social media were first contributed to the conference, which is in line with observations that analysis of social media use during crises, disasters and emergencies took hold only in 2007 (Palen & Hughes, 2018). The number of such works has been increasing over time and their focus changing constantly. Meanwhile, Twitter consistently remained the champion of all social media platforms mentioned in these papers.

Platforms: Examining the general development of platforms addressed in papers, we observe a rise with one or multiple peaks for a few years after the emergence of each platform, then a steep decrease followed by another climb. This reflects the dynamics of social media which are introduced, temporarily drawing the focus of entire communities and research on them, and then declining in use or interest over time, possibly being replaced by newer networks. Temporal variations may also be related to the corresponding events in which they have been used. We found a number of correlations, indicating a dependence on papers' country of origin, the locations where characteristic disasters tend to occur and certain platforms are popular at a given time. Furthermore, the regular fluctuations can be explained by the conference location alternating between Europe and North America, resulting in each of these continents producing a peak number of papers every two years.

Types of Crises: Within our focus on research concerning natural disasters, we found that the distribution over the different kinds of disasters was rather comparable, the most frequent ones being fires, earthquakes, floods and landslides. Although there is still a strong focus on Twitter based studies, the location of analyzed crises receives a more international backdrop (Olteanu et al., 2015; Reuter & Kaufhold, 2018). Considering the recent increase of terrorist attacks in Europe, such as the 2015 Paris shootings (Wiegand & Middleton, 2016), 2016 Brussels bombings (Mirbabaie & Zapatka, 2017) or 2016 Munich shootings (Nguyen et al., 2017), we anticipate an increasing effort, in terms of papers and projects, of research of social media use during human-induced crises in Europe. This alley could potentially also lead to increased contact and cross-fertilization of ISCRAM with security-related events, journals or conferences (such as the European Intelligence and Security Informatics Conference, EISIC[6]).

[6] http://www.eisic.eu/

Languages and Regions: Limitations in platform and language processing capabilities are evident: Most studies deal with social media content in English, predominantly on Twitter (Reuter & Kaufhold, 2018). Due to the conference's origin in Belgium, it is no surprise that - especially in the first years - Europe was the focus of the majority of ISCRAM publications. Here, we observe a contrast to earlier studies on crisis management publications where the focus was found to lie firmly on the US (Reuter & Kaufhold, 2018).

Over time, an increasing amount of papers focuses on crises in North America and Asia. Such works also significantly correlate with the use of Twitter, which could explain the prevalence of this particular network in ISCRAM research. Interestingly, even though a substantial part of the population of the US speaks Spanish as a first or second language, research on the use of Spanish social media content is scarce. Furthermore, even though social media are used and investigated in the context of Australia and New Zealand, these seem to be all but missing from ISCRAM. Especially in 2010 and 2011, both states were hit by major disasters: The Queensland floods (Bruns et al., 2012) and the earthquake in Christchurch (Bruns & Burgess, 2012), where social media have been used by both citizens and emergency managers to a similar extent as in other examined countries.

With these biases, conducting a quantitative analysis on ISCRAM papers on the use of social media in crisis situations does not produce a representative picture of the actual situation. The topic of how the foundation of analyzed data can be extended to avoid such a limited focus will have to be addressed in the future.

Data Processing: Another obstacle for a broader analysis of social media in general is the trend towards privacy, which is likely to lead to even more complicated data-extraction scenarios. Terms of use are restricting the further processing of social media posts, such as the deprecation of Facebook's public post search[7] (Apr 30, 2015) and the introduction of Instagram's sandbox mode[8] (Nov 17, 2015). The upcoming "European General Data Protection Regulation (GDPR)[9]" may reduce the amount of user data publicly available and processable dramatically.

Automatic processing of data and especially the field of sentiment analysis have been examined by many ISCRAM papers and various solutions have been implemented. However, these still encounter problems such as gaps in NLP and text classification tools. Although these areas, along with Machine Learning, are advancing fast, there is work to be done to allow for an efficient process of information extraction, filtering, categorization and interpretation. Most of the frameworks described in papers are prototypes or theoretical results. Besides increasing the data processing capabilities, Imran et al. (2015) argue that human-centered approaches are required "toward making the computing research the foundation of viable systems that emergency responders can implement."

Technology and Industry: Our analysis indicates a relatively small contribution to actual technology and industry. Papers presented at ISCRAM are mostly written with the aim to facilitate the work of first responders and emergency managers, dealing with variations in communication supply and requirements from citizens. From a technological point of view, we observe a trend towards multimedia content supported by the heavy increase in mobile devices, faster and cheaper connectivity, and general technological advances reflected in the platforms themselves. Most contributions concentrated on text-based posts. Whereas textual content will certainly **not** disappear in the foreseeable future, media types other than text and further developments will become more frequent and relevant in crisis communication. Such shifts will require further analyses in the future.

Since its inception, being established by scholars, the conference has had a rather academic, theoretical focus. However, as we have seen from the quality of contents, ISCRAM has the potential to be the base for technological innovations and to provide substantial contributions to the area of disaster communication and management where ICT has become indispensable. By adding corresponding tracks, adjusting evaluation criteria towards practicability, and drawing experts from industry to the venue, this trend could be redirected in the future.

6. CONCLUSION AND RECOMMENDATIONS

In this work, we have carried out a quantitative analysis of all ISCRAM papers related to social media, published until 2017. Referring to the trends in social media research in the emergency management context, we found related contributions starting in 2008 and constantly increasing their shares, representing more than half of the submitted papers in 2017. Apart from analysis of predominantly English-language social media posts, a focus on the platform Twitter and on crises occuring in Europe and North America could be observed.

Our limitation to papers addressing social media in the natural-disaster context from a single conference does not allow us to offer a comprehensive overview of all research on ICT in emergency management. Furthermore, a purely quantitative review does not replace a thorough investigation of trends, problems and suggestions found in ISCRAM papers over the years. However, it did allow us to identify gaps which can be filled by future work in

[7] https://developers.facebook.com/docs/graph-api/using-graph-api/v2.0#search
[8] https://www.instagram.com/developer/changelog/
[9] https://www.eugdpr.org

this area.

To broaden the overview of contributions in the area of emergency management, a similar review will need to be carried out for other related and established conferences and journals, such as CHI, ICIS, and ISCRAM venues in localized contexts. Our suggestions also include further examination of human-induced events, works in other languages apart from English, and suitable media to support planning for, responding to and recovering from different types of crisis, as well as warning and communication for different stakeholders. The theory on users' preference of familiar social media platforms in such events can be further pursued at this point. Insights into this context can contribute to a diversification of ISCRAM research, overcoming biases found in earlier examinations of the area's literary landscape.

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APPENDIX 1: DISTRIBUTION OF THE SOCIAL MEDIA PLATFORMS ACROSS THE YEARS (FIGURE 3)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Facebook	2,20%	1,56%	3,57%	2,83%	4,41%	7,35%	7,69%	7,43%	4,59%	9,47%
Flickr	1,10%	0,00%	2,68%	0,94%	0,00%	0,00%	0,00%	1,35%	0,92%	2,11%
Instagram	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	1,71%	2,03%	0,00%	2,11%
Microblog	0,00%	0,00%	0,00%	0,00%	0,74%	0,00%	3,42%	1,35%	0,92%	3,16%
Mtruk	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	2,11%
OpenStreetM	0,00%	0,00%	0,89%	0,00%	2,21%	1,47%	1,71%	3,38%	4,59%	4,21%
Periscope	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,92%	0,00%
Telegram	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	1,05%
Twitpic	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Twitter	2,20%	3,13%	10,71%	5,66%	15,44%	14,71%	30,77%	17,57%	16,15%	27,37%
Ushahidi	0,00%	1,56%	2,68%	0,94%	2,94%	5,15%	5,13%	0,68%	1,83%	5,26%
Vimeo	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Vine	0,00%	0,00%	0,89%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Weibo	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	1,71%	0,00%	0,92%	0,00%
WhatsApp	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,92%	2,11%
YouTube	0,00%	0,00%	0,00%	0,94%	0,74%	0,00%	2,56%	0,68%	0,00%	1,05%

APPENDIX 2: DISTRIBUTION OF CRISIS EVENTS IN THE PAPERS (FIGURE 4)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
earthquake	0,2%	1,7%	6,4%	4,5%	4,0%	2,3%	2,9%	5,2%	8,5%	9,7%	7,9%	9,8%	17,3%	19,8%
flood	0,3%	0,6%	1,5%	4,4%	1,5%	6,3%	4,7%	7,1%	3,3%	3,7%	14,0%	14,8%	21,7%	16,0%
hurricane	0,1%	0,2%	3,8%	6,3%	6,6%	4,6%	4,3%	7,1%	3,1%	6,1%	10,9%	10,5%	18,1%	18,2%
hazard	0,4%	1,1%	3,5%	6,0%	5,7%	3,3%	1,8%	8,5%	4,4%	5,7%	19,1%	16,3%	15,4%	8,8%
wildfire	0,0%	1,9%	0,3%	0,0%	17,0%	10,4%	8,8%	5,8%	2,7%	1,6%	5,5%	16,4%	16,4%	13,2%
landslide	0,0%	4,2%	1,8%	4,2%	1,3%	0,2%	0,4%	2,2%	1,3%	5,8%	31,3%	4,4%	18,7%	24,0%
typhoon	0,5%	0,0%	4,1%	3,7%	0,5%	0,5%	1,4%	0,0%	0,9%	6,4%	15,5%	33,8%	9,1%	23,7%
tornado	0,0%	0,9%	1,9%	3,4%	0,6%	0,3%	1,9%	3,7%	20,4%	12,0%	38,6%	4,0%	3,1%	9,3%
quake	0,0%	0,0%	0,4%	0,9%	0,4%	1,8%	0,9%	0,9%	5,8%	12,4%	1,3%	4,4%	1,8%	69,0%
drought	0,0%	0,8%	3,2%	2,4%	3,2%	4,0%	0,8%	3,2%	7,3%	2,4%	6,5%	1,6%	29,0%	35,5%
avalanche	0,0%	8,2%	2,0%	8,2%	2,0%	0,0%	2,0%	0,0%	0,0%	14,3%	4,1%	34,7%	4,1%	20,4%
mudslide	0,0%	0,0%	0,0%	15,4%	0,0%	3,8%	0,0%	0,0%	0,0%	15,4%	38,5%	3,8%	7,7%	15,4%
heatwave	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	66,7%	33,3%	0,0%	0,0%
snowstorm	0,0%	0,0%	0,0%	15,0%	10,0%	0,0%	5,0%	0,0%	5,0%	5,0%	0,0%	20,0%	0,0%	40,0%
flashflood	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%
fire	2,1%	1,8%	2,5%	5,5%	5,7%	6,8%	6,3%	6,7%	7,6%	5,5%	3,5%	11,7%	15,6%	18,6%