Understanding Public Perception Towards Weather Disasters Through the Lens of Metaphor

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Abstract

Extreme weather can lead to weather-induced disasters. These have a profound impact on communities worldwide, causing loss of life, damage to properties and infrastructure, and disruption of daily activities. In alignment with the United Nations Sustainable Development Goals, addressing the increasing frequency and severity of these events, exacerbated by climate change, is imperative. Exploring public perception and responses to weather disasters becomes crucial for policymakers to formulate effective strategies that not only mitigate the impacts but also contribute to the goal of ensuring sustainable and resilient communities. Social media, as a pervasive and real-time communication platform, has gathered a large amount of public opinion. In this work, we analyze public perception towards weather disasters based on tweets and metaphors. Metaphor, as a linguistic device, plays a pivotal role in unraveling cognitive processes and understanding how individuals perceive and make sense of concepts. We focus on tweets related to four distinct types of weather disasters i.e., floods, hurricanes, tornadoes, and wildfires, aiming to extract nuanced insights regarding public perceptions, concerns, and attitudes towards these specific events. We also deliver constructive recommendations, based on the insights.

1 Introduction

Weather disasters exert a far-reaching and lasting impact on communities across the globe, leading to profound consequences such as loss of life, property and infrastructure damage, and disruption of routine activities. The intensification and increased frequency of these events, attributable to climate change [Benevolenza and DeRigne, 2019], underscore the critical importance of comprehending how the public perceives and responds to such calamities. This is because public perception informs disaster preparedness and risk communication strategies [Cambria et al., 2024]. Mitigating the impacts of weather disasters aligns with the United Nations Sustainable Development Goals, such as "Good Health and Well-being", "Climate Action", "Partnerships for the Goals".

This research focuses on extreme weather-induced disasters (referred to as weather disasters), distinct from other natural disasters, e.g., earthquakes and human-made disasters such as oil spills. The motivation for studying weather disasters stems from the escalating frequency and severity of extreme weather events due to global climate change [Stott, 2016]. Given the evolving climate, policymakers must identify climate adaptation strategies accepted by the public, minimizing social unrest and fostering global collaboration for effective mitigation. Weather disasters impact diverse demographics across different communities and economies worldwide, emphasizing the importance of tailored measures accepted by communities facing various types of disasters.

In this work, we study four types of weather disasters, namely floods, hurricanes, tornadoes, and wildfires. [Wiegmann et al., 2020] have developed a large human-annotated corpus, providing precise relevance labels for disaster types in association with tweets. This corpus, to our knowledge, stands as the most extensive collection, encompassing a vast array of public opinions with reliable human annotations. An innovative aspect of our work is the use of metaphors and a computational metaphor processing tool to study public perceptions. Metaphors reflect the concept mappings from target domains to source domains, uncovering deeper cognitive and emotional constructs within the human psyche. Metaphors serve as linguistic and cognitive tools through which individuals conceptualize abstract or complex ideas (e.g., target concepts) by likening them to more tangible or familiar concepts (e.g., source concepts). This dynamic allows metaphors to provide a distinctive perspective for grasping how individuals perceive, construe, and emotionally grapple with weather disasters, thereby exposing the foundational cognitive frameworks that shape the collective comprehension of such phenomena. The ubiquity of metaphors in everyday speech, coupled with their potency in deciphering the conceptual linkages embedded within them, motivates our choice to utilize metaphors as the medium for investigating public perception towards weather disasters. The rationale of studying cognition via metaphors will be further discussed in Section 3. A metaphor processing tool, MetaPro [Mao et al., 2023b] is used to parse the corpus of [Wiegmann et al., 2020] that contains 18,521 tweets related to our focused weather disasters. There are 8,548 tweets containing 12,744 metaphorical concept mappings after parsing.

We study public perception from these concept mappings. A concept mapping is represented as the mapping of a target concept and a source concept in the form of "a target concept is a source concept". For example, given the sentence "the flood *thundered* below", MetaPro can yield the concept mapping of ACT IS NOISE, where ACT is a target concept; NOISE is a source concept[1]. The metaphorical verb "*thundered*" implies that the speaker considers the movement of a flood as an ear-splitting sound. Different speakers may have different perceptions towards different disasters, using different metaphors, e.g., "the flood *raged* below" or "the wildfire *devoured* the village". Thus, we can gain cognitive insights of the public through statistical analysis of their concept mappings. We aim to answer the following research questions:

1. What common concept mapping patterns are observed among the public concerning diverse weather disasters?

2. What distinctive perceptions do the public hold regarding different types of weather disasters?

Our major findings can be summarized as follows: **RQ1.** There is a pervasive tendency among individuals to conceptualize disaster management as a strategic battle, emphasizing the importance of mental preparedness, resource assessment, and adaptive planning reminiscent of military strategies (ACTIVITY IS FIGHT). Additionally, the dynamic and transformative perspective of disasters (EXPANSION IS MOTION) underscores the urgency and intensity associated with their rapid escalation. The public places considerable emphasis on proactive disaster response, as evident in the concept mapping of PRODUCTION IS ACTION, emphasizing the need for effective measures, such as early warning systems, resource allocation, and community resilience initiatives. Furthermore, the subjective interpretation of the magnitude of floods and wildfires through the concept mapping, SIZE IS IMPORTANCE, indicates the potential stress and nervousness individuals associate with these disasters. **RQ2.** The findings extend to specific disaster perceptions, such as collaborative responses and fluid nature in floods, emotional reactions to hurricanes, fundamental cognitive processes in tornadoes, communal support in tornado events, and the portrayal of wildfires as hostile events with sustained impacts.

Our contribution is threefold: (1) A cognitive analysis was conducted on four significant types of weather disasters occurring between 2012 and 2017. This analysis encompassed the examination of distinguishable concept perception between different disaster types and the common concept mappings. To the best of our knowledge, this research represents a pioneering effort in investigating public perception within the disaster domain through a large volume of concept mapping analysis. (2) The study provides valuable recommendations derived from a comprehensive analysis of public perceptions of weather disasters. These insights have the potential to inform policy formulation and mobilization strategy development. (3) We introduce a novel cognitive analysis process driven by data mining techniques to examine public perceptions of weather disasters. This analytical pipeline, shown in our study, can be applied to gain cognitive insights from a

large population during various disaster scenarios. The limitations can be summarized as follows: First, social media platforms, such as Twitter, are the most immediate and dynamic channels for the dissemination of public opinion. Analyzing public perceptions through tweets enables us to derive findings that encompass a significant portion of the population. However, it is essential to note that our findings may not encompass the perspectives of individuals who do not use Twitter. Second, our findings represent the general perception of Twitter users regarding weather disasters, rather than providing a cognitive analysis specific to disaster victims. Due to constraints in our data source, we cannot distinguish whether a tweet originated from a disaster victim or a normal Twitter user. Finally, our data mining findings provide a valuable reference point, offering insights into the overall public perception of weather disasters. For targeted mitigation strategies in specific regions and events, it is advisable to validate general findings and recommendations with specific populations through human-involved laboratory tests.

2 Related Works

[Smith *et al.*, 2007] conducted a case study to emphasize effective communication of risks and mitigation strategies to decision-makers. [Ukkusuri *et al.*, 2014] explored crisis informatics using social media data, specifically analyzing sentiment in microblogs post-tornado. [Cvetković and Stanišić, 2015] studied the relationship between demographic and environmental factors and students' knowledge and perceptions of natural disasters, revealing the influence of factors, e.g., gender, age, family, school, and media. [Sun *et al.*, 2017] conducted a thematic analysis on religious-related issues in the context of natural disasters, highlighting the significance of religious beliefs in understanding and responding to disasters. [Ismail *et al.*, 2019] studied the engagement of young people on social media during occurrences of natural disasters. They found that young people exhibit a preference for accessing news and information via social media platforms when faced with natural disasters like flooding, landslides, and haze events. [Cvetković and Grbić, 2021] explored the factors influencing public perception of climate change and its impact on natural disasters, pinpointing education level, employment status, and age as significant predictors.

These studies collectively contribute to an understanding of the diverse aspects influencing public perception and communication strategies in the context of natural disasters. Nevertheless, previous studies often restricted their scope to specific cases, a particular disaster event, or limited variables in their analyzes of perception. A thorough investigation with conceptual explainability [Cambria *et al.*, 2023; Turbé *et al.*, 2023] into public perception across a diverse array of concept domains, encompassing floods, hurricanes, tornadoes, and wildfires, has been notably lacking.

3 Preliminary: Metaphors and Cognition

Metaphors provide a distinctive perspective for exploring human cognition and the process of conceptualization. They illustrate the transformation of complex and abstract target

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[1]Italics denote metaphors; Small capital words denote concepts.

concepts into tangible and experiential source concepts. Contrary to being solely rhetorical tools of expression, metaphors are integral to our cognitive mechanisms. They are present in our everyday language, delivering subtle influence on our thoughts and behaviors, often functioning within the recesses of our subconscious.

The theoretical foundation of this work is rooted in Conceptual Metaphor Theory (CMT) [Lakoff and Johnson, 1980]. According to CMT, metaphors shape our thoughts and understanding of abstract concepts through the mapping of target and source concepts. In the context of "she *attacked* his arguments", the metaphorical verb *attacked* implies the target and source concept mapping of ARGUMENT IS WAR. This mapping results in a series of war-like behaviors, such as offense, defense, and the use of strategy during an argument. Consequently, people may become confrontational and forget to control their speaking volume, use a gentle tone of voice, and find common ground. CMT also argues that humans learn abstract concepts from metaphors. For instance, the cognition of LOVE, which serves as the target concept, is frequently associated with metaphorical source concepts such as JOURNEY, MADNESS, MAGIC and so on. These source concepts play a fundamental role in enriching the cognitive framework of the target concept, providing a more comprehensive and nuanced comprehension of the multifaceted nature of LOVE, e.g., love is a journey, associated with madness, magically bringing us the emotional experiences we have never explored before. What this kind of narrative understanding implies is people's perception of concepts.

While early insights into conceptual metaphors were largely derived from linguistic analyzes [Ge *et al.*, 2023], recent years have witnessed a burgeoning of non-linguistic empirical evidence that underscores the pivotal role of conceptual metaphors in shaping human cognition. Current studies have demonstrated that our representations of abstract concepts such as TIME [Casasanto and Boroditsky, 2008], NUMBER [Casasanto and Pitt, 2019], and various facets of social cognition—including VALENCE [Meier *et al.*, 2004], POWER [Schubert, 2005], and MORALITY [Zhong and Liljenquist, 2006]—is deeply intertwined with metaphors rooted in lived experiences. On the other hand, metaphors' influence is not limited to shaping thought patterns alone. They have tangible real-world consequences, influencing perceptions, attitudes, and actions. For example, individuals who conceptualize climate change through the metaphor of WAR perceive it as a more pressing and imminent threat, showcasing a higher readiness to participate in pro-environmental actions when compared to those who perceive it through the metaphor of RACE [Flusberg *et al.*, 2017]. This underscores the formidable power of metaphorical framing in steering public perception for complex issues such as climate change, thereby forming a foundation upon which we base our recommendations to policy-makers.

Finally, the examination of human cognition through concept mappings has an extensive historical background. These mappings have been frequently employed in diagnostic psychological assessments, taking shape in various methods such as word-association tests[2], thematic apperception tests[3], and the Rorschach test[4] [Rapaport *et al.*, 1946]. These assessments use different types of concept mappings to illuminate distinct cognitive patterns, personalities, and emotional functions in subjects and are still vivid nowadays. We choose to use metaphors as the media to study concept mappings because of the aforementioned theoretical background. More importantly, metaphors are more frequent than we think in our everyday language [Mao *et al.*, 2018]. We can easily obtain a large number of concept mapping samples from corpora, thus, revealing the perception of the public at scale. Compared to interview-based psychological or cognitive studies, analyzing concept mappings from daily social media posts has more ecological validity, because the posts are more likely to reflect the genuine feelings of subjects in a real-world context.

While investigating cognition through metaphors and concept mappings is theoretically well-founded, earlier studies often utilized traditional qualitative analysis and involved human testing with constrained sample sizes due to limitations in research methodologies. The novelty of our methodology lies in the utilization of advanced technology and a substantial research sample to study perception trends conveyed through metaphorical expressions in diverse disaster contexts. This approach has a significantly inspiring impact on conventional cognitive research methodologies.

4 Corpus and Statistics

We employ a corpus developed by [Wiegmann *et al.*, 2020] to study public perception towards weather disasters. The original corpus contains tweets, related to 48 separate disaster events and 10 distinct disaster categories. Human annotators have labeled these tweets to indicate their relevance to a respective disaster type. Since we aim to analyze public perception towards weather disasters, we only use tweets that are relevant to floods, hurricanes, tornadoes, and wildfires. Our employed data cover a total of 22 weather disaster events, including 9 floods occurring in the Philippines (2012), Queensland (2013), Sardinia (2013), Alberta (2013), Colorado (2013), Manila (2013), India (2014), Pakistan (2014), and Sri Lanka (2017). Additionally, there are 9 hurricanes, namely Sandy (2012), Pablo (2012), Yolanda (2013), Hagupit (2014), Odile (2014), Pam (2015), Harvey (2017), Irma (2017), and Maria (2017). One tornado event is included from Oklahoma (2013), and 3 wildfires from Colorado (2012), Australia (2012), and California (2014). In total, there are 18,521 tweets, related to these disaster events in our metaphor analysis. Then, MetaPro is used for parsing concept mappings from the 18,521 tweets. There are 8,548 tweets remaining after parsing because MetaPro did not detect metaphors in the rest of the tweets.

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[2]Word association tests involve presenting a stimulus word to a participant, who responds with the initial word that comes to mind.

[3]The thematic apperception test is a projective psychological test where subjects deliver interpretations for ambiguous visual scenes.

[4]The Rorschach test is a projective psychological test in which subjects are prompted to describe what they see in 10 inkblots, some of which are black or gray, while others include patches of color.

Disaster	# tweet	# metaphor	# uniq. CM
Flood	3,278	4,838	1,685
Hurricane	3,791	5,743	2,020
Tornado	1,038	1,555	710
Wildfire	441	608	380
All	8,548	12,744	3,163

Table 1: The number (#) of the analyzed tweets, parsed metaphors, and unique concept mappings (uniq. CM).

Within the 8,548 tweets, we have obtained 12,744 metaphors and 3,163 associated concept mappings where the number of unique source and target concepts is 1,116. Table 1 shows the statistics of tweets, metaphors, and concept mappings that are used in the following analysis by different weather disaster events.

5 Methodology and Evaluation

Our perception analysis involves the following pipeline: data acquisition, concept mapping parsing, and statistical analysis for concept mappings. The source data were gathered by [Wiegmann *et al.*, 2020] and publicly available. Privacy protection concerns have been mitigated via the concealment of links, numbers, hashtags, and user IDs. We employ a subset of the corpus where the tweets are related to weather disasters. Next, we employ MetaPro [Mao *et al.*, 2023b][5] to extract concept mappings from tweets. Finally, we analyze the similarity and dissimilarity in perception across various disaster types by examining the most frequently shared concept mappings and distinct ones associated with each disaster. The most common concept mappings represent shared perceptions, while the distinguishable ones capture unique perceptions specific to each disaster type. This distinction can offer valuable insights into disaster-specific mitigation actions.

To the best of our knowledge, MetaPro is the sole end-to-end expert system for concept mapping parsing [Ge *et al.*, 2023]. It consists of three sub-modules, e.g., metaphor identification [Mao and Li, 2021], metaphor interpretation [Mao *et al.*, 2022], and concept mapping generation [Ge *et al.*, 2022][6]. First, the metaphor identification module aims to detect the metaphoricity of each word in a sentence. Next, the metaphor interpretation module paraphrases the identified metaphors into their literal counterparts. Finally, the concept mapping generation module abstracts a target concept from the paraphrase and abstracts a source concept from the original metaphor. The example input and output can be viewed in Figure 1. The definition of the generated target and source concepts can be viewed from WordNet [Fellbaum, 1998]. To verify MetaPro-generated concept mappings on our dataset, we conduct two evaluation tasks, namely perception examination (Task 1), and human evaluation of concept mappings (Task 2). In Task 1, we plot the distributions of various disaster events based on averaged concept mapping representa-

[5]https://metapro.ruimao.tech
[6]The detailed evaluation of the sub-modules of MetaPro on benchmarking datasets can be viewed from these papers.
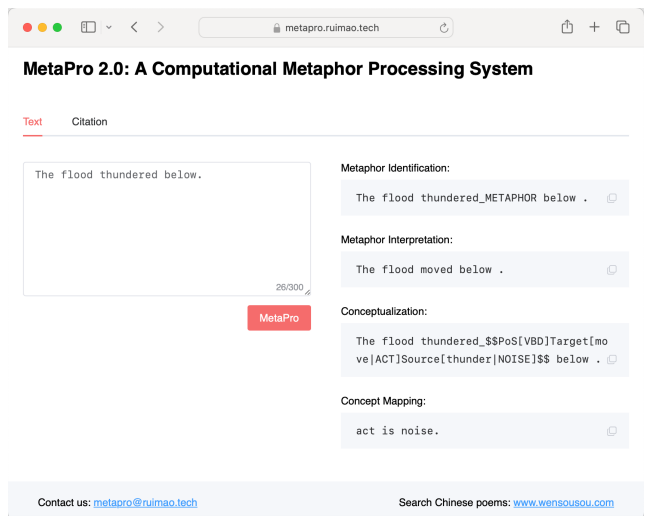
Figure 1: The example input and output of MetaPro.

tions within a disaster event[7]. The distribution reflects the spatial relationships of public perceptions towards different disaster events. We hypothesize that the perceptions of an identical disaster category should exhibit similarity, reflected by the proximity of disaster events in vector space. However, the distribution patterns of perception may not necessarily demonstrate clear distinctions across different disaster types due to the interconnected nature of these weather disasters in terms of their impact on human lives, encompassing factors such as loss of life and property. As seen in Figure 2, events categorized under the same disaster type tend to cluster together. This distribution suggests a relative consistency in concept mapping-reflected perceptions across diverse disaster events. It also proves the robustness of using MetaPro to parse concept mappings in various disaster events.

In Task 2, we perform human evaluations to examine individual concept mappings produced by MetaPro. Three participants, specializing in Psychology, were invited for this assessment. Metaphor Identification Procedure [Pragglejaz, 2007] and CMT were used for instructing their evaluation tasks. We randomly selected 300 tweets, ensuring that MetaPro identified at least one metaphor in each sampled tweet. Among these 300 tweets, MetaPro generated a total

[7]The general perception of a disaster event is given by the averaged concept mapping representations. First, we collect all concept mappings of a specific disaster event ($d \in D$, where D is a set of disaster events) with MetaPro. The concept mapping is represented as "T IS S", where T and S denote target and source concepts, respectively. Then, the representation ($r_i^{(d)}$) of a concept mapping (i) is given by the concatenation ($\oplus$) of the associated target and source concept embeddings (v), where the concepts are embedded with GloVe.6B.50d. Then, $r_i^{(d)} = v_T \oplus v_S$. The averaged concept mapping representation reflects the general perception (p) of d because it represents the major concept mapping patterns from d ($p^{(d)} = \frac{1}{N} \sum_{i=1}^{N} r_i^{(d)}$, where N is the total number of concept mappings from d). Finally, we employ t-SNE [Van der Maaten and Hinton, 2008] to reduce the dimensionality of $p^{(D)}$ from 100 to 2 for visualization.
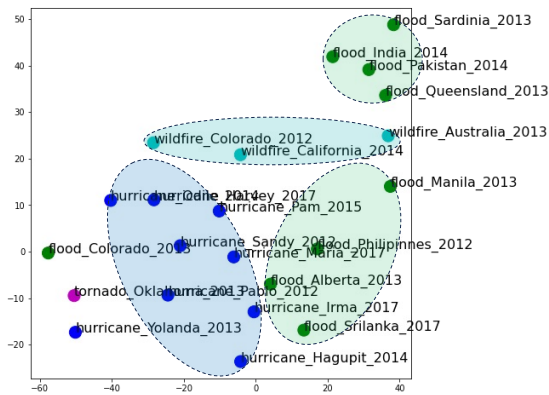
Figure 2: The distribution of disaster events by their concept mapping representations (the average of concept mapping embeddings).

Figure 3: Frequent concept mappings in common.

of 437 concept mappings from metaphors, with 375 concept mappings deemed accurate and attaining consensus among at least two participants (Fleiss' kappa: 0.72). Participants also identified 52 metaphors that MetaPro did not detect within the 300 sampled tweets (Fleiss' kappa: 0.67).

6 Frequent Concept Mappings in Common

We first analyze common concept mapping patterns among different weather disasters (RQ1). We chose the top-10 concept mappings for each disaster and standardized their frequency relative to the highest occurrence. Figure 3 encompasses 26 concept mappings, highlighting the overlap in frequently encountered concept mappings among diverse disasters. The ensuing analysis focuses on these shared concept mappings observed in multiple disaster types.

ACTIVITY IS FIGHT appears in floods and tornadoes. People compare activities against disasters to fights, which reflects the innate human tendency to draw parallels between challenging situations and adversarial battles [Ward, 2003]. This analogy signifies the mental preparedness required to confront disasters, akin to strategizing for a battle. Just as in a fight, individuals facing disasters need to assess their resources, plan their approach, and adapt swiftly to the changing circumstances [Norris *et al.*, 2008].

EXPANSION IS MOTION appears in floods, tornadoes, and wildfires, indicating that people perceive the expansion of these disasters as dynamic and transformative processes [Costabile and Macchione, 2015; Davies-Jones, 2015; Duong *et al.*, 2024; Duong *et al.*, 2022]. This concept mapping also conveys a sense of urgency and intensity associated with the expansion of a disaster. Just as motion can escalate in speed and intensity, the expansion of a disaster is seen as a rapidly advancing and escalating phenomenon.

PRODUCTION IS ACTION appears in hurricanes and wildfires, indicating that the proactive nature of production aligns with the necessity for effective efforts in responding to these disasters. Understanding production as an action force highlights the importance of proactive measures, such as early warning systems [Escaleras and Register, 2008], resource alloca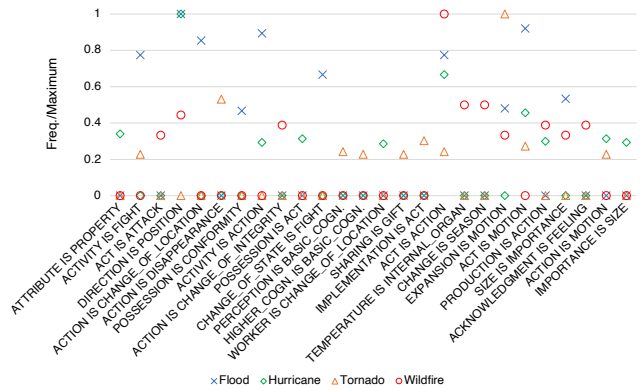tion [Fiedrich *et al.*, 2000], and community resilience initiatives [Mayer, 2019], all of which contribute to mitigating the impact of natural disasters.

SIZE IS IMPORTANCE appears in floods and wildfires, suggesting that the public tends to interpret the magnitude and influence of floods and wildfires, which are objective measures in the concept domain of SIZE, through a subjective lens of IMPORTANCE. The size, magnitude, or scale of these disasters is seen as a reflection of their perceived importance and impact. [Han *et al.*, 2022] also found such concept mappings commonly appeared in the cognition of depressed persons. It reflects the nervousness of the public about the disasters. The changes in the magnitude and influence of floods and wildfires are projected to the level of importance, assigned to them, showing how people perceive these disasters on a subjective scale of significance.

DIRECTION IS POSITION appears in floods, hurricanes, and wildfires. Humans naturally navigate and interact with their environment, relying on spatial understanding. Concepts related to space and spatial relationships are fundamental to human cognition [Mark, 1993]. DIRECTION and POSITION are closely tied to how we perceive and describe spatial relations, making them common in metaphoric expressions.

ACTIVITY IS ACTION , **ACT IS ACTION**, **ACT IS MOTION**, and **ACTION IS MOTION** can be found in multiple disasters. These mappings commonly appear in conventional verb metaphors, no matter whether the metaphors are used in the disaster context or other contexts [Mao *et al.*, 2023a; Mao *et al.*, 2024]. The prevalence of verbal metaphors can be ascribed to the fundamental embodiment of human cognitive systems, wherein our conceptual comprehension is closely intertwined with our physical experiences and actions [Jamrozik *et al.*, 2016]. Our grasp of concepts is primarily influenced by sensory and motor experiences [Kiefer and Pulvermüller, 2012], and verbs, as linguistic devices of actions, play a vital role in conveying these embodied experiences. We often employ concept mappings that link tangible, physical actions to abstract concepts as a means to comprehend the intricacies of the world. Verbal metaphors serve as a bridge between the abstract and the concrete, allowing us to fathom complex ideas through familiar linguistic expressions.
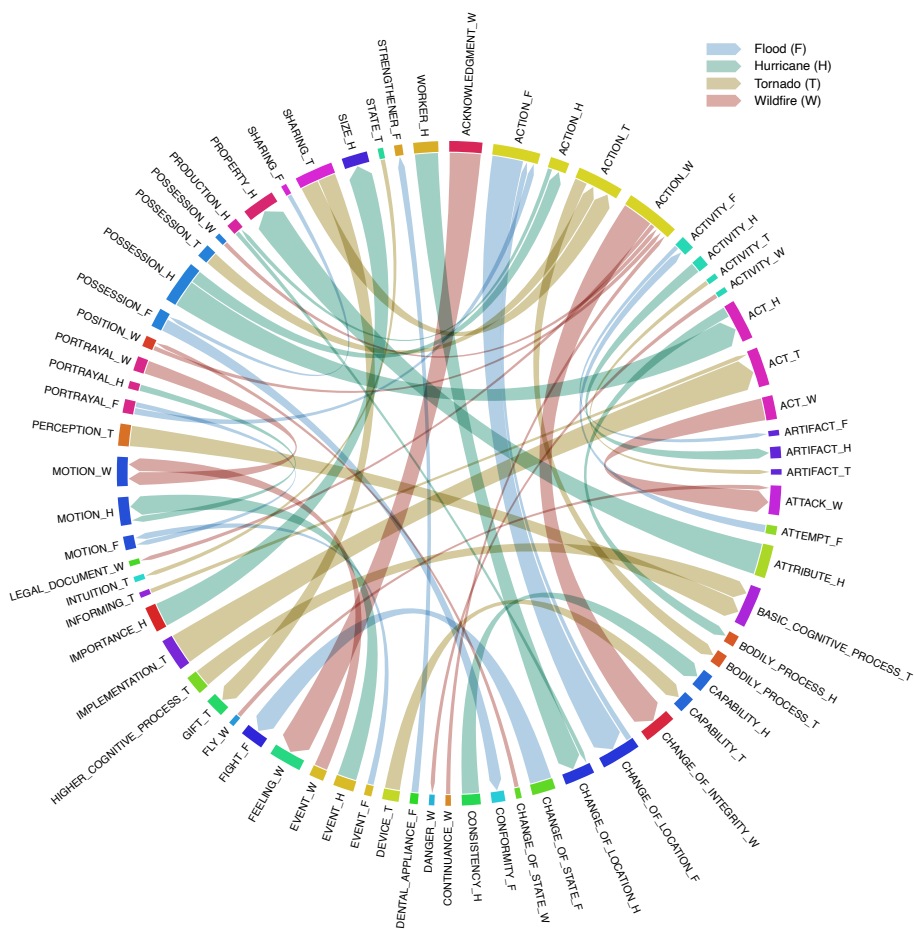
Figure 4: Distinctive concept mapping patterns by different disasters. Arrows indicate a direction from target to source concepts.

7 Distinctive Perceptions between Disasters

Figure 4 illustrates the most frequent and distinguishable concept mappings associated with different disasters. This visualization serves as a means to investigate the distinct perceptions held by the public regarding different types of disasters (RQ2). The criteria for selecting distinguishable concept mappings entail choosing the most frequent mappings within a disaster class that do not appear among the top 10 frequent ones in other classes. We compile the 10 most frequent and distinguishable mappings based on this criterion. If certain mappings share the 10th rank, the total number of included mappings for a disaster class may exceed 10. Consequently, Figure 4 encompasses a total of 50 concept mappings.

Floods. The target concepts in the metaphorical expressions related to floods generally suggest a cognitive framework emphasizing collaborative responses (SHARING), ownership (POSSESSION) or control (ATTEMPT) over affected areas/resources. The source concepts suggest a perception of the flood disaster as a dynamic, fluid event involving changes in geographical locations (CHANGE_OF_LOCATION) and water flow (MOTION). Additionally, the source concepts indicate a recognition of the need for resilience (FIGHT), establishing norms in teamwork (CONFORMITY), and the involvement

of reinforcing factors (STRENGTHENER) and tangible objects (ARTIFACT) in response to the floods. The concept mapping, CHANGE_OF_STATE IS FIGHT[8] suggests that the impact of floods has been viewed metaphorically as a struggle, possibly requiring resilience, effort, and proactive measures to navigate and mitigate adverse effects [Bosher *et al.*, 2009].

Hurricanes. The target concepts, e.g., ATTRIBUTE, IMPORTANCE, and CONSISTENCY suggest that the public might conceptualize the hurricane disaster in terms of its features, significance, and regularity. The choice of source concepts, e.g., PROPERTY, SIZE and CHANGE_OF_LOCATION suggest that the perception of the public towards hurricanes is mainly about their inherent attributes or characteristics. The concept mapping, POSSESSION IS ACTION[9] highlights a deep emotional reaction to hurricanes' impact. This conceptual framework distills the perceived hurricane influence into tangible manifestations, encapsulating their profound effects on individuals' lives through concrete actions [Trumbo *et al.*, 2016].

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[8]For example, "during one week of work in flood *hit* [affected] areas, I found that many Kashmiri Pandits have returned to valley".

[9]For example, "Ruby slowed down but maintained its strength, *packing* [having] max sustained winds at 205 kilometers per hour".

Tornadoes. The target concept IMPLEMENTATION was frequently mentioned to emphasize the need for the realization of plans against tornado disasters. Both the abstract target concepts, PERCEPTION (e.g., detection, and sensing) and HIGHER_COGNITIVE_PROCESS (e.g., search, thinking, deciding, and knowing) were mapped to the source concept of BASIC_COGNITIVE_PROCESS (e.g., attention, apperception, feeling, and learning), suggesting that individuals rely on fundamental cognitive functions when processing and responding to tornado-related events. These basic cognitive processes include directing attention to relevant stimuli, engaging in the apperception of sensory information, and incorporating learning mechanisms for adapting to and understanding tornado-related experiences over time [Schumann III *et al.*, 2018]. The concept mapping, SHARING IS GIFT[10] shows that the public is willing to actively provide humanitarian aid to the victims of tornadoes [Deryugina and Marx, 2021].

Wildfires. The incorporation of target concepts such as AC-KNOWLEDGMENT and PORTRAYAL suggest that the public not only acknowledges the presence of wildfires but also places emphasis on how these events are represented and communicated. This may indicate a cognitive focus on the perception and transmission of information regarding the disaster through various channels. Conversely, source concepts, e.g., ATTACK and DANGER as aggressive forces, potentially likening them to hostile attacks fraught with inherent risks and threats [McLennan *et al.*, 2019]. The inclusion of CHANGE_OF_INTEGRITY signifies a cognitive recognition that wildfires are associated with a fundamental transformation in the environment, possibly affecting the landscape, ecosystem, or overall safety [Wardle *et al.*, 2003]. The concept mapping, CONTINUANCE IS ACTION[11], underlines concerns about properties potentially being damaged by wildfires, thus highlighting the ongoing nature of the disaster and its impact on individuals [Westerling and Bryant, 2008].

8 Summary and Recommendation

The analysis of the common conceptual mappings across various weather disasters reveals underlying cognitive patterns that reflect the human response to challenging situations. A deeply ingrained tendency to frame the confrontation with disasters as a strategic battle, e.g., ACTIVITY IS FIGHT, highlighting the need for mental preparedness, resource assessment, and adaptive planning akin to military strategies. EXPANSION IS MOTION portrays a dynamic and transformative view of disasters, underscoring the urgency and intensity associated with their rapid escalation. The public also delivered great emphasis on the proactive nature of disaster response via the concept mapping of PRODUCTION IS ACTION, underscoring the need for effective measures such as early warning systems, resource allocation, and community resilience initiatives. Finally, the notion of SIZE IS IMPORTANCE indicates that individuals interpret the magnitude of floods and wildfires through a subjective lens of importance, indicating the potential stress and nervousness about disasters.

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[10]For example, *donating* [giving] our time to help the victims.

[11]For example, "California wildfire evacuees just want to 'go home' if they have a home still *standing* [staying safe].

The distinctive concept mapping analysis suggests that different natural disasters lead to distinct cognitive frameworks in public perception. The perception of floods emphasizes collaborative responses, ownership, and control, with resilience and teamwork as key components. The metaphorical portrayal of floods as a struggle signifies the perceived necessity for proactive measures and resilience due to their dynamic and fluid nature. Hurricanes are perceived through attributes, significance, and regularity, with POSSESSION IS ACTION illustrating a deep emotional reaction to their distinct features and deep impacts on individuals' lives. Tornado-related perceptions center around the execution of plans, relying on fundamental cognitive processes, e.g., attention, apperception, and learning. The concept mapping of SHARING IS GIFT indicates a sense of communal support and solidarity in responding to tornado events. In the case of wildfires, ACKNOWLEDGMENT and PORTRAYAL are central, reflecting awareness of how information about these disasters is perceived and communicated. The aggressive forces of AT-TACK and DANGER, coupled with recognition of a fundamental environmental transformation, portray wildfires as hostile events with inherent risks. The concept mapping of CONTIN-UANCE IS ACTION underscores concerns about the sustained impact of wildfires on properties, highlighting the ongoing nature of the disaster and its implications for individuals.

Based on the common concept mapping patterns, these findings enhance the development of promotional materials and action plans for natural disaster mobilization [Flusberg *et al.*, 2017]. Thus, we propose the following recommendations:

General Recommendations. (1) Advocate for increased funding in climate-resilient infrastructure, incorporating innovative designs that consider dynamic and transformative aspects of disasters (EXPANSION IS MOTION) to mitigate the impact of floods, hurricanes, tornadoes, and wildfires. (2) Endorse interdisciplinary research and training initiatives to improve public comprehension of disaster response strategies. Encourage cooperation between emergency services and mental health professionals, developing effective action plans and facilitating mental preparedness (ACTIVITY IS FIGHT). (3) Establish global partnership for sharing best practices and resources related to disaster response (PRODUCTION IS ACTION). Encourage international cooperation in developing and implementing early warning systems, resource allocation strategies, and community resilience initiatives.

Disaster-specific Recommendations. (1) Recognizing the dynamic and fluid nature of floods, policies should prioritize measures addressing risk in the geological environment (CHANGE_OF_LOCATION) and water flow (MOTION). (2) Encourage joint efforts in developing and implementing resilience plans that consider both the physical (PROPERTY) and emotional (POSSESSION IS ACTION) impacts of hurricanes. (3) Strengthen humanitarian aid efforts to actively provide support in response to tornado-related events (SHARING IS GIFT). (4) Promote the implementation of community-level continuity planning, taking into account the prolonged effects of wildfires. Provide backing for efforts that prioritize long-term resilience and recovery, particularly in regions susceptible to wildfires (CONTINUANCE IS ACTION).

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