Social Media in Extreme Snow Disasters: A Risk Perception Study Based on the LDA Topic Modelling

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Abstract

Under the global climate change scenario, the frequency of extreme weather disasters poses severe challenges to human society. Public risk perception plays a crucial role in self-protection and effective disaster preparedness during the prevention and response processes. Social media, as the most frequently used instant communication tool by the public, becomes a valuable data source for disaster prevention and management due to its fast flow and wide coverage of interactive information. This study attempts to explore the intrinsic characteristics and spatial distribution of climate disaster risk perception, which has not been addressed in previous research. To this end, taking the ice and snow disaster in the central and eastern regions of China during the 2024 Lunar New Year Travel period as an example, a snow disaster dataset was constructed using social media information from the Weibo platform. A TF-IDF based LDA topic model was established to mine keywords and extract topics. **The results revealed five main findings: (1)** Risk perception themes encompass six categories: Macroeconomic & Industry Impacts, Extreme Climate Change, Disaster Response Behavior of Distressed Groups, Government Response and De-Icing Operations, Road Emergency and Rescue, Lunar New Year Travel and Railway Transport. **(2)** Risk perception of snow disasters can be divided into three categories: perceived social risks, perceived disaster risks, and perceived public opinion risks. **(3)** The spatial distribution of risk perception does not completely align with the spatial distribution of snow disaster intensity. **(4)** Henan, Hubei, and Jiangxi province exhibit the highest comprehensive perceived risks. In Henan, perceived social risks rank higher than disaster and public opinion risks, indicating that its preventive measures should focus more on reducing and managing climate risks and social impacts. In contrast, Hubei shows the highest levels of perceived disaster and public opinion risks, highlighting significant concerns regarding the health and safety of trapped groups. **(5)** The peak of information release on social media highly synchronizes with the actual occurrence of snow disasters. However, different themes exhibit lag effects, psychological bias effects, and social network amplification effects. The theoretical and practical significance of this study enriches the understanding of public snow disaster risk perception and provides effective reference guidelines for policymakers to identify disaster events, promote disaster risk management, and enhance emergency response.

Key words: risk perception, extreme snow disasters, social media, LDA topic model, disaster management

I. Introduction

In 2024, a widespread and persistent low-temperature snow and ice event affected the central and eastern regions of China. The cumulative snowfall in some areas surpassed historical records for the same period. This event, characterized by extensive snow coverage, prolonged duration, significant freezing rain, and high risk of snow and ice disasters, coincided with the massive travel surge of the Chinese New Year (Spring Festival). It adversely impacted transportation, power supply, and daily life. In the face of such disasters, people tend to rely on personal experience to assess risks, and the level of risk perception often influences their behavior. For instance, during this snowstorm, numerous high-speed trains were halted for extended periods due to severe weather. Additionally, highways in Hubei, Hunan, Anhui, and other central and eastern regions experienced prolonged traffic jams and temporary closures. Drivers were trapped in cars on icy highways, passengers struggled to rebook canceled trains and flights, and many returning home were stranded en route, leading to frequent traffic accidents on icy roads.

Risk perception refers to individuals' subjective judgments and understanding of specific risks. In this event, the public's perception of the adverse effects of snowfall (such as disrupting normal life and threatening personal safety) was intense. A survey indicated that excessively high and unrealistic risk perceptions could lead to unreasonable fear, causing social unrest and increased life pressure. Conversely, individuals with low risk perception often fail to take protective measures and emergency preparations, exacerbating the human impact of natural disasters, especially when meteorological disaster risks are challenging to assess accurately. Therefore, analyzing risk perception can provide policymakers with psychological and social science perspectives, aiding in the management of public mental and physical health risks related to frequent extreme weather disasters globally.

Notably, the Lunar New Year Travel period (Chunyun) is a highly publicized topic that easily resonates with the public. Chunyun, or Spring Festival transportation, refers to the massive transportation surge in China around the Lunar New Year. Lasting about 40 days, it is termed the "largest annual human migration." In 2024, Chunyun saw 9 billion trips, with travel numbers peaking and increased demand for energy, daily necessities, and agricultural supplies. The road network faced the dual challenges of high traffic volume and severe weather, leading to frequent traffic congestion and accidents. As a typical public event, most people have personal experiences or similar experiences related to Chunyun, fostering a strong sense of resonance. Furthermore, Chunyun is a seasonal topic that, through repeated coverage and discussion over time, has become familiar to most netizens, making related discussions accessible and likely to spark widespread public attention.

Extreme weather events, characterized by wide impact, significant influence, and prolonged duration, easily trigger public sensitivity and online public opinion. In recent years, China has faced numerous extreme rainfall and snowfall disasters. For example, in 2023, the remnants of Typhoon Doksuri brought extreme heavy rainfall to Beijing-Tianjin-Hebei, causing severe flooding, landslides, and mudslides. In 2022, a widespread low-temperature snow and ice disaster affected southern China, impacting 6.092 million people across 77 cities in nine provinces. In 2021, Henan province experienced an unprecedented heavy rainstorm, breaking historical records for hourly rainfall and causing direct economic losses of 120.06 billion yuan. These extreme weather events generate significant public and media attention, quickly becoming hot topics and potentially leading to negative public opinion. Policymakers need to accurately grasp public risk perception of such events to formulate effective risk response strategies promptly. Monitoring social media discussions and information flow helps identify public risk perception of extreme snow disasters during the Lunar New Year Travel period, observe

temporal and spatial trends, and facilitate disaster risk response while managing public emotions to avoid public opinion conflicts and social panic.

To date, research on risk perception of extreme weather disasters has included studies on floods, hurricanes, droughts, and heatwaves. However, ice and snow disaster warnings are relatively complex due to difficulties in accurately predicting vertical distributions of temperature and precipitation. In contrast, tropical cyclone path and intensity forecasts are more mature, based on satellite and radar data models. Snow disasters can form a chain of "low temperature-snow-ice" events, potentially disrupting ground and air transportation and affecting agriculture and livelihoods. Current snow disaster research mainly focuses on disaster science, geoscience, and meteorology. Domestic studies have centered on the Qinghai-Tibet Plateau, the Xilingol Grassland in Inner Mongolia, and southern China, assessing comprehensive risks and impacts on agriculture and livestock. International research has examined sources of information used by the Scottish public in preparing for and responding to heavy snow emergencies and simulated snowfall over Istanbul. However, few researchers have studied the socio-economic risk perception of snow disasters. Understanding public risk perception of snow disasters, its multifaceted characteristics, and contributing factors is crucial. Addressing irrational risk perceptions can more effectively control public opinion without diverting unnecessary government attention. In this paper, using natural language processing on Weibo data, we identify features and influencing factors of snow disaster risk perception and compare specific aspects of risk perception across different regions.

The main contributions of this study are summarized as follows: First, the findings reveal the formation process of public risk perception of extreme snow disasters during the massive population movement of Chunyun, aiding discussions on managing extreme climate disaster risks and public opinion risks effectively. Second, unlike previous studies, we investigate the spatial distribution characteristics of risk perception, providing a guide for policymakers to identify vulnerable groups and regions. Finally, this study expands the application of social media big data in disaster and emergency management. By leveraging the unique situational awareness and information-sharing characteristics of social media, and through natural language processing and geospatial analysis, we analyze public behavior and responses during snow disasters, reflecting dynamic interactions between people, disasters, and infrastructure. This helps better plan disaster emergency responses and improve overall resilience against the backdrop of global climate change.

The structure of this paper is as follows: Section 2 introduces the research methodology, including data collection, text analysis, and geospatial analysis. Section 3 presents the analysis results, spatial distribution characteristics of risk perception across Chinese provinces, specific manifestations of different risk perceptions, and influencing factors of snow disaster risk perception. Finally, Section 4 discusses the analysis results and their implications.

II. Methodology

1. Data Source and Processing

The data for this study were sourced from Sina Weibo. Hot posts related to the Spring Festival snow disaster were collected through keyword searches and topic tracking. The specific keyword combinations included "rain and snow weather," "Lunar New Year Travel," "highway," and "transportation." These keywords and topics served as filters to retrieve Weibo data relevant to the snow disaster event. Considering data availability, the data acquisition scope included all 31 provinces, autonomous regions,

and municipalities in China (excluding the Hong Kong Special Administrative Region, Macao Special Administrative Region, and Taiwan). The collected data included Weibo ID, user ID, username, Weibo text, information source, publication time, number of reposts, likes, comments, and the IP location at the time of posting. Relevant posts and comments during the 2024 snow disaster period in China were collected. The data collection period was from January to March 2024, and after cleaning, a final dataset of 18,293 valid entries was obtained, as shown in **Fig. 1**. and **Fig. 2**.

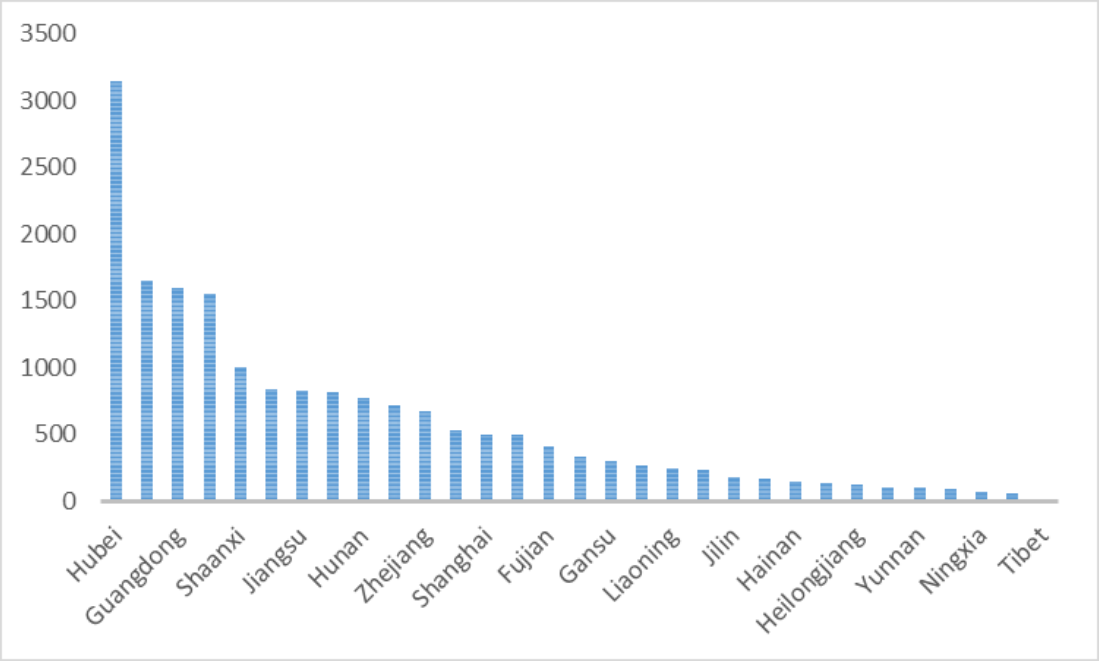


Fig. 1. Number of snow disaster-related Weibo texts by region.

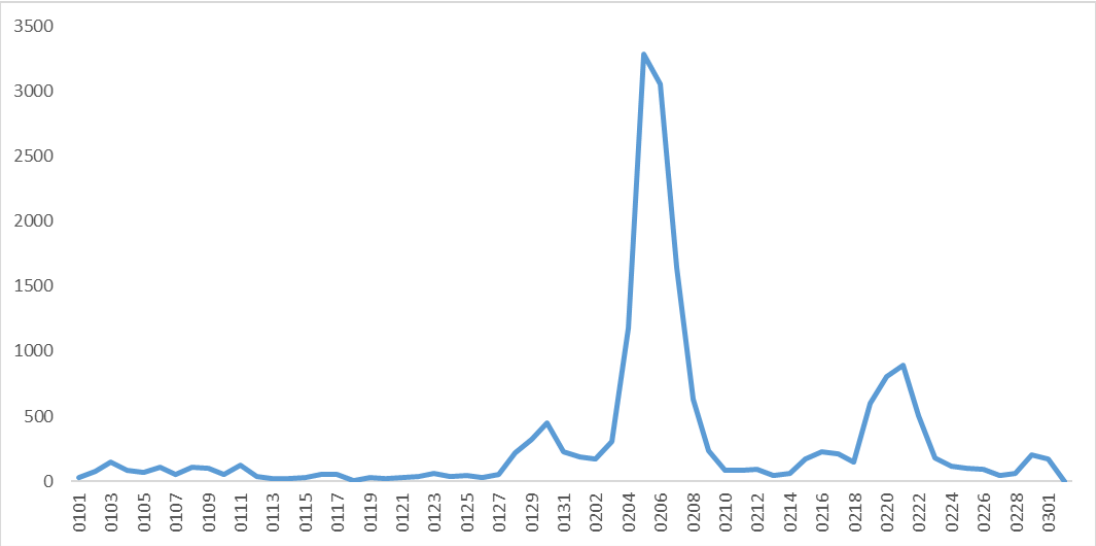


Fig. 2. Temporal trend of snow disaster-related Weibo texts.

2. LDA Topic Model

Latent Dirichlet Allocation (LDA) is a topic model that identifies main topics and focal points in text data by extracting themes from the texts. This study employs the LDA model to analyze social media data to uncover the primary concerns and discussion topics during the extreme snow disaster.

Based on the mined text information, the documents were first segmented into words, and stop words were removed to construct a dictionary. The corpus was then vectorized. The TF-IDF algorithm

was used to extract latent thematic information from the corpus to identify factors influencing public risk perception during this event. This study employed content analysis, using the LDA model to deeply analyze Weibo texts on the snowstorm topic. Content analysis is a quantitative research method based on qualitative research, analyzing the information content and its changes in large-scale texts to make reproducible and valid inferences.

With the LDA topic model, meaningful discourse frameworks can be extracted from massive texts to identify factors influencing public risk perception. TF-IDF is an algorithm used for information retrieval and text mining, which can evaluate the importance of a word or term in a text or corpus. The algorithm consists of two parts: term frequency (TF) and inverse document frequency (IDF). The core idea is that if a word frequently appears in a document but rarely in other documents or corpora, it has good representativeness and is suitable as a topic word. The TF-IDF algorithm is expressed as follows（1）（2）（3）:

$$tf_{i,j} = \frac{n_{i,j}}{\sum_k n_{k,j}} \tag{1}$$

Where $n_{i,j}$ is the frequency of term t_i in document d_i, and the denominator is the sum of frequencies of all terms in document d_i.

$$idf_{i,j} = \lg \frac{|D|}{|\{j: t_i \epsilon d_j\}|} \tag{2}$$

where $|D|$ is the total number of documents in the corpus, and $|\{j: t_i \epsilon d_j\}|$ is the number of documents containing termt_i (i.e., the number of documents where $n_{i,j} \neq 0$). To avoid a zero denominator, we generally use $1 + |\{j: t_i \epsilon d_j\}|$.

$$TF - IDF = tf_{i,j} \times idf_{i,j} \tag{3}$$

where $TF - IDF$ is the weight value of term t_i.

III. Results

1. Word Frequency Analysis Results

The top 100 keywords with the highest frequency weights extracted by the LDA model are presented in **Table 1** and visualized as a word cloud using Python, as shown in **Fig. 3**. This allows us to conduct a preliminary analysis of the discussion topics related to risk perception during this snow disaster. Social media users' focus on snow disaster risks primarily centered around affected geographical areas, weather phenomena, traffic conditions, emergency responses, and personal and societal impacts. Through the analysis of these high-frequency keywords, as illustrated in **Fig. 4**, we gain a better understanding of public risk perception and concerns. This information provides valuable insights for relevant departments to enhance disaster management and emergency response measures.

Table 1

Extraction of Top100 keywords.

Vocabulary	Word freq.	Vocabulary	Word freq.	Vocabulary	Word freq.	Vocabulary	Word freq.
Hubei	0.1185	high speed rail	0.0176	roads	0.0109	Villagers	0.0085
Highway	0.1171	emergency response	0.0165	Our country	0.0109	Most	0.0085
Rain and snow	0.0951	local area	0.0163	road	0.0109	Situation	0.0085

Freezing rain	0.0575	Wuhan	0.0161	carriageway	0.0107	100	0.0084
Blizzard	0.045	Ice	0.0156	Returning home	0.0105	Train	0.0082
Spring Festival	0.0342	Traffic jam	0.015	Expected	0.0103	Out of Service	0.0081
Freezing	0.0316	North	0.0149	Shandong	0.0102	Entrance	0.0081
Area	0.0263	Guizhou	0.0144	South	0.0102	Congestion	0.0081
Hunan	0.0254	Traffic	0.0142	Traffic Police	0.01	Hangrui	0.008
Tollbooths	0.0251	Heavy snow	0.0141	Road	0.0098	Ltd.	0.008
Trapped	0.0234	Central Weather Bureau	0.0138	Traffic	0.0096	Jiangxi	0.008
Middle East	0.0232	Travellers	0.0137	Drivers	0.0094	Ice and snow	0.008
Snowfall	0.0225	Snow accumulation	0.0136	China	0.0094	Foam	0.0079
2024	0.0225	Cold wave	0.0134	Extreme	0.0094	Tunnel	0.0079
Impact	0.0224	Closures	0.0129	Rain and snow	0.0094	North Central	0.0079
Henan	0.0224	Service Area	0.0128	Process	0.0091	Cold air	0.0079
Highway	0.022	Going home	0.0126	Early Warning	0.0091	Forecast	0.0079
Travelling	0.0213	Low temperature	0.0125	Charge	0.009	G56	0.0079
Vehicle	0.0202	Many places	0.0124	Cooling	0.0089	Snow removal	0.0077
Hour	0.0192	Spring Festival	0.012	Day to	0.0088	Mostly	0.0077
Temperature	0.0184	South	0.0117	Hot water	0.0088	Continuing	0.0076
Stagnation	0.0183	Chinese New Year	0.0112	Hubei Province	0.0087	Interval	0.0076
Direction	0.0179	Kilometres	0.0111	Free	0.0087	Xiantao	0.0076
Road	0.0178	East	0.011	national highway	0.0087	Release	0.0075
Anhui	0.0178	Jiujiang	0.011	Netizen	0.0087	West	0.0074

Fig. 3. Word cloud diagram

1.1 Geographic Locations and Affected Areas

These high-frequency terms indicate that the public's primary concern regarding the impact of extreme snow disasters is focused on specific geographical locations and regions. Provinces such as Hubei, Hunan, and Henan appear to be hotspots of discussion. Hubei Province and its highways are severely affected by extreme snow disasters, and the public is concerned about the traffic conditions.

1.2 Weather Phenomena and Meteorological Conditions

These terms are related to snowfall and associated meteorological phenomena, reflecting the public's concern about weather conditions. The frequent occurrence of such terms suggests that extreme weather events are the central topic of discussion on social media.

1.3 Traffic Conditions

Traffic is another major theme of public concern. High-frequency terms indicate that the impact of extreme snow disasters on traffic is a focal point of social media discussion, especially regarding the operational status of important transportation infrastructure such as highways and high-speed railways.

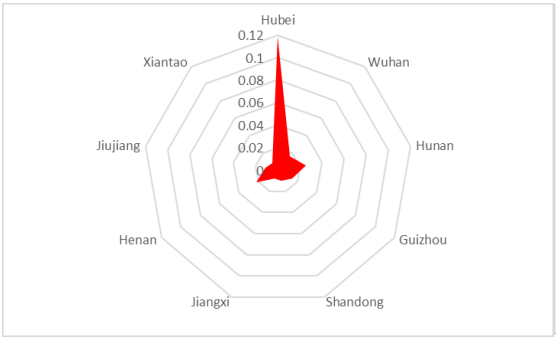
1.4 Emergency Response and Public Services

These terms indicate the public's concern about government and related agencies' emergency response measures and public services. For example, the work of traffic police and the Central Meteorological Observatory, as well as activities like snow removal and warning measures, are hot topics.

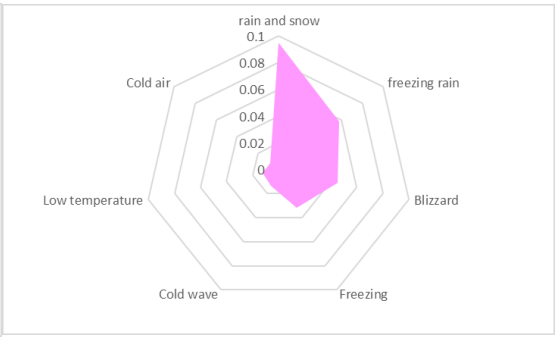
This reflects society's expectations and evaluations regarding disaster management and emergency response measures.

1.5 Personal and Social Impacts

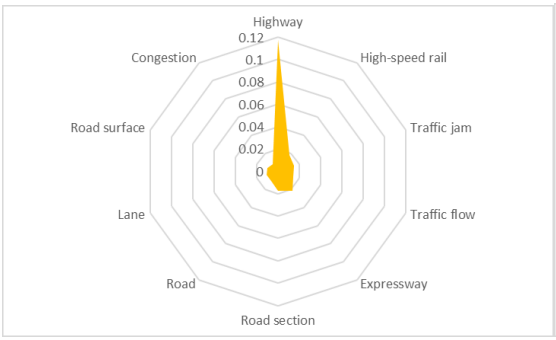
On social media, the impact of extreme snow disasters on personal life is also a significant aspect of discussion, especially during the Chinese New Year period, where travel and returning home become focal points of public concern.



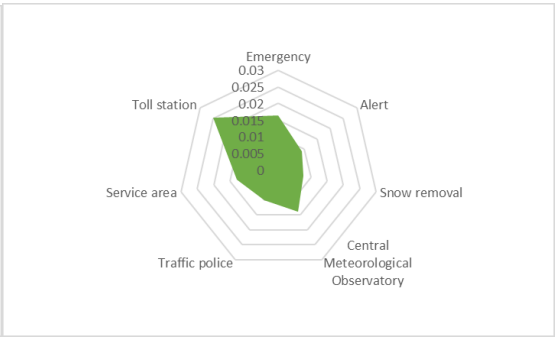
(a) Regions



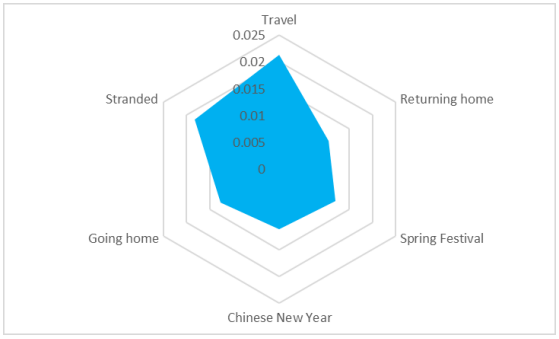
(b) Weather



(c) Transportation



(d) Emergency Response



(e) Impact

Fig. 4. Word Frequency Radar Chart

2. Topic Model Extraction Result

In this study, the Dirichlet prior parameters α and β are set to 0.1 and 0.01, respectively, following standard settings in the literature. The range of topic numbers K is set to [1, 10], and perplexity is introduced as a criterion for determining the optimal number of topics. Subsequently, a perplexity line chart related to the number of topics is plotted using the Python data visualization package Matplotlib (as shown in **Fig. 5**). Perplexity is defined by formula (1).

$$\text{Perplexity} = \exp\left\{-\frac{\sum_{d=1}^{M}\log_P(w_d)}{\sum_{d=1}^{m}N_d}\right\} \quad (1)$$

As the value of K (Number of Topics) increases, the perplexity gradually decreases. According to the elbow method, the point of sharp decrease followed by stabilization in the curve can be considered as the optimal number of topics for the corpus. In the test set's line graph, the number of topics at the inflection points are 3, 4, and 6 respectively. Therefore, K=3, K=4, and K=6 are input into the LDA model. Subsequently, the LDA model is visualized and analyzed using the sklearn package in pyLDAvis. When K=3, as shown in the Fig. below, there is significant overlap between Topic 6 and Topic 8; additionally, Topics 2 and 4 also partially overlap. Due to the presence of many common key words in each topic, it is challenging to generalize the topics. When K is less than 6 and greater than 6, the curve is, when K=6, as shown in the Fig. below, each topic has clear boundaries, with no overlap and good independence. Therefore, after comparison, the optimal number of topics is determined to be 4. Consequently, an LDA topic model with K=4 is established.

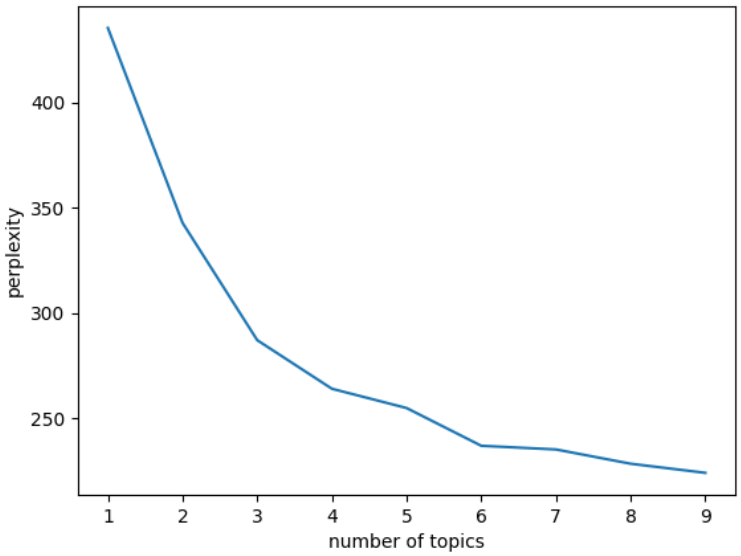
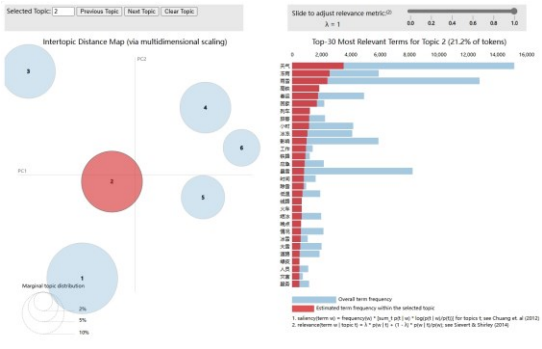


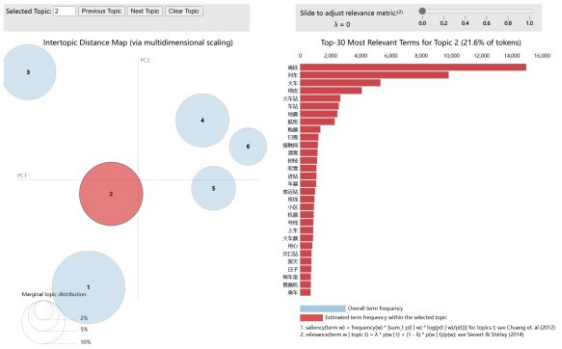
Fig. 5. Line Graph of Perplexity vs. Number of Topics

The results from pyLDAvis in **Fig. 6** show the following: Panel (a) displays the relative distances and sizes of each topic. Topics that are closer together indicate more similar word distributions. Larger circles represent topics that have a higher proportion within the entire corpus.Panel (b) shows the vocabulary for each topic. Words in red are the most relevant, while words in blue indicate their frequency in the entire corpus. When the relevance parameter λ=1, it shows the most frequent words; when λ=0, it shows words unique to that specific topic.

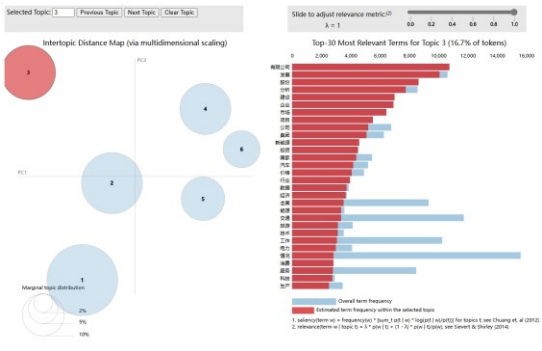
（a）topic=1，λ=1　　（b）topic=1，λ=0



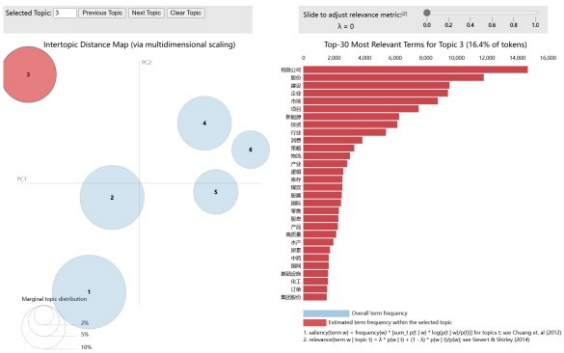
（a）topic=2，λ=1



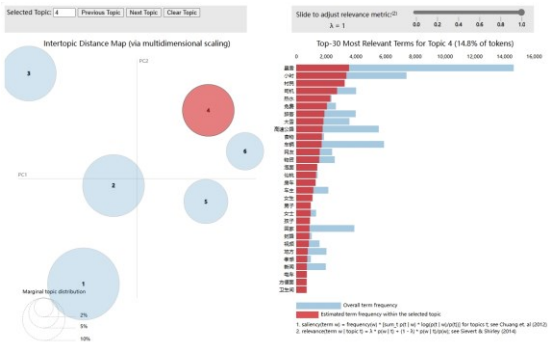
（b）topic=2，λ=0



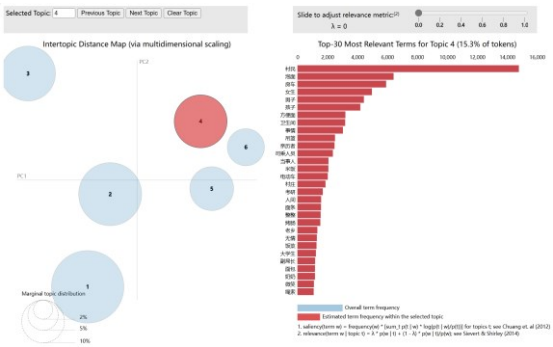
（a）topic=3，λ=1



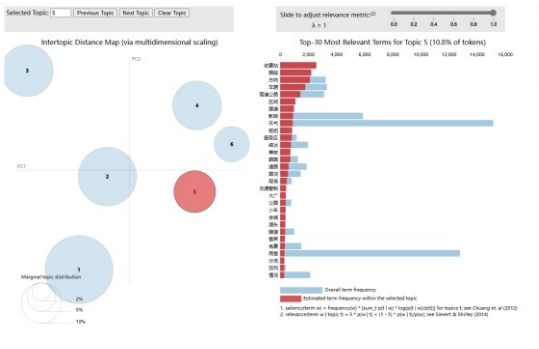
（b）topic=3，λ=0



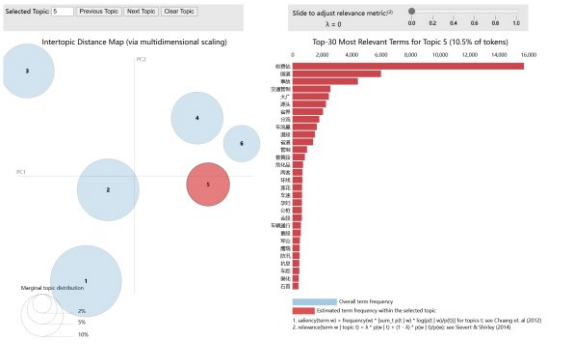
（a）topic=4，λ=1



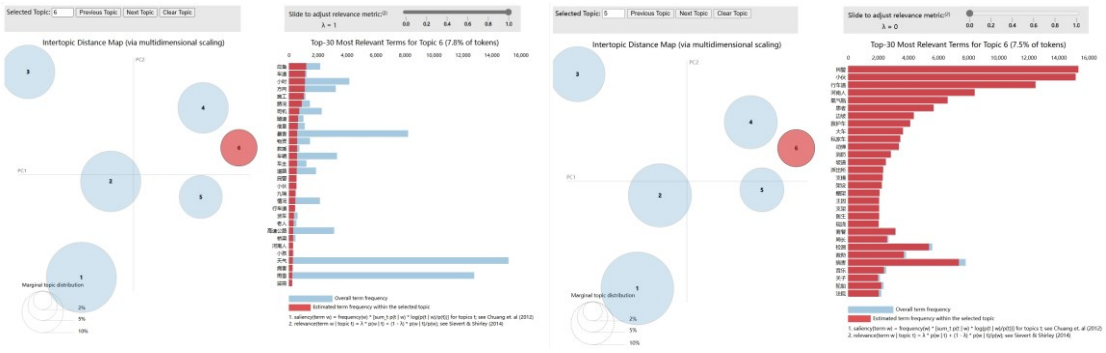
（b）topic=4，λ=0



（a）topic=5，λ=1



（b）topic=5，λ=0



（a）topic=6，λ=1　　（b）topic=6，λ=0

Fig. 6. Visualization of pyLDA results for each topic

The training results of the LDA topic model are shown in **Table 2**. Within each topic, there exists a probability distribution of words, where higher probabilities indicate stronger associations with the topic. Each topic contains the top 25 keywords ranked by their frequency weights. Based on the descriptions of these keywords, the topics are categorized as shown in **Table 3**. Through the distribution of "topic-word" in each text, further exploration of the relationships between key words with high probabilities has identified six dimensions of topic content. Further reduction analysis has classified topics related to risk perception into three categories: perception of social risk, perception of disaster risk, and perception of public opinion risk.

Table 2.

Distribution of Topics and High-Probability Feature Words in the LDA Model.

Topic	Keywords
Topic #0	Limited company, development, shares, analysis, construction, enterprise, market, project, company, group, new energy, investment, national, automobile, price, industry, data, economy, nationwide, energy, transportation, tourism, technology, work, electricity.
Topic #1	Weather, rain and snow, region, blizzard, impact, freezing rain, ice freeze, temperature, Lunar New Year Travel rush, snowfall, cold wave, process, forecast, local, warning, cooling, majority, extreme, low temperature, prediction, cold air, duration, sustained, majority of areas.
Topic #2	Blizzard, hour, villagers, drivers, hot water, free, travelers, heavy snow, expressway, food, vehicles, netizens, supplies, instant noodles, Xiantao, RVs, car owners, women, men, ladies, children, return home, road closure, video, local.
Topic #3	Emergency, lane, hour, direction, construction, road conditions, drivers, tunnel, information, blizzard, supplies, rescue, vehicles, car owners, roads, police officer, young man, Jiu Rui, situation, driving lane, truck, elderly person, expressway, bridge, people from Henan.
Topic #4	Toll station, section, direction, vehicles, expressway, section, national highway, impact, weather, hub, service area, icing, accident, road surface, road conditions, scene, traffic control, Da Guang, highway, small car, entire route, source, tunnel, provincial border.
Topic #5	weather, freezing rain, rain and snow, high-speed rail, Lunar New Year Travel rush, returning home, train, passengers, hours, freezing, impact, work, railway, emergency response, blizzard, time, snow removal, low temperature, route, train, icing, delay, situation, snow

Table 3.

Categories of Risk Perception Themes.

Category	Topic Types	Corresponding topic numbers
Perception of social risks	Macroeconomic and industry impacts	Topic #0
	Lunar New Year Travel Rush and Railway Transportation	Topic #5
Perception of disaster risks	Extreme Climate Change	Topic #1
	Road Emergency and Rescue	Topic #4
Perception of public opinion risks	Government Response and De-icing Operations	Topic #3
	Behavior of Trapped Groups in Disaster	Topic #2

Perceiving social risks focuses on the impact of snow disasters on socio-economic activities, including aspects such as macroeconomic conditions, industry development, and transportation. For instance, snow disasters can lead to traffic disruptions, affect population movements during the Lunar New Year Travel, thereby influencing economic activities and social stability. **Perceiving disaster risks** focuses on snow disasters as direct risks brought by natural disasters, such as life and property losses due to extreme climate change, and the challenges posed to road emergency and rescue systems. The public expresses concerns about how to prevent and respond to these risks. **Perceiving public opinion risks** involve the dynamics of public opinion and public sentiment during snow disaster events. The effectiveness of government responses and de-icing operations, as well as the coping behaviors of stranded groups, all affect the public's trust and evaluation of government and societal response mechanisms.

In the theme of Macroeconomic and Industry Impacts, keywords such as "national," "economic," "price," and "energy" primarily express concerns about potential disruptions in supply chains, decreases in productivity, and increased risks to energy supply due to disasters. Snowstorms can severely impact infrastructure such as electricity, gas, and water supply systems, potentially causing issues like frozen pipelines and icy power lines, which disrupt normal supply. Terms like "new energy" and "electricity" reflect public concerns about the performance of new energy vehicles under extreme weather conditions, highlighting expectations for sustainable transportation solutions and demands for technological progress and innovation. For instance, discussions like #Cold Wave Blizzard Exposes the Vulnerabilities of New Energy Vehicles# underscore how severe weather conditions affect the range anxiety of stranded owners of new energy electric vehicles, especially when stuck in extreme low temperatures on highways. Such risk perceptions may drive industries to explore methods to enhance the winter performance and safety of new energy vehicles, emphasizing the importance of considering regional climate conditions in the design and promotion of new energy vehicles.

In the theme of Lunar New Year Travel and Railway Transport, keywords like "Lunar New Year Travel rush," "high-speed rail," and "train" highlight that railway stations become critical hubs for people returning home and traveling during this period, resulting in a tremendous surge in passenger traffic and significant operational pressures. Particularly, the impact of ice and snow weather on traffic safety and operational efficiency makes the reliability of railway transportation a focal point of public concern. For instance, incidents like the #Yueyang City Government's deployment to shelter stranded passengers from the blizzard backlash# underscore how in such high-pressure environments, passengers' emotions can become more sensitive and irrational, potentially leading to more intense reactions to any

inconvenience or changes. People discuss the blizzard's impact on family reunions and effective management to mitigate transportation delays caused by adverse weather conditions, highlighting the challenges faced by government departments in handling emergencies and maintaining a good service attitude.

In the theme of Extreme Climate Change, discussions from "blizzards" to "cold waves" highlight the impact of extreme weather events on daily life. In recent years, China has seen an increase in frequency and intensity of extreme weather events, spanning from scorching summers to frigid winters. Keywords such as "blizzards," "cold waves," and "cold air" underscore public concerns about extreme low-temperature events, which can lead to traffic disruptions, energy supply constraints, and damage to crops. Additionally, terms like "warnings" and "forecasts" indicate that accurate weather predictions and timely information dissemination are crucial in reducing disaster risks. Against this backdrop, discussions on social media reflect public worries about extreme climate change and expectations for government and societal response measures. These discussions may drive more effective disaster prevention and response strategies, as well as long-term improvements in infrastructure and community resilience.

In the theme of Road Emergency and Rescue, the main discussions revolve around the increased risk of accidents on highways during extreme weather conditions, and the potential impact of these accidents on traffic flow and public safety. Keywords such as "toll stations," "highways," and "traffic control" indicate public concerns regarding the effectiveness of road emergency response and rescue services. This also underscores the importance of maintaining traffic flow and providing timely rescue operations during disasters and emergencies. Governments and relevant departments need to develop more comprehensive emergency plans to address traffic accidents caused by extreme weather or other sudden events, ensuring the rapid and effective restoration of traffic and provision of necessary rescue services. When designing and managing highway systems, consideration of extreme weather and other factors that may cause traffic disruptions is essential. Furthermore, public education and enhancing drivers' safety awareness are crucial for reducing accidents and improving road safety.

In the theme of Government Response and De-Icing Operations, public concern focuses on the government's emergency response and the effectiveness of de-icing operations. Keywords such as "emergency," "construction," and "rescue" indicate that the public expects the government to react swiftly to minimize the impact of disasters on daily life, reflecting their assessment and perception of government disaster management capabilities. Addressing the hashtag "#Why Were The Two Hubei province More Seriously Affected Than Henan In Blizzard Forecasts," some netizens criticized that Hubei did not clear the highway surfaces promptly like Henan did but instead chose to close the highways directly, resulting in a large number of stranded vehicles. In contrast, timely snow removal on highways in Henan ensured smooth traffic flow, reducing inconvenience and risks for the public. Such public discourse underscores the critical role of governments in disaster management and highlights the perceived differences in emergency response and disaster management capabilities among different regions, emphasizing the importance of proactive preparation and rapid response in mitigating disaster impacts.

In the theme of Disaster Response Behavior of Distressed Groups, discussions center around key terms like "villagers," "drivers," and "passengers," focusing on their basic life needs such as obtaining food, water, and access to public facilities while stranded on highways. Social media discussions not only highlight the difficulties faced by stranded groups but also reflect societal spirit of mutual assistance. For instance, hashtags like "#Girl Stranded On Highway In Motorhome Lends

Bathroom To Others," "#Young Man From Henan Helps Woman Stranded On Highway During Heavy Snow," and "#Elderly Man Using Cane Walks Mountain Roads To Deliver Hot Water To Stranded People On Highway" showcase positive perceptions of mutual support during challenging times.On the other hand, hashtags like "#Villagers Selling Instant Noodles At Double Price To Drivers On Highways" and "#Children Wearing QR Code On Chests Deliver Hot Water" have sparked discussions about ethics and interests. These topics easily trigger perceptions of public opinion risks on social media because they touch upon people's sensitivities and complex emotions regarding behavioral norms during crises. They reflect varying views on what constitutes appropriate and ethical behavior during a crisis, revealing conflicts in societal values during emergencies.

3. Spatiotemporal Evolution Analysis of Risk Perception

Based on 18,239 texts, aggregating the total counts of messages, comments, and reposts, the Twitter user activity on snow disaster topics from January 1th to March 1th was obtained. Combining the TF-IDF algorithm, probabilities of topics for all words in each text segment were calculated to identify the highest probability risk perception topic. After classification and statistical analysis, six categories of different risk perception topics were derived, along with regional participation activity under each topic. The participation activity of topics on social media signifies the speed and breadth of information dissemination among user groups. When users in a region increase their discussions and participation in a specific risk event, it may be because the event is closely related to their lives or has significant influence and potential harm. Such heightened attention can reflect an increase in risk perception levels. Many organizations and government departments are now using social media as a tool for risk communication and response. High participation in social media topics can assist governments and relevant departments in better understanding the public's response to risk events, thereby implementing more effective response measures. Therefore, depicting risk perception levels using user activity involves first plotting the curve of risk perception changes over time, then visualizing the data using ArcGis software after associating it with IP addresses to derive the snow disaster risk perception levels across different regions and topics.

3.1 Analysis of Temporal Evolution Characteristics

Through time series analysis, as shown in **Fig. 6**, it was found that peaks in information dissemination on social media highly synchronize with the actual occurrence of snow disasters. The risk perception levels of all topics were relatively low at the beginning of January but significantly increased over time, especially towards late January and early February. This increase is associated with the approaching Chinese New Year and the increasing incidence of related disaster events. Public attention to snow disasters peaks in the days immediately before and after Chinese New Year, then gradually declines by early March but remains at a relatively high level. For some severe events, public attention persists longer, reflecting the enduring impact of disasters. In particular, "Lunar New Year Travel Rush and Railway Transport" and "Behavior of Stranded Groups in Disasters" reached very high levels of risk perception in early February. The risk perception related to Lunar New Year Travel and railway transport was initially high in early January, fluctuated slightly thereafter, significantly rose in early February, especially on February 5th and 6th, and remained high through mid and late February, peaking on February 19th and 20th, and maintaining a high level into early March. The risk perception regarding behavior of stranded groups in disasters was lower at the beginning of the month, peaked on January 28th, sharply

increased in early February, especially on February 5th and 6th, and continued at a high level through late February and early March, correlated with increased incidents of snow disaster and resulting social sentiments.Additionally, the overall risk perception of extreme climate change was relatively high in early January and significantly increased from late January to early February, peaking from January 28th to 30th, fluctuating greatly in early and mid-February, peaking again on February 6th and 7th, and reaching another peak on February 20th. This indicates that public perception of climate risks precedes the actual occurrence of meteorological disasters and persists longer. This phenomenon may be attributed to disaster prevention campaigns by governments and organizations, early warnings by media and social media, historical experience and collective memory, and the amplification effect of social networks. These activities increase public awareness of impending disasters, thereby enhancing risk perception.

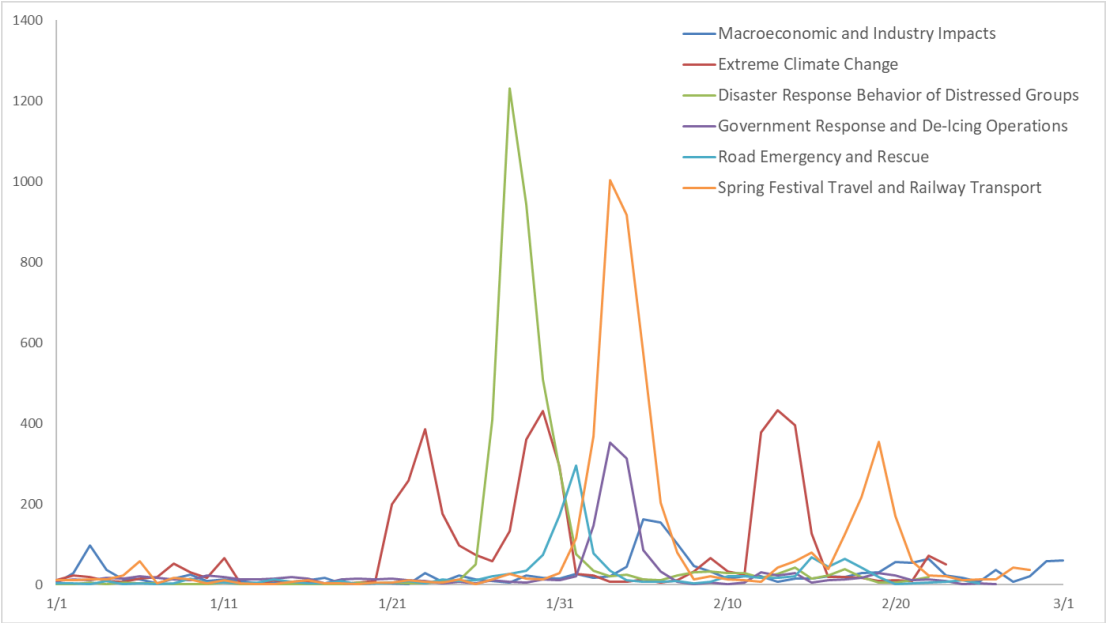


Fig. 6. Risk Perception Levels Over Time

3.2 Spatial Evolution Analysis

The study results depicted in **Fig. 7.** and **Fig. 8.** show that the spatial distribution of snow disaster risk perception does not completely align with the actual spatial distribution of snow disasters. There are also differences in the distribution of perceived social risk, disaster risk, and public opinion risk in specific provinces.

During the study period, the center of snowfall gradually shifted from Henan to Hubei, Hunan, and Jiangxi over time, which closely corresponds to the center of risk perception. Among the three categories of risk perception, Henan, Hubei, and Jiangxi Province perceive relatively higher risks. In Henan, perceived social risk is higher than perceived disaster risk and public opinion risk, suggesting that preventive measures should focus more on reducing and managing risks from extreme weather and macro social impacts, such as efforts to maintain social stability. Hubei Province exhibits the highest levels of perceived disaster risk and public opinion risk, with perceptions centered on the large number of stranded groups due to the disaster, ranging from several hours to four to five days of immobilization. This urgent response from the affected groups seeks attention through social media, seeks safe shelters, mutual assistance, and information sharing, thereby effectively responding to disasters. In Jiangxi, the highest risk perception is related to government response and de-icing operations, primarily due to concentrated

occurrences of freezing rain disasters. Compared to rain and snow disasters, severe ice formation on the ground, roads, and plant surfaces poses greater safety hazards. Guangdong Province shows an overall higher level of risk perception mainly due to high-risk perceptions among migrant workers returning home. Guangdong is a major destination for labor migration, while Henan, Heilongjiang, and Hubei are major labor-exporting provinces and cities. During the Lunar New Year Travel rush, the flow of migrant workers exhibits tidal characteristics. Due to the large population returning to Henan and Hubei and their central location in transportation hubs, they cannot avoid snow disasters during their journeys, resulting in a higher overall risk perception in Guangdong Province.

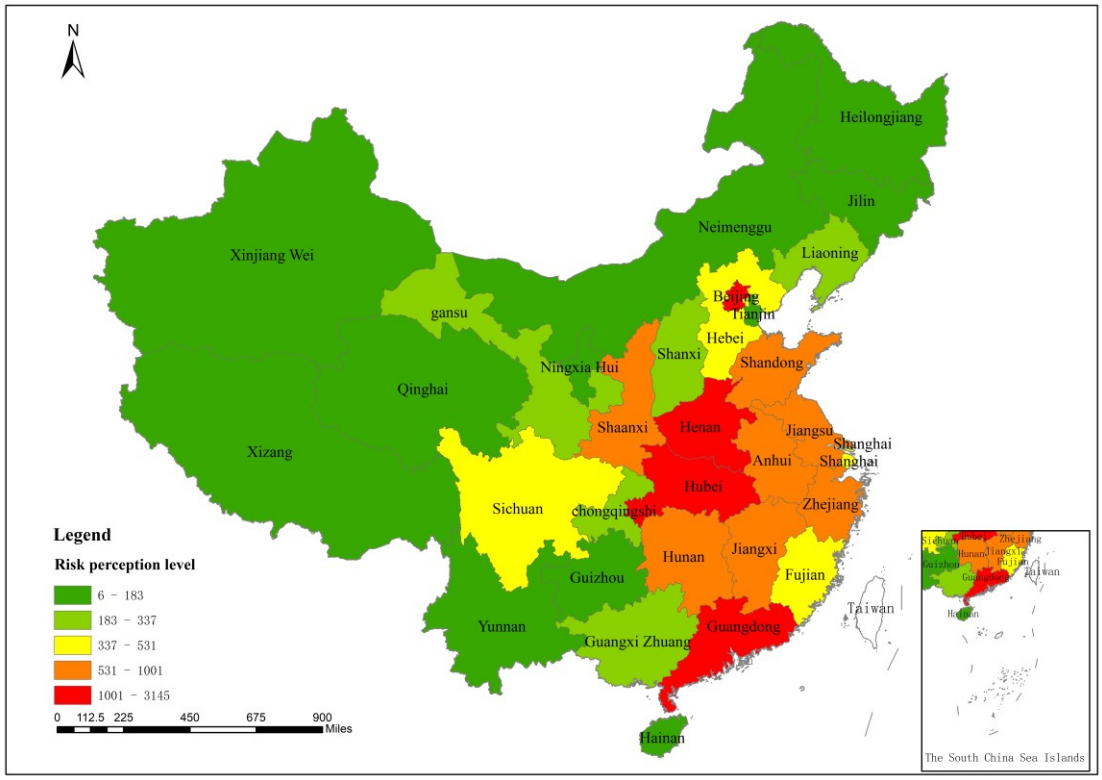
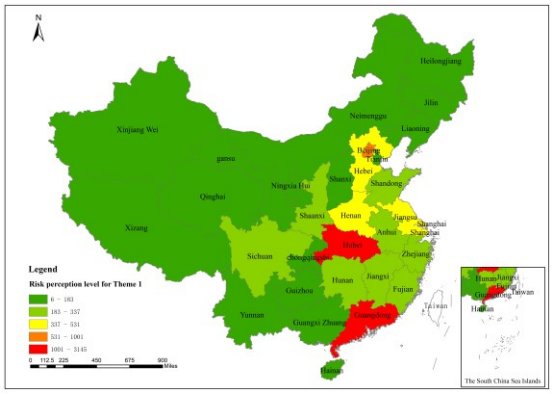
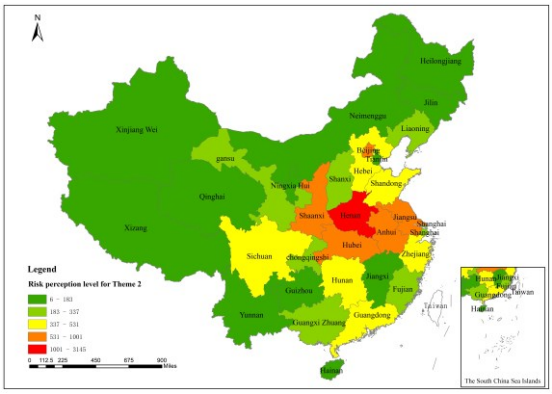


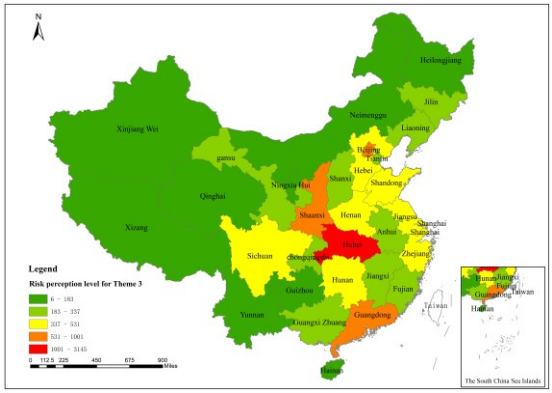
Fig. 7. Comprehensive Perception of Snow Disaster Risk Levels Across Regions



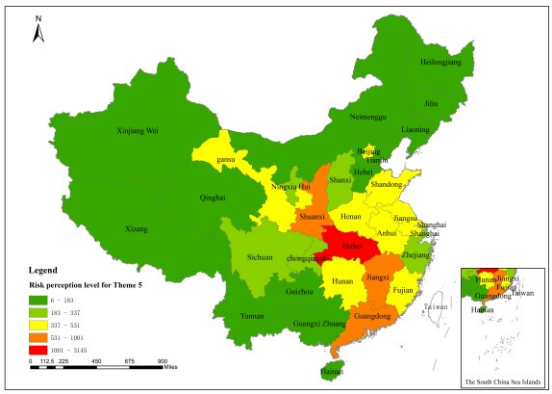
(a)Topic 1: Macroeconomic& Industry Impact



(b) Topic 2: Extreme Climate Change



(c) Topic 3: Disaster Response Behavior of Distressed Groups (d) Topic 4: Government Response and Deicing Operations



(e) Topic 5: Road Emergency and Rescue (f) Topic 6: Lunar New Year Travel and Railway Transport

Fig. 8. The perception level of snow disaster risk in various regions under six themes.

IV. Discussion and Conclusion

In recent years, frequent occurrences of extreme weather events have had significant impacts on society and the economy. Extreme snow disasters have resulted in transportation disruptions, infrastructure damage, and casualties. Therefore, understanding and perceiving the risks associated with such disasters are crucial. This study expands on previous research by utilizing big data from social media to investigate the inherent characteristics and spatiotemporal distribution of snow disaster risk perception. It identifies public risk perception patterns regarding extreme snow disasters, explores emotional responses and focal concerns among the public, and proposes corresponding disaster management recommendations. These findings can serve as references for governmental efforts to guide public perception of social risks, disaster risks, and negative emotional responses related to public opinion risks.

The thematic coverage of snow disaster risk perception encompasses social risks, disaster risks, and public opinion risks, each demonstrating distinct internal variations. Specific aspects requiring greater governmental attention aid in understanding the extent to which different risk types influence public behavior and societal responses, thereby guiding the formulation of appropriate risk management and response strategies.

In terms of temporal evolution, fluctuations in comprehensive risk perception levels highly synchronize with actual occurrences of snow disasters, albeit with corresponding lag effects,

psychological biases, and amplification effects on social media networks. Firstly, information dissemination across different risk themes may exhibit delays, implying that consensus and attention regarding specific disaster risks may require extended periods to form among the public. Secondly, the influence of individual and collective psychological factors on social media information dissemination may distort or lead to partial understandings, potentially affecting the genuine perception and behavioral responses to risks, thereby impacting the effectiveness of emergency management. Lastly, information on social media can rapidly proliferate, generating cascading and amplification effects that might exaggerate information dissemination, increase public panic, or mislead perceptions.

Regarding spatial distribution, although there exists spatial variability in the intensity of snow disasters, the spatial distribution of risk perception does not fully align with it. Henan, Hubei, and Jiangxi provinces are identified as regions with the highest integrated risk perception, necessitating targeted risk communication and emergency response strategies. **A comparison between Henan and Hubei provinces reveals that risk perception in Henan Province focuses more on social risks**, suggesting a need for enhanced management and preventive measures against climate risks and their social impacts. **In contrast, Hubei Province emphasizes disaster and public opinion risks,** particularly concerning the safety and health of stranded populations, necessitating enhanced disaster response and rescue capabilities. Therefore, efforts in Henan Province should prioritize responses to social risk perception, while Hubei Province should focus on responding to disaster risks near the center of snow disasters and addressing public opinion risks related to group response behaviors.

The research findings provide critical references for formulating regional and differentiated risk management strategies, enhancing societal perception and response capabilities against climate disaster risks, thereby strengthening overall disaster resilience. This study represents a rare analysis of spatiotemporal characteristics in extreme weather disaster risk perception from the perspective of big data mining. Governments and relevant organizations can improve disaster warning systems and emergency response measures by recognizing the role of social media in climate disaster early warning and emergency management.

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