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# Editorial: Prevention, mitigation, and relief of compound and chained natural hazards, volume II

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Editorial on the Research Topic
Prevention, mitigation, and relief of compound and chained natural hazards, volume II

## Introduction

In the face of global climate change and intensifying environmental variability, the frequency, magnitude, and complexity of natural hazards have significantly increased (Masson-Delmotte et al., 2021; Xu and Xu, 2021; Huang et al., 2023; Gao et al., 2024; Wang et al., 2025; Wu et al., 2025; Xu et al., 2025). These events rarely occur in isolation. Instead, they interact spatially and temporally, generating compound and chained disasters that amplify impacts across interconnected systems (Pescaroli and Alexander, 2015; Gill and Malamud, 2017; Zscheischler et al., 2018; Van Wyk de Vries, 2025). This presents unprecedented challenges to disaster risk science and emergency management.

Building upon the success of the first volume of this Research Topic, which focused on earthquake-related hazard chains and geohazards (Xu et al., 2024), the second volume expands its scope to encompass a broader array of hazard interactions, covering geophysical, hydrological, and anthropogenic domains. It directly responds to the original call for papers, which emphasized five core themes: (1) formation and evolution mechanisms of compound and chained hazards, (2) multi-hazard model building and chain-breaking strategies, (3) source detection and database construction, (4) intelligent early warning and risk assessment technologies, and (5) emergency equipment and post-disaster recovery.

This editorial provides a structured synthesis of the 14 accepted contributions in Volume II. The articles are grouped thematically and highlight emerging research frontiers including artificial intelligence (AI), high-resolution geospatial analysis, integrated physical and empirical modeling, and intelligent sensing technologies for real-time hazard monitoring.

## Mechanisms and models of earthquake-triggered chained hazards

Earthquakes remain key initiators of cascading hazard sequences such as landslides, ground ruptures, and surface deformation (Keefer, 1984; Xu et al., 2014; Zhao et al., 2023; Li et al., 2024; Yu et al., 2024; Zhang et al., 2024; Huang et al., 2025). Liu et al. developed empirical relationships between Arias Intensity (AI) and peak ground acceleration (PGA) for western China, uncovering region-specific differences influenced by local site conditions and providing a new framework for energy-based seismic hazard metrics. Lu et al. compared a logistic regression-based data-driven model Xu et al. (2019) and a physics-based Newmark model to evaluate coseismic landslides after the 2022 Ms 6.8 Luding earthquake. Results show that the logistic model achieved higher accuracy and efficiency in emergency contexts. Wang et al. evaluated the predictive impact of lithology and precipitation in machine-learning models of earthquake-induced landslides. Surprisingly, they found these commonly used factors negatively affect model performance due to spatial clustering and data resolution issues. Hu and Ren proposed a probabilistic displacement hazard model for distributed surface ruptures along strike-slip faults in the Tibetan Plateau. Their work enables engineers to assess fault displacement risk for linear infrastructure exposed to large-magnitude events. Together, these studies deepen our understanding of chained seismic hazards and underscore the critical need for regionally adaptive, data-informed modeling strategies.

## Smart monitoring and early warning of mining-induced geohazards

Mining operations represent hotspots for compound geological risks due to induced stress fields, water infiltration, and roof instability (Wang et al., 2018; Ma et al., 2022). Zhang et al. developed a comprehensive early warning method for coal mine roof and floor cracking and water inrush, using microseismic monitoring of source parameters such as apparent stress and energy. Their tri-dimensional model of fracture depth, intensity, and risk represents a significant advancement in real-time hazard forecasting. Sun et al. applied abrasive jet-based hydraulic fracturing technology for gently inclined hard roof treatment. Field results confirmed effective crack generation and reduced stress concentration, highlighting a safer alternative to traditional blasting. Hou et al. analyzed surface subsidence and crack development across super-long working faces. Their findings offer new insights into asymmetric settlement curves and secondary subsidence effects, vital for infrastructure protection over mining zones. These contributions collectively reinforce the value of multi-sensor integration and mechanistic insight for mining hazard mitigation.

## Hydro-Geomechanical coupling and ground deformation dynamics

Groundwater level fluctuations and geologic structures play crucial roles in land subsidence and rebound phenomena (Chaussard et al., 2014; Jeanne et al., 2019). Liu and Bai investigated land deformation in Beijing's Chaobai River plain using InSAR and borehole extensometers. They discovered a previously undocumented uplift zone driven by managed aquifer recharge (MAR), controlled by fault permeability and lithologic variation—a paradigm shift in subsidence control theory. This work illustrates the evolving complexity of hydro-mechanical feedback loops in anthropogenic hazard settings.

## Landslide inventories, mapping, and spatial distribution analysis

Reliable landslide inventories are foundational for hazard zoning and regional risk assessment (Guzzetti et al., 2012; Xu, 2015; Shao and Xu, 2022; Feng et al., 2024; Shao et al., 2024). Xue et al. compiled 3,979 landslide relics in Zhenxiong County, Yunnan using human-machine interactive visual interpretation. They identified four high-density landslide zones, emphasizing terrain incision and hydrological development. Wang and Xu built a database of 5,517 landslides in Minhe County, Qinghai, revealing the dominance of slope angle (15°–25°), elevation (2000–2,100 m), and proximity to rivers (0–2 km) in governing spatial susceptibility. Such granular spatial datasets are key to advancing machine-learning-based susceptibility mapping and chain hazard simulations.

## Monitoring, reinforcement, and failure simulation in complex geological settings

Hazard dynamics in karst, loess, and liquefiable sites require specialized monitoring and engineering solutions (Zhao et al., 2012; Koseki et al., 2015; Lian et al., 2020). Wu Liang et al. used MEMS sensors in a series of slope model experiments to monitor internal displacements with high accuracy (<6% error), suggesting a promising alternative to traditional PIV methods in deep slope stability monitoring. Wu Yi et al. conducted six model tests on geotextile reinforcement of karst subgrades. They found that tensile membrane effects significantly reduced displacement—up to 66% under static loads—offering theoretical and design support for infrastructure in karst-prone zones. Peng et al. performed fully coupled dynamic effective stress analysis on liquefiable interlayers under bidirectional ground motion. Their results confirm that near-field vertical seismic components significantly increase ground settlement, reshaping our understanding of site response mechanisms. Zhao et al. simulated a loess landslide event in Shaanxi Province using discrete and finite element models to quantify impact damage on housing. The findings offer a blueprint for quantitative vulnerability assessment in loess terrain, a critical step in pre-disaster planning.

## Conclusion and outlook: toward data-driven, intelligent multi-hazard resilience

While the contributions in this volume provide valuable insights into specific aspects of compound and chained natural hazards—particularly in the contexts of earthquake-induced geohazards, mining-related instabilities, and site-specific deformation phenomena—they only partially address the full breadth of challenges outlined in the original call for papers. Research gaps remain in areas such as meteorological hazard interactions, hydrological-ecological feedbacks, and transboundary disaster chains. Nevertheless, the application of machine learning, microseismic monitoring, geospatial mapping, and physical modeling across these case studies reflects a promising step forward in hazard assessment and scenario-based analysis.

We recognize that a comprehensive understanding of multi-hazard dynamics requires sustained and interdisciplinary efforts. To that end, we are continuing this Research Topic in future volumes, and we sincerely welcome further contributions that address broader hazard types, integrative modeling approaches, and proactive mitigation strategies. We invite researchers from around the world to join us in advancing science-based solutions for reducing the risks and cascading impacts of natural hazards.

## Author contributions

CX: Funding acquisition, Writing – review and editing, Writing – original draft, Conceptualization. QY: Writing – review and editing. XH: Writing – review and editing. WQ: Writing – review and editing. SM: Writing – review and editing. WY: Writing – review and editing. LT: Writing – review and editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

## Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

## Publisher's note



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