

# Social Media Discourse in Disaster Situations: A Study of the Deadly July 21, 2012 Beijing Rainstorm

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## ABSTRACT

The July 21, 2012 Beijing rainstorm was a devastating catastrophe that caused 79 deaths, raising a great deal of attention all over the world. This research aims to explore emotions, attitudes, and views of citizens during the period surrounding this major rainstorm from a social media perspective. The results show that first the rainstorm-related posts of micro-bloggers in Beijing outnumbered that in Hebei, which also outnumbered the other provinces of China. Second, within the most reposted Weibo posts, a strong proportion is storm related and private bloggers are found to be more influential than government agencies. Third, the four district groups in the Beijing metropolitan region expressed a high-low-high sentiment before, during and after the rainstorm, respectively, and a quite uneven trend was observed across the different groups. Topics extracted through LDA modeling also exhibited a striking space-time pattern.

## KEYWORDS

Weibo, disasters, rainstorm, content analysis, sentiment analysis

## 1. INTRODUCTION

In recent years, social media platforms have burgeoned in popularity worldwide. Social media is a widespread and important way for interactive communication, involving characteristics of participation, openness, conversation, community, and connectedness [1]. It allows the individuals, organizations and communities of the general public to receive live information online virtually without intermediaries or delay, and to also contribute to it. Individuals can share opinions, insights, experiences and perspectives with others via social media [2], while organizations can disseminate informational notices and use posts as crowdsourced information guiding actions and interventions, such as emergency crew dispatching. The crowdsourcing of widespread and deep participation across a territory or jurisdiction provides the basis for user-generated media. When one kind of social media initially is launched, the contents are often personal and seemingly inconsequential updates

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*EM-GIS'17*, November 7–10, 2017, Redondo Beach, CA, USA

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ACM ISBN 978-1-4503-5493-6/17/11...\$15.00

<https://doi.org/10.1145/3152465.3152468>

on what is going on in everyday life [3]. Later on, organizations and influential individuals adopt the media and grasp the main stream of the media. Using social media for updates on public events allows the users to stay informed on current events and for the public organizations, commercial industries, research institutes to receive feedback with little delay.

Crises, such as disasters caused by natural or man-made hazards, are events during which the use of social media takes on quite distinct modalities. They present unique challenges for researchers who have studied communication under these conditions because this type of research requires specific approaches and techniques [4]. Disaster situations are likely to create the convergence of various problems and uncertainties, and the necessity for quick decision making under limited information. Recent research has revealed the important role of social media communication before, during, and after a disaster [5], owing to the large volume and fast transfer qualities of information sharing enabled by the technology, and the pervasive nature and lower reliance on ground-based infrastructure of social media platforms.

The richness of social media makes it possible to screen millions of data points to draw the general outline for the entire event or focus on a particular viewpoint. The development of different social media platforms on mobile phones, computers and other mobile technologies is reshaping the network communication structure and the way we connect with each other. Studies have shown that live and online crisis response activities are becoming increasingly "intertwined" [8]. Social media have become an essential part of the actual crisis response. For example, the social networking service Twitter was used to quickly share initial information and updates during the 2009 US Airways flight 1549 crash into the Hudson River [9], the 2010 Haiti earthquake [10], and the Tunisian uprising in 2011 [11].

In our research, we focus on microblogging during a powerful rainstorm disaster in Beijing, China that lasted from July 21, 2012 10:00:00 am to July 22 04:00:00 am. It was a serious catastrophe that caused 79 deaths, raising a great deal of attention all over the world. Research on Chinese social media during a natural disaster has so far been rather limited compared with the English-based

Twitter and Facebook services. Most of the literature has also focused on more extreme types of disasters such as earthquakes and tsunamis, whereas rainstorm-induced disasters are a common natural phenomenon that is less destructive and seldom lethal. The Beijing rainstorm is also interesting to study because it turned out to be more devastating than anticipated, with many casualties, and a deeper sense of powerlessness in the local population than many other similar storm would generate. Also, the storm occurred at a time when social media were not yet deeply anchored in the social fabric of Chinese urban residents.

We formed three main research questions. The first question aims to determine the differences in the reactions of people in Beijing, Hebei province and other Chinese provinces, respectively, to the extreme weather event on social media. Beijing was the province affected most by the storm. While Beijing is mostly surrounded by Hebei province, the latter was only mildly touched by this storm, and other provinces were not directly affected at all. Yet, since people's migratory and recurring travel relations between Beijing and Hebei are frequent and strong, it is intriguing to identify how different the attitudes and emotions of micro-bloggers vis-a-vis the rainstorm were in these two provinces, using the rest of the country as a control. The second question pertains to Weibo reposts during the weather event to identify the most popular and influential posts and the topics they relate to. In China, the government and public service departments play an important role in all public matters. Influential individuals also react quickly to hot social topics and receive a significant amount of public feedback. Thus, we want to explore what the most frequently mentioned topics were and identify the differences between posts from official and personal accounts. The third question is what were the dominant topics broached in posts made by users in different parts of the Beijing Metropolitan Region. Here, given that the severity of the storm was quite uneven across Beijing districts, which manifested itself through spatially heterogeneous consequences (both in terms of human loss and material hardship), we want to know whether people in separate areas of Beijing reacted to the rainstorm differently, and if so, to identify the main topics expressed in their micro-blogging discourse.

## 2. Background and Analytic Methods

### 2.1. Weibo Social Media Data

Weibo is a form of mediated communication platform and can be regarded as the Chinese version of the Twitter microblog. Weibo is used by over 30% of Internet users in China, with a market penetration similar to Twitter in the rest of the world. It was launched by SINA Corporation in 2009. Weibo users can post short messages with a word limit of 140 Chinese characters (the limit was raised to 2000 characters in 2016) on the website (<http://www.weibo.com>) or through the App on different types of mobile devices. Apart from posting, the users can also repost the messages authored by other users. Weibo allowed individuals the unprecedented ability to rapidly broadcast and exchange small amounts of information with large audiences regardless of

distance [5]. With the rapid development of mobile technologies, Weibo's primary focus turned to the integration with mobile/cellular devices, which created the potential for an alternative communication system. At the end of 2014, the number of monthly active users had reached 176 million, 80% of which made use of mobile terminals.

Weibo has become an indispensable tool for government and public organizations during disasters and crises. They have utilized Weibo to report up-to-date disaster or crisis situations, to disseminate information regarding their programs and services, to interact with the public, as well as to conduct disaster relief tasks. The research literature on social networking and social media in disasters and crises is still quite limited. This is understandable because social media are a relatively new phenomenon. Although 'new media', such as the Internet, have received attention from academia for a decade or more, limited research on social networking started in 2007. Studies on social media in disaster situations have been conducted as part of a broader body of literature aimed at examining the functioning of social interaction as a community building tool by means of the Internet and mobile devices [12]. About 1% of Weibo posts have geo tags, and these posts are named check-in Weibos. The geo-information is acquired by the GPS recording of the mobile terminal location at the time of posting or reposting.

Dr. King-wa Fu (University of Hong Kong) developed a data collection and visualization system called Weiboscope and made use of the Sina Weibo Open API to access the Weibo social media data [13]. His research team systematically searched Weibo users in each region of China since late 2010 through a non-random sampling scheme. Through this process, they generated a list of 14,388,385 Weibo accounts. The selection of high-follower-count samples can minimize the number of spam accounts in the data. Between January 1, 2012, and December 31, 2012, the system collected 226,841,408 Weibos, 1,760,335 of which with geo-information. Dr. Fu's Weiboscope is the source of Weibo posts used in this research.

### 2.2. The Beijing storm on July 21-22, 2012

The Beijing storm on July 21, claimed at least 79 lives (seventy-one were identified) [14, 15]. The storm caused tremendous economic losses estimated at about US\$1.6 billion, widely attracting public and social concerns [15, 16]. Precipitation exceeded 100 mm in all the districts of Beijing, except Yanqing District, and the average precipitation reached 190.3 mm. This storm turned out to be the heaviest storm in Beijing since 1951, breaking precipitation records at 11 local weather stations. In some locations, the one-day precipitations surpassed the annual average totals. It rained 460 mm in Hebei town, Fangshan District, which is the highest on record for that day. The storm lasted 42 hours, from Saturday, July 21, 2012, 10:00 am to Sunday, July 22, 4:00 am, covering around 16,000 km<sup>2</sup> [17].

Highway and public transportation traffic suffered heavy perturbations as a result of the uninterrupted rain. Ninety bus lines were forced to stop serving some stations, and some lines stopped working altogether. Subway service was also seriously affected,

where water leaked in Shunyi Station on line 15, leading to the closure of that station from 4:30 pm onward. Service was degraded on line 13 from Lishuiqiao Station to Huoying Station, on which the operational speed was limited to 40 km/h. The airport line stopped operation from Dongzhimen Station to T3 Terminal Station. Affected by heavy rainfall, the Beijing Capital International Airport cancelled a total of 571 flights on July 21 and delayed 701 flights. Nearly 80,000 people were reported trapped at the airport at the same time. Railway transportation also was affected by the heavy downpours, where part of the trains on the Jingyuan, Fengsha, S2, Jingcheng, and Jington Lines were delayed; most of the delayed trains were heading to or from southwest Beijing.

There are 16 districts in Beijing, and in 10 of those, deaths were reported. Fangshan District in Southwest Beijing accounts for the majority of the death toll (46 dead). For part of the analysis, we differentiate three time intervals according to the relationship to the rainstorm: before (07/19/2012 12:00:00 am – 07/21/2012 10:00:00 am), during (07/21/2012 10:00:00 am – 07/22/2012 04:00:00 am), after (07/22/2012 04:00:00 am – 07/24/2012 12:00:00 pm). We also categorized the 16 districts in Beijing into 4 groups: west, north, center and east of Beijing (Figure 1).

There were 904 valid check-in records during the rainstorm, and 620 of the check-in users identify themselves as male in their profiles, while the rest claimed themselves as female. Also, according to the user profile, 677 of all the check-in users claimed to be from Beijing, and 3 claimed to be from Hebei. For comparison, the check-in points from micro-bloggers in Beijing and Hebei were 891 and 5 before the rainstorm, and 916 and 5 after the rainstorm.

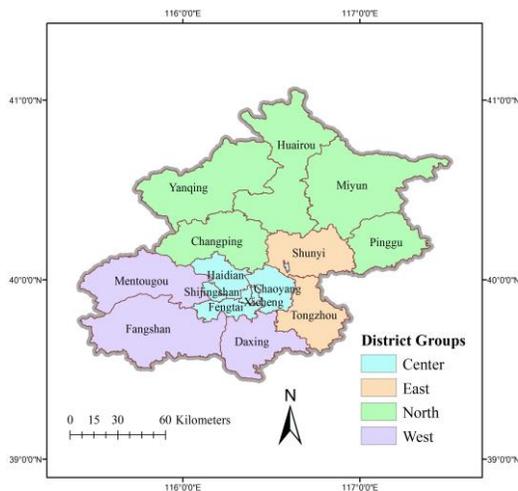


Figure 1: Map of Beijing districts and their grouping.

### 2.3. Chinese NLP Analysis: Topic Modeling and Sentiment Analysis

#### 2.3.1. Topic Modeling.

Topic modeling is a commonly used text-mining tool for the detection of hidden semantic information in large volumes of unlabeled text, based on the Latent Dirichlet Allocation (LDA) theory [18]. The "topics" produced by topic modeling techniques are clusters of words that tend to co-occur in posts. A topic model, as a type of statistical model, captures the main lines of discourse in the text corpus under study in analytical terms. The framework can check the training documents and discover structures embedded in the document [18]. Topic models can infer the probability that an unclassified text body belongs to different topic categories. In addition, topic models can help us organize and provide insight into a collection of unstructured texts.

In this research, we use the robust open-source Python toolkit Gensim for vector space modeling and topic modeling. Gensim is specifically designed to handle large text collections, using data streaming and efficient incremental algorithms, which differentiates it from most other scientific software packages that only target batch and in-memory processing. The Chinese text segmentation tool for this research is Jieba toolkit. Each post has a probability distribution on the top 10 topic categories. The sum of probabilities of the 10 topic categories for one post is rescaled to 1. In order to acquire the number of posts for each category, first, we select the posts whose maximum probability is over the threshold 0.15; second, we obtain the top 3 probabilities of a post and unify these 3 probabilities; third, we add the probabilities of each post. To test the robustness of the analysis to these assumptions, we also evaluated results by setting the threshold to 0.2 and 0.3. No meaningful changes were observed, which establishes the stability of our results.

#### 2.3.2 Sentiment Analysis.

Sentiment analysis refers to the use of natural language processing, text analysis and computational linguistics to systematically identify, extract and quantify emotional status and subjective information in a corpus of documents. In general, sentiment analysis is intended to determine the attitude of a writer or another subject to some topic, or the overall contextual or emotional response to a document, interaction, or event whose occurrence can be clearly isolated.

The bosonnlp Chinese natural language processing toolkit with a large amount of Chinese social media corpus is applied here for the sentiment analysis. Each evaluated sentence achieves a sentiment level between 0 and 1. A high value indicates an optimistic sentiment while a low value indicates a negative sentiment.

## 3. RESULTS AND DISCUSSION

### 3.1. Question 1: What are the differences in the reactions of people in Beijing, Hebei province and the other Chinese provinces, respectively, to the extreme weather event on social media?

We acquired the posts from July 19 12:00:00 am to July 24 12:00:00 am made by people who claim to be from Beijing, Hebei

and another province in their user profiles, separately. Topic modeling is applied to extract 10 topic categories, based on all the text information in the posts. The number of topics was set to 10 to avoid high similarities between topics and keep each topic more distinct as well. The 10 categories for micro-bloggers in Beijing, Hebei and other provinces are listed below by decreasing accumulated probability of Weibo posts to each category, marked as topic A, B, C, etc. We judge a topic to be related to the storm when one or more most-frequent keyword is about rain, weather, disaster, or their consequences. Five of the 10 topics extracted from the text corpus of Beijing micro-bloggers related to the rainstorm, and the Weibo posts belonging to these five topics occupied 69.27% of all the posts. The Five topics are as follows:

Topic A: People require government to take action to protect the life and job during the tsunami-like weather.

Topic B: The rainstorm has turned Beijing into a disaster zone.

Topic C: The media provides in-depth coverage of this serious disaster.

Topic E: Wish the affected people a better life, and wish the dead rest in peace.

Topic J: Wish the dead from the natural disaster rest in peace.

For micro-bloggers in Hebei and the rest of China, the rainstorm accounts for a lower share of meaningful topics extracted, namely 3 and 2, respectively. The Weibo posts belonging to the rainstorm-related topics account for 36.23% and 18.30%. For Hebei bloggers, the relevant topics are as follows:

Topic A: The disaster area has heavily affected citizen's daily lives.

Topic E: The rainstorm affected Beijing's Fangshan District very seriously.

Topic F: Timely public services are available in the disaster zone to receive first aid.

As for the people from other provinces, only 2 of their topics are related to the rainstorm:

Topic B: A wild rainstorm bursts in Beijing.

Topic G: The rainstorm is like a tsunami, bringing about various adverse effects.

The rainstorm and its circumstances became a common topic of discussion on Weibo all around China. The micro-bloggers in Beijing talked about it the most because they were experiencing it firsthand. The three most important topics were closely related to the rainstorm. Different topics expressed different aspects of the disaster. Topic A is about the complaints and expectations vis-à-vis the government's responsibilities. Topic B is a descriptive statement about the rainstorm's destructive power. Topic C is about the media report on the storm and its unpredictability. The other two topics both express the deep sympathy for the deaths in the rainstorm. Generally, each topic reflects particular aspect of this rainstorm. Rainstorm-related topics account for half of all the topics of micro-bloggers in Beijing, indicating the deep influence brought by the storm in the social discourse of the city.

For micro-bloggers in Hebei, the three topics are not that emotional and tend to be more factual. They did not complain about the bad weather; instead, they just reiterated the facts of chaos left by the storm. The rainstorm-related topics also occupied an essential part of the social media discourse. For other people,

the two rainstorm topics form only a smaller portion of all the topics, compared with micro-bloggers in Beijing and Hebei. However, they also express a nationwide shock in regard to the rainstorm. The topics became even more general than in Beijing and Hebei. They did not focus on specific aspects of the storm; instead, all storm-related issues organize around two topical categories.

### **3.2. Question 2: What are the most popular and influential posts and the topics they belong to?**

We sorted all the posts according to the number of reposts and acquired the top 10 most reposted Weibo posts from July 19 12:00:00 am to July 24 12:00:00 am. We restricted the original micro-bloggers and the reposters to Beijing to guarantee the consistency and avoid exogenous interferences. Among these posts, posts that are most, second most, third most and fifth most frequent reposts are related to the storm. According to the timing of posts, we find that as the rainstorm grew heavier, all the main concerns turned to the rainstorm. The No. 1 post is a user's personal log about the severity of the disaster situation. The No. 2 post is a humoristic post about vehicle license plates lost in the rainstorm. The No. 3 is a complaint about the government and its response to the emergency. The No. 5 describes the death of a person in a vehicle, who was an editorial director for a magazine. The popularity of the rainstorm was amply proved by the large number of reposted Weibo posts. They described common people's reactions to, and experience with, the disaster. These emotional responses were quickly and broadly relayed by other bloggers as an indication of the emotional intensity of these few hours.

For comparison, we also acquired the Weibo posts made by government or public service sector officials. All the topics are all related to the rainstorm except the first one. The No. 2 is about the first sacrifice of a policeman in the rainstorm. The No. 3, No. 6, No. 7, No. 8, No. 9 and No. 10 Weibo posts are about the current rainstorm conditions. The No. 4 is an after-rainstorm notice. The No. 5 is a report about the next scheduled rain event, which gained a lot of attention because of the destructive effects of the rainstorm on July 21.

The posts made by the officials are more factual and less emotional, along with fewer reposts compared with those authored by individuals. The most reposted item related to the rainstorm, and pertained to the sacrifice of a policeman who died in the line of duty. With this post, people were encouraged to appreciate the remarkable contributions of the courageous emergency responders and safety officers and electrified the atmosphere.

### **3.3. Question 3: What are the dominant topics in different district groups?**

We also conducted topic modeling for all the check-in posts from July 19 12:00:00 am to July 24 12:00:00 am. The leading topics are as follows.

Topic A: It is a cool experience to watch the rain while eating.

Topic B: The heavy rain is marvelous, and we feel happy for it.

Topic C: The rain leads to commercial flight delays.

Topic D: The rain has various effects in our daily life.

Topic E: We were trapped in the restaurant by the rain, but finally we are back home.

Topic F: Feel very sorry for the loss of life during the storm.

Topic G: In spite of the bad weather, I have to continue working.

Topics H, I, J are not related to the storm. The top 7 categories are related to the rainstorm, demonstrating that the rainstorm is the most important event in that period of time. The check-in data are more in line with the local conditions and telling of the state of mind of people. The seven topics sum up different aspects of an individual's lived experiences.

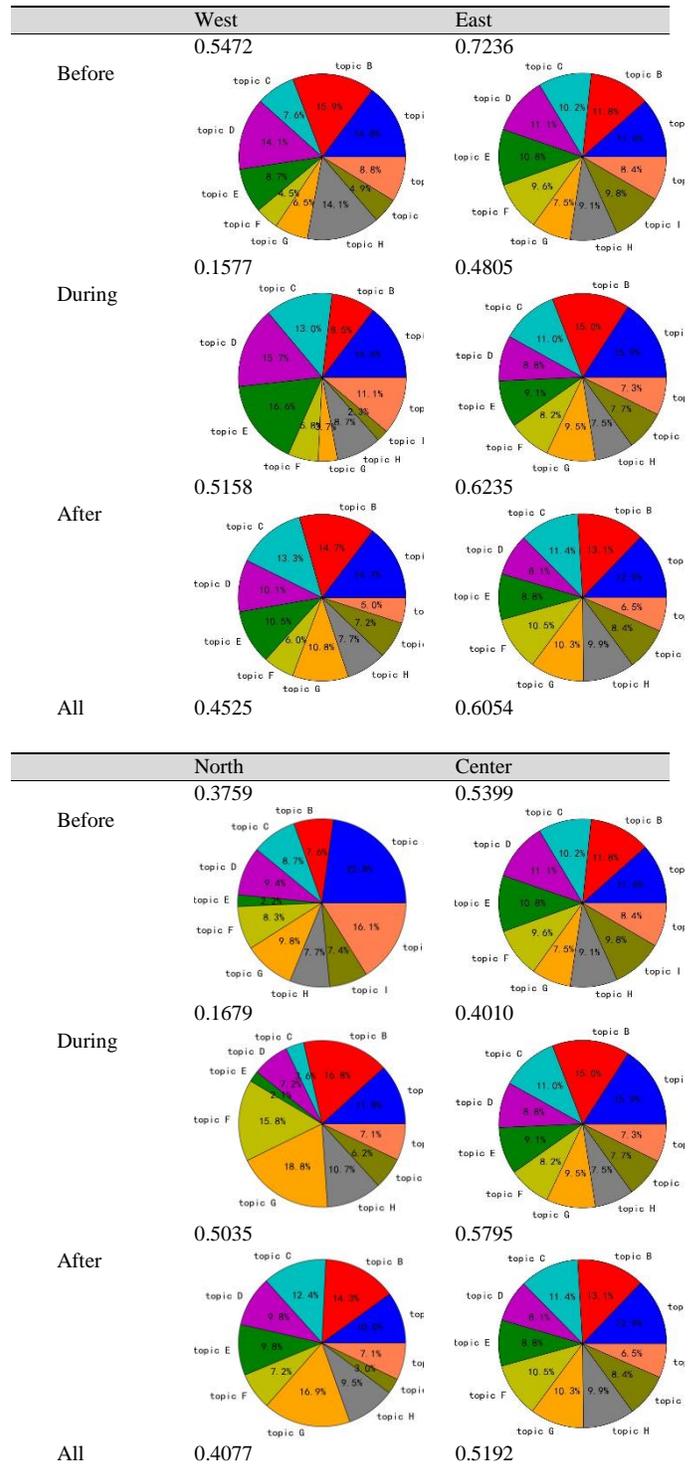
We calculated the average sentiment score for the Weibo contents belonging to different topics, as indicated in Table 1. Topics C and F are the two most negative topics, because of the delay at the airport and the death toll, respectively.

**Table 1: Sentiment analysis for different topics.**

Topic	Score	Topic	Score
A	0.5484	F	0.4566
B	0.5821	G	0.5334
C	0.4701	H	0.5290
D	0.5185	I	0.5488
E	0.5443	J	0.5748

We also calculated the percentage of different topics and the average sentiment score of posts most associated with each topic, in different periods of time for each of the four different district groups, as indicated in Table 2. We conclude that during the rainstorm, the sentiment in the entire Beijing Metropolitan Region is significantly more negative than before and after the storm and this is particularly true in the West (where the badly hit Fangshan district is located) and North of the Metropolitan Region. Of the 10 topics, we can find that during the rainstorm, topic C accounts for a low percentage in the north area, indicating that people there do not care much about flight delay issues. Topic A, which is closest to the storm event, is about eating issues and the four district groups are similar in this respect. After the rainstorm, we did not find topic F in the west area to be a larger percentage than anywhere else, which means the feelings of sorrow and sadness of the entire city was not a response to the hardship felt locally, but instead a shared feeling experienced because of the trauma associated with the entrapment indoors during the deluge that hit the whole urban region.

**Table 2: Percentage of 10 topics in 4 district groups before, during and after the storm.**



## 4. CONCLUSIONS

Due to their unpredictability and short-term destructiveness, sudden natural disasters harm people's lives, property, and affects their emotions. Heavy rain as a common natural phenomenon is not often subject to much attention. However, on July 21, 2012, a sudden, heavy rainstorm severely impacted the residents of Beijing, China. In this paper, we have explored this storm based on the Weibo social media data, using topic modeling and sentiment analysis. In addition, the user profile information and the geo-information were combined. Moreover, we divided Beijing into 4 different contiguous and compact district groups for analysis purposes. We also differentiated 3 time periods--before, during and after the storm--in order to detail the reactions of people spatially and temporally. The findings in Beijing were also benchmarked with those in Hebei and the other provinces. Prior to the emergence of big data, the research on natural disasters in China heavily relied on statistical yearbooks and reports. The big, open, and crowd-sourced social media data used in this study helps in facilitating our understanding of people's feelings, behaviors and concerns from a different perspective. These data made it possible to derive and evaluate topic categories and to characterize the pattern of their spatial and temporal change. They can facilitate future research by identifying distinct models for emergency evaluation and post-disaster reconstruction.

The detailed findings of this paper are as follows. First, this storm had a nationwide range of effects for people. The rainstorm-related posts of micro-bloggers in Beijing outnumbered that in Hebei, which also outnumbered the other provinces, thus further confirming the reduction of the popular event's effects with an increase in distance from the "eye of the storm". Micro-bloggers in Beijing paid more attention to the complaints, media behaviors and best wishes after the rain; micro-bloggers in Hebei focused on the facts of the severe weather conditions; the other provinces cared about general issues only. Second, within the most reposted Weibo posts, we observed a strong storm-related proportion. The ratio of the 4 rainstorm-related Weibo posts versus the ten most reposted Weibo posts indicated that the rainstorm was the most heated topic at that time. Weibo posts made by the government and public services received less attention than individual posts. Third, the four district groups in Beijing expressed a high-low-high sentiment before, during and after the rainstorm, respectively. In the west and north sections of the metropolitan region, the sentiment changes seemed to be more dramatic. The distinctions of topic portions of different district groups were also quite variable across time periods. This study focused on the Beijing rainstorm on July 21-22, 2012 from an alternative perspective, and the adoption of social media data contributed to the study. Nevertheless, several limitations still exist in the current study that should be alleviated in our future research. First, we identified micro-bloggers in different provinces according to their self-reported profiles, which had the potential to be incomplete or erroneous. Second, we had limited records with geo-tags in the

research, and the small number of cases raised uncertainties regarding the geospatial disaggregation of the analysis.

## ACKNOWLEDGMENTS

We thank Dr. King-wa Fu for providing the Weibo social media data.

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