中国科学院地理科学与资源研究所
Institute of Geographic Sciences and Natural Resources Research, CAS

Center for Natural Hazard Research

Institutional Strengths and Contributions to ICEIDR

Peng Cui, Yan Wang

16 July 2026

Contents

The Center for Natural Hazard Research

IGSNRR Profile

Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

Institutional members

- **2,835 staff and students**, including 643 permanent employees and 1,222 graduate students
- **194 Professors** and **307 associate researchers**

Talent Strength

- **16 academicians**, including members of CAS, CAE, and international academies
- **220 recipients of major national and international talent awards**

Academic Excellence

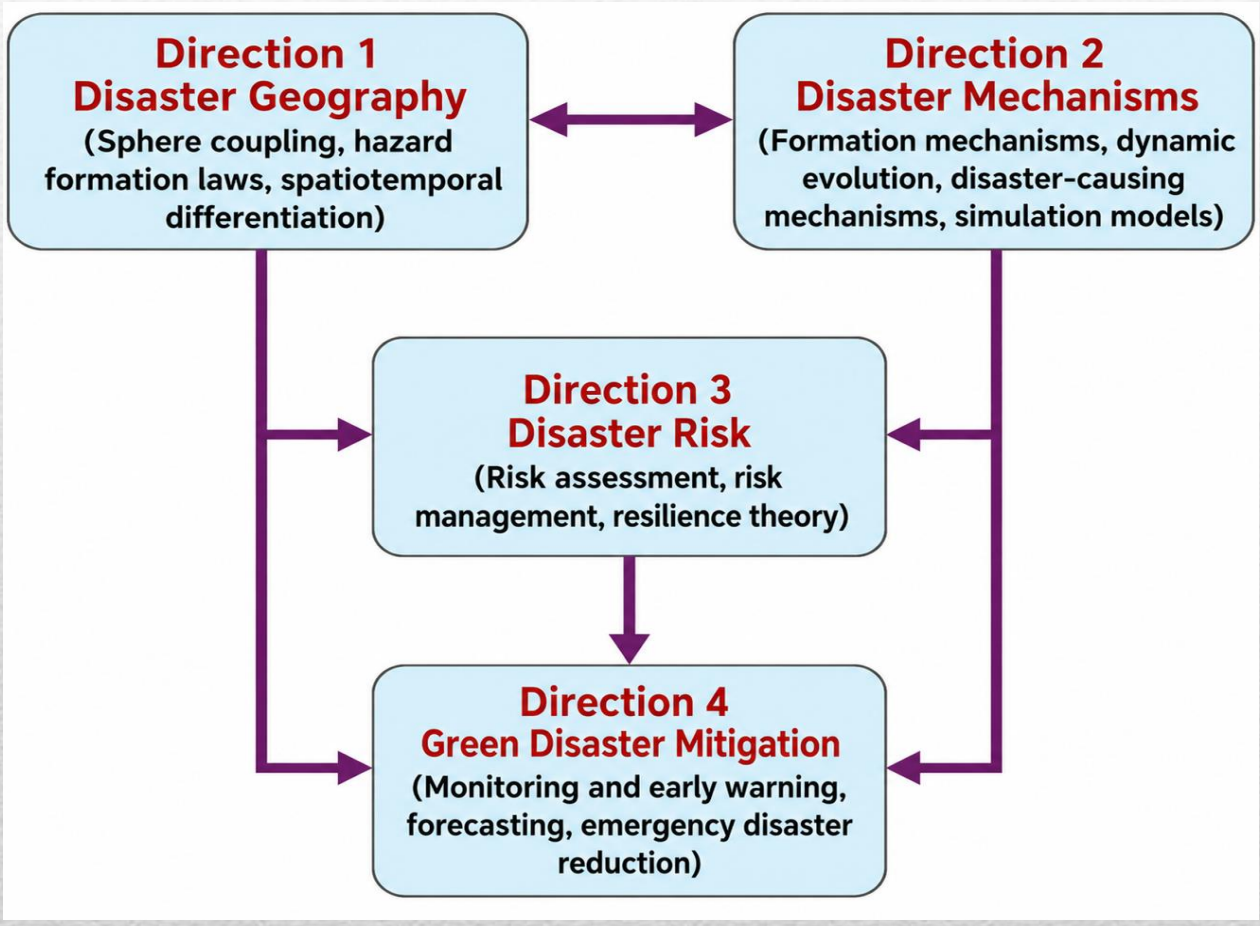
- Authorized to confer doctoral and master's degrees in multiple disciplines
- **Six disciplines ranked among the global top 1% in ESI**
- Geography ranked **No. 1 in China** and received an **A+ rating** in the national disciplinary evaluation

Research Strengths

Center for Natural Hazard Research:

- Multi-sphere Interactions
- Hazard Formation Laws
- Cascading Hazard Dynamics
- Hazard Tracking in Harsh Environments
- Multi-timescale Forecasting and Early Warning
- Dynamic Risk Assessment and Zoning
- Nature-based and Green Disaster Mitigation

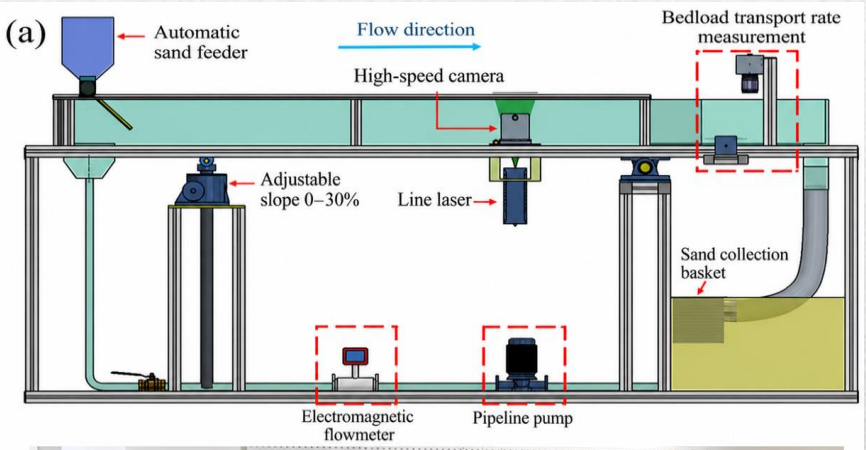
Integrated Capacity from Hazard Mechanisms to Risk Governance



Research Facilities and Platforms

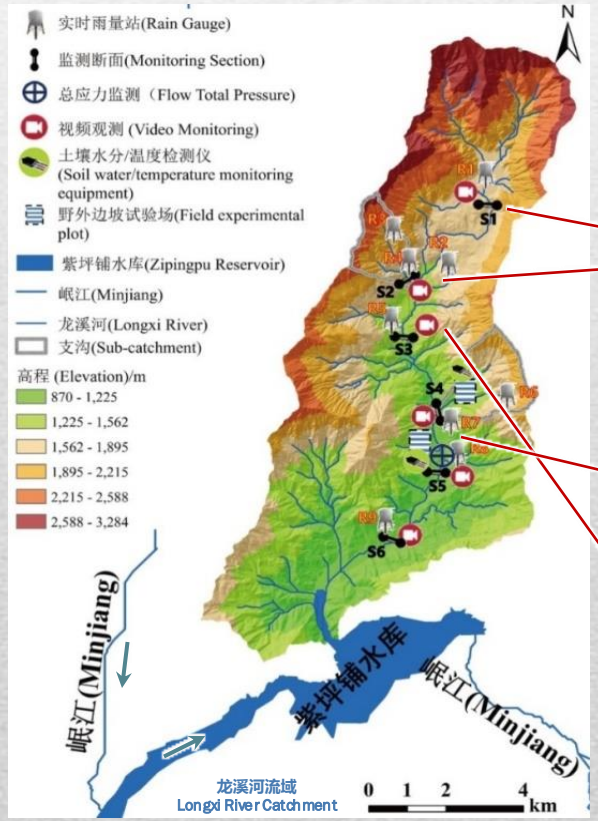
Indoor Laboratories, Beijing

Controlled flume experiments on sediment transport, erosion dynamics, and cascading hazard processes



Integrated Field Observation Network, Sichuan

Long-term, multi-scale monitoring of rainfall–runoff processes, soil and slope responses, sediment transport, and debris-flow evolution across the hillslope–channel–catchment continuum



Research Facilities and Platforms

Large-Scale Field Experimental Base, Nyingchi

Operated through a **“one base, multiple sites”** model, with approximately **5,000 m²** of space for observation, research, data processing, equipment storage, and logistical support.

Joint and Key Research Laboratories

Key Laboratory of Disaster-Chain Monitoring, Assessment and Risk Prevention, Ministry of Emergency Management

An interdisciplinary platform for disaster-chain monitoring, process simulation, risk assessment, early warning, and integrated prevention.

Joint Laboratory for Mountain Hazard Prevention and Disaster Risk Reduction

Jointly established by research institutes, universities, and government partners to advance collaborative research, talent development, and technological innovation in mountain hazard mitigation.

Research Team

Team Overview

Led by Prof. Peng Cui, the IGSNRR team integrates expertise in mountain hazards, climate risk, hydrology, geomorphology, risk modeling, and infrastructure resilience.

4 Professors: Senior scientists

5 Associate Professors: Research backbone

4 Assistant Researchers: Early-career researchers

8 Postdoctoral Researchers: Young research force

15 Doctoral students: Research training pipeline

Role	Member	Position / Title	Main Expertise
Co-Director / Lead Scientist	**Prof. Peng Cui**	Professor; CAS Academician	Mountain hazards; debris flows; landslides; disaster chains
Deputy Director	**Dr. Yan Wang**	Associate Professor; Doctor	Mountain meteorology; climate change; disaster effects
Core Member	**Prof. Yunhe Yin**	Professor; Doctor	Climate change risks; disaster risk management; adaptation
Core Member	**Dr. Guotao Zhang**	Associate Professor; Doctor	Mountain hydrology; flash floods; debris-flow warning
Core Member	**Dr. Chendi Zhang**	Assistant Researcher; Doctor	Flash flood mechanisms; fluvial geomorphology; sediment transport
Core Member	**Dr. Jian Guo**	Assistant Researcher; Doctor	Landslides; debris flows; disaster-chain risk
Core Member	**Dr. Yaqiao Wu**	Postdoctoral Researcher; Doctor	Disaster risk modeling; infrastructure resilience; cascading risks

Mechanism Research → Monitoring & Forecasting → Risk Assessment → Early Warning → Resilient Mitigation & Governance

Research Team

Core Member

Peng Cui

- CAS Academician
- Foreign Fellow, Pakistan Academy of Sciences
- UNESCO Chair on Mountain Disaster Risk Reduction and Resilience
- Recipient of Pakistan's Sitara-e-Imtiaz
- 2023 EGU Sergey Soloviev Medal
- 400+ SCI papers and 12 monographs
- 16 granted invention patents
- Leader in mountain-hazard science and disaster risk reduction

Yunhe Yin

- 100+ papers
- 20+ major researchprojects
- Global Top 2% Scientist

Yan Wang

- CAST Young Talent
- 30+ papers
- 1800+ citations

Guotao Zhang

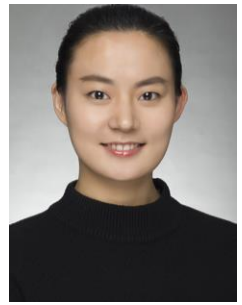
- IRDR Young Scientist
- 19 first/corr. papers
- National hazard standard

Chendi Zhang

- Flash-flood co-authored studies
- Mountain-river process work
- Hazard mitigation studies

Jian Guo

- IMPACT Lab member
- Disaster-chain studies
- Mountain risk control work



Yaqiao Wu

- Natural Hazards PhD
- Infrastructure resilience studies
- Cascading-risk assessment

Ongoing Research Projects

Major National and Strategic Projects

- Compound disaster-chain mechanisms, forecasting and risk prevention
- Hazard-triggering meteorological factors and early-warning thresholds in high-mountain regions
- Key risk-source identification for complex mountainous environments
- Natural-disaster risk survey, assessment and integrated prevention
- … …

Funded Research Projects

- Compound heat–drought extremes and cascading risk impacts
- Ice–snow disaster-chain formation mechanisms and quantitative risk assessment
- Climate resilience and disaster-risk modelling under changing environments
- Nature-based mitigation technologies for mountain torrents and debris-flow hazards
- … …

Service-Oriented Disaster Reduction Projects

- Monitoring and early-warning systems for snow avalanche hazards
- Flash-flood and debris-flow monitoring, forecasting and risk prevention
- High-resolution meteorological forecasting for complex mountainous regions
- Decision-support services for disaster prevention, emergency management and engineering safety
- … …

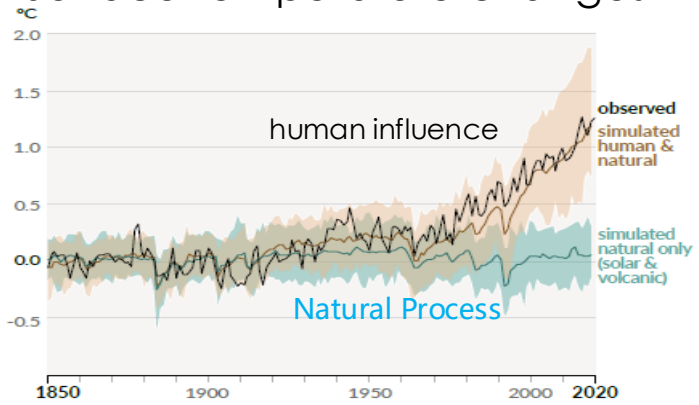
From mechanism research to early warning and practical disaster-reduction services

Acheivements

1. **Climate Change-Induced Hazard Evolution and Risk Prevention in High-Altitude Cold Regions**
   - Climate Change Is Modifying Mountain Hazard Environments
   - Climate Change Reshapes Multi-Sphere Coupling and Disaster Evolution
   - Climate Change Amplifies Cascading Disaster Risk
2. **Data–Physics Dual-Driven Simulation and Early Warning System for Flash Floods / Debris Flows**
   - Early Warning System Design
   - Full Process Simulation
   - Model integration
   - Mountain hazard risk numerical simulation monitoring platform

Human activity

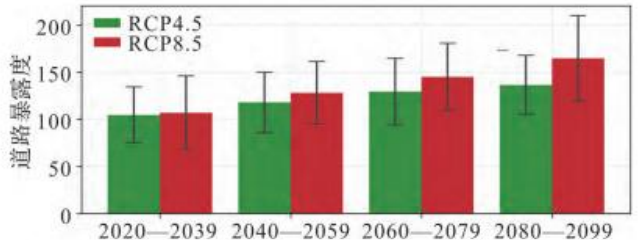
Surface temperature changes



(*IPCC 2021*)

Hazard level increase with extreme climate event

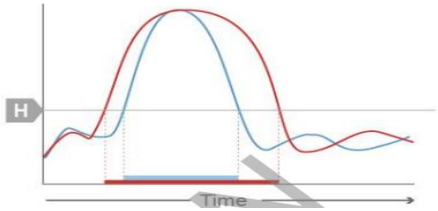
Vulnerability increases with urbanization



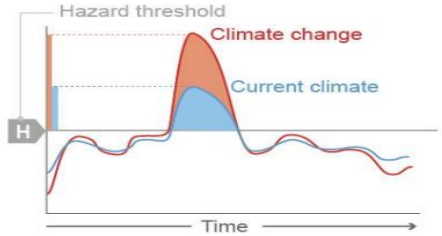
Exposure increases with globalization

New feature of disasters

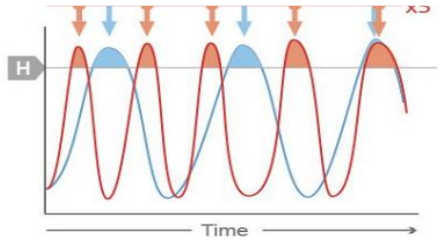
- Longer Duration



- Larger Intensity and scale



- Higher Frequency



No Climate Change

Climate Change

Drivers → **Disaster risk trend** (*IPCC 2021*)

Climate change is leading to an increasing trend in global disaster risks.

◆ Climate Change Is Modifying Mountain Hazard Environments

□ Increased Water and Moisture Supply

- Greater atmospheric moisture under warming
- More intense rainfall and enhanced runoff
- More meltwater from snow, ice, and permafrost thaw

□ More Unstable Material Sources

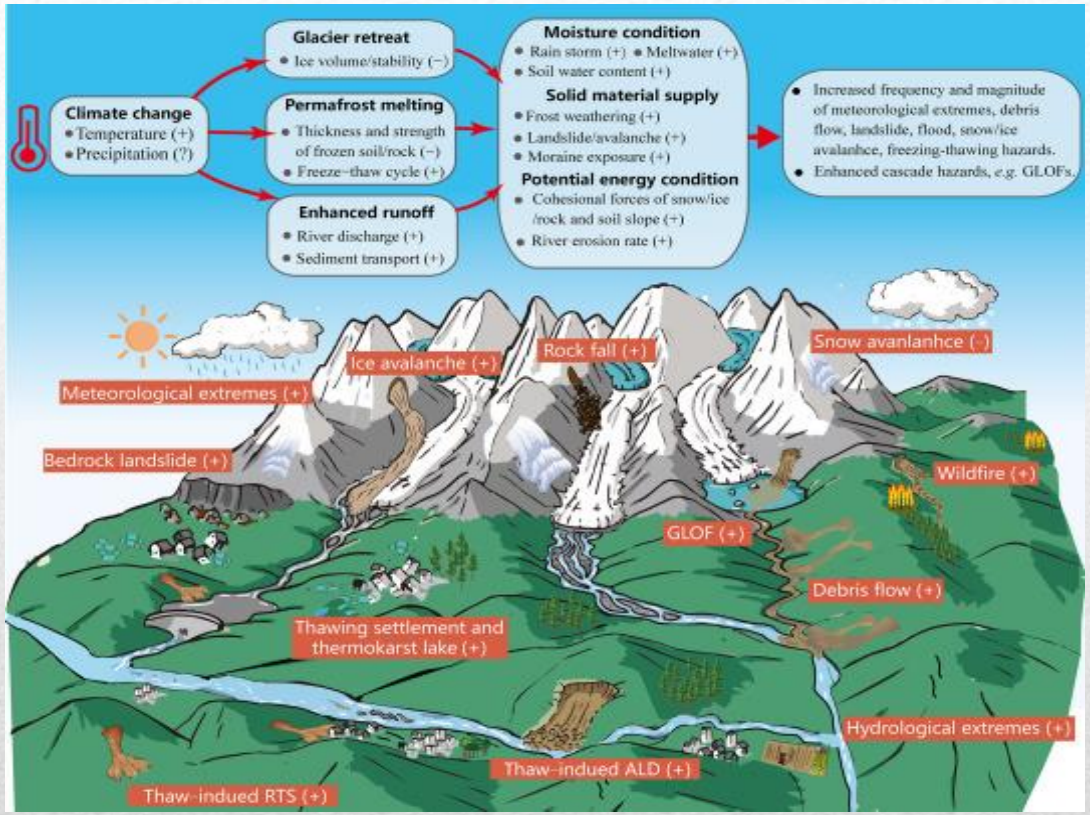
- More aerosols and condensation nuclei in rain–snow processes
- Stronger weathering and increasing loose materials
- Permafrost degradation reducing slope and soil stability

□ Stronger Energy and Dynamic Conditions

- Glacier retreat and destabilization increasing potential energy release
- Extreme runoff increasing erosion and relief-driven instability
- Ocean and local convection providing more energy for storms

□ Stronger Coupling of Hazard Drivers

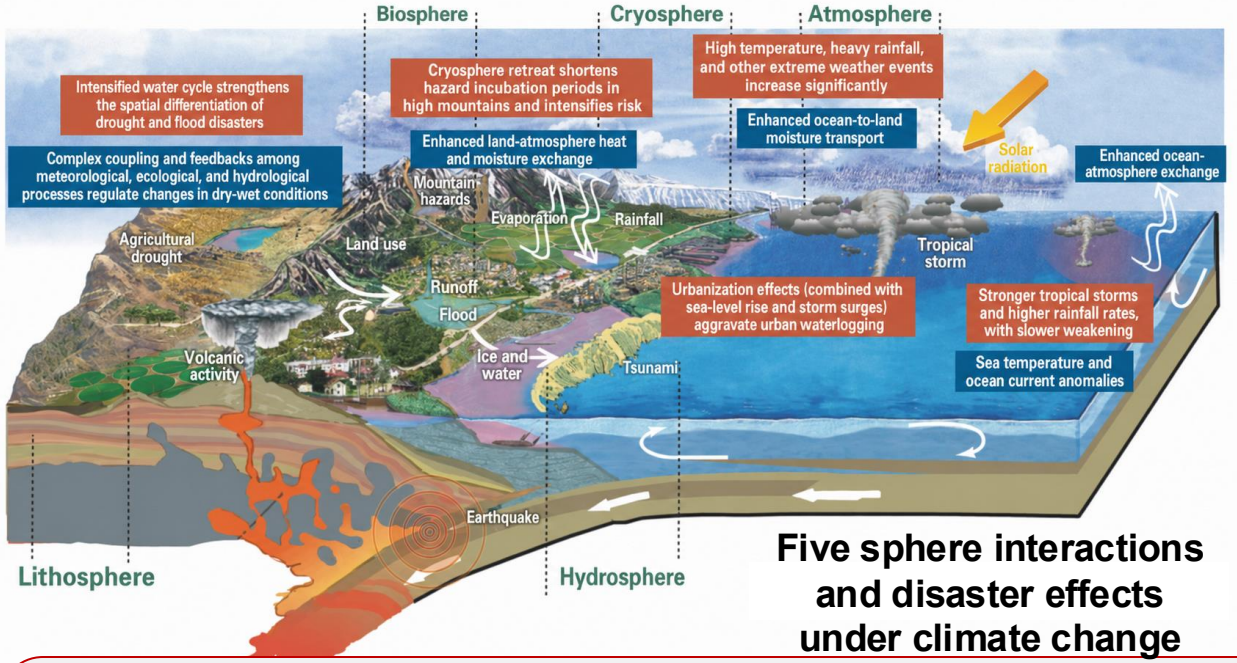
- Stronger climate–terrain–hydrology interactions
- Higher probability of rain–heat synchronization and compound hazards



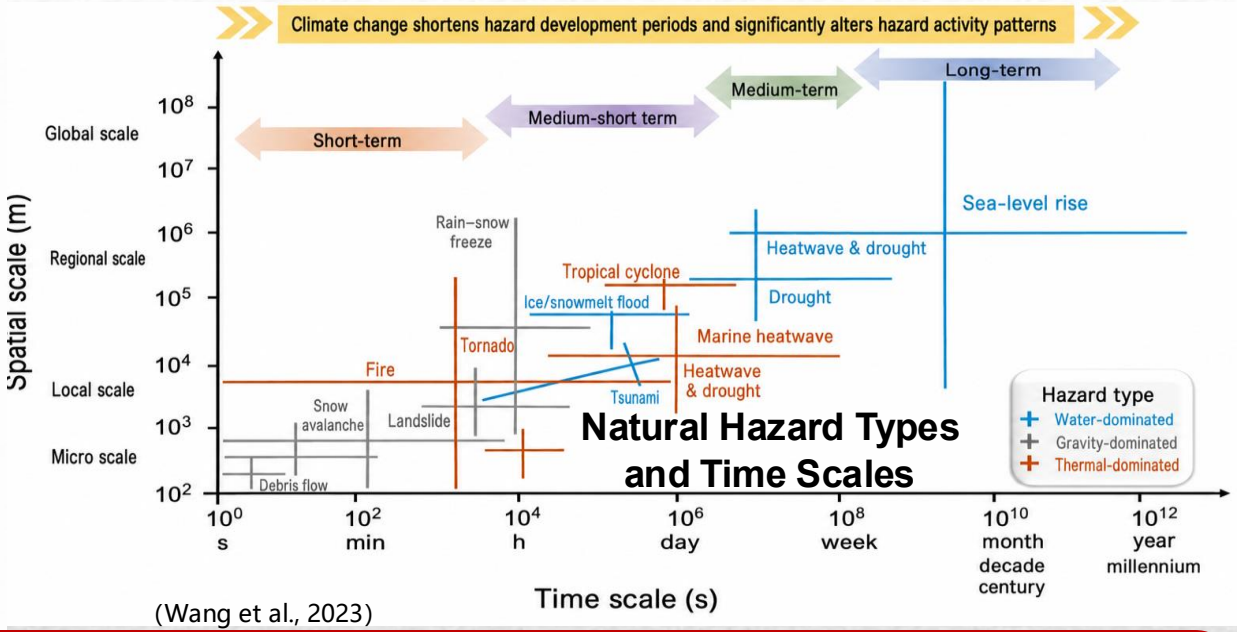
(Jana Eichel et al., 2023; Wang et al., 2023)

Shorter hazard cycles, more hazard-prone environments, and higher mountain disaster risks.

◆ Climate Change Reshapes Multi-Sphere Coupling and Disaster Evolution



Five sphere interactions and disaster effects under climate change

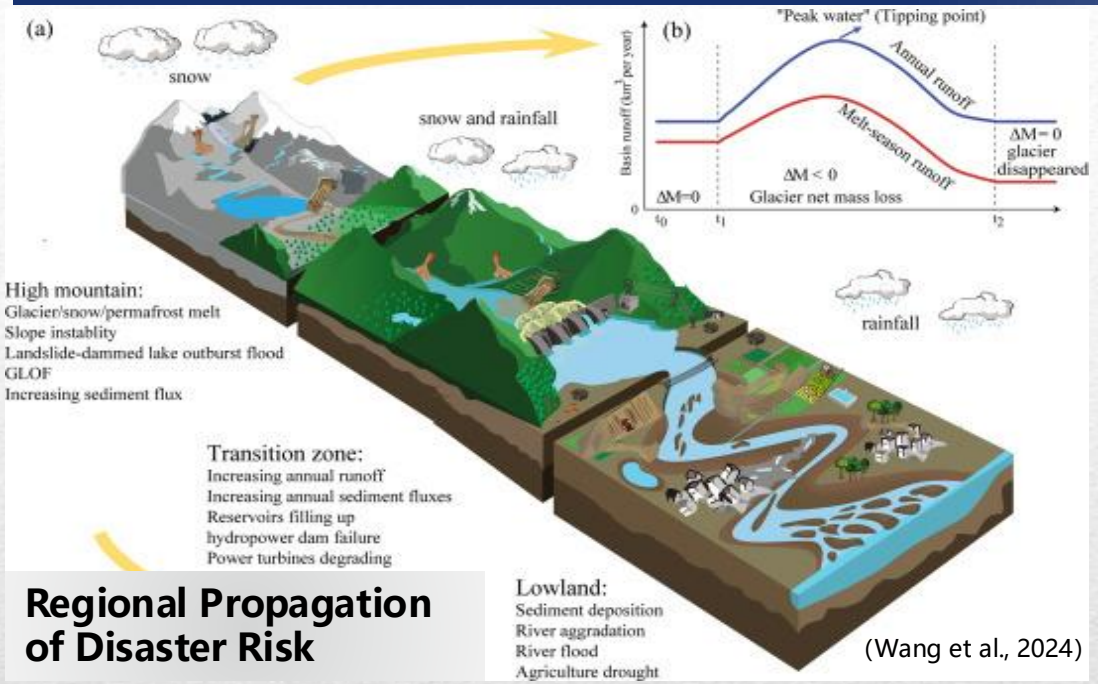


(Wang et al., 2023)

Climate change intensifies multi-sphere coupling and reshapes disaster intensity, frequency, timing, and spatial extent.

- **Increasing intensity and frequency:** Stronger heatwaves, heavy rainfall, floods, and storm surges.
- **Changing duration and timing:** Longer heatwaves/droughts; shifted frost, rainfall, snowmelt, and flood timing.
- **Expanding spatial extent and scale:** Wider marine heatwaves, cyclones, rainstorms, and flood impacts.
- **Increasing compound and cascading risks:** More mega-disasters, compound events, and cascading disaster chains.

◆ Climate Change Amplifies Cascading Disaster Risk



Regional Propagation of Disaster Risk

(Wang et al., 2024)

Climate Change Transforms Isolated Hazards into Cascading Disaster Chains, Amplifying Systemic Risk

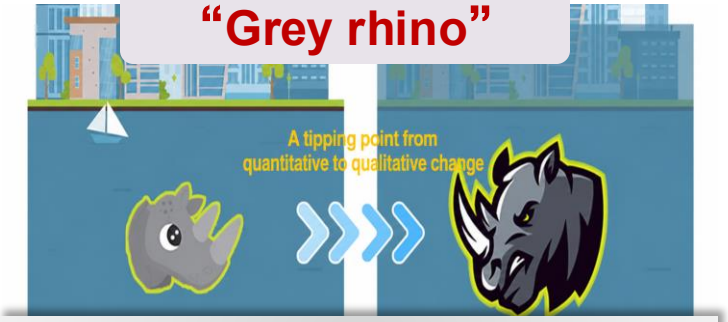
How do we prepare for what we don't see coming?

"Black swan"

Information Gaps

Why do we ignore the big threats we already know?

"Grey rhino"



Known but Underestimated Risks

How do small things escalate?

"Butterfly effect"

Complex Propagation Mechanisms
Unpredictable Hazard Evolution

Acheivements

1. Climate Change-Induced Hazard Evolution and Risk Prevention in High-Altitude Cold Regions
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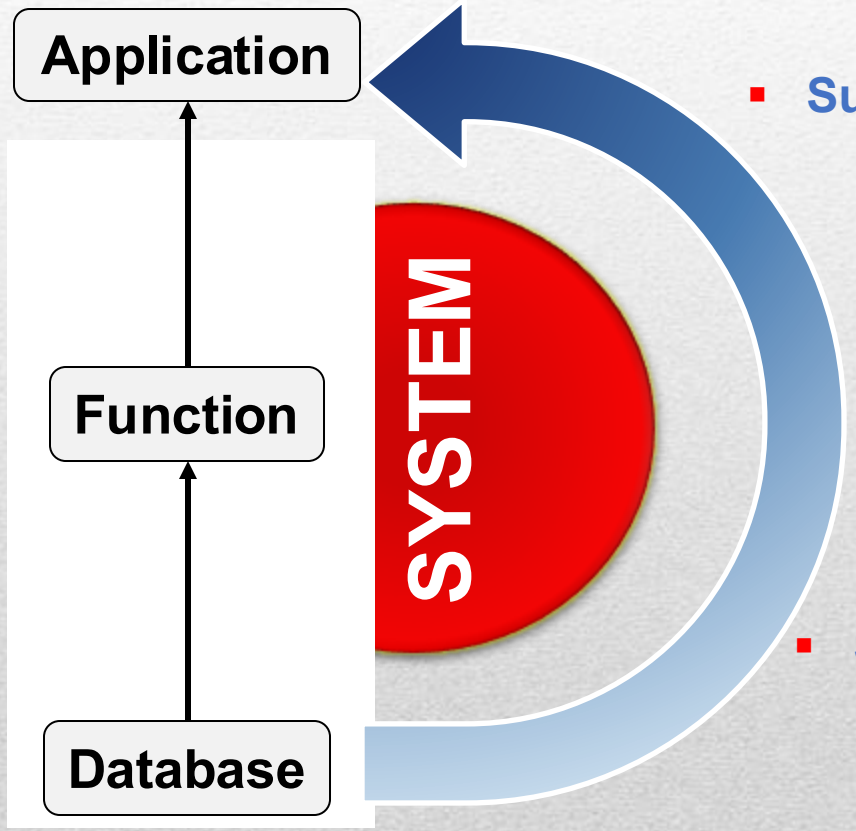
   - Full Process Simulation
   - Model integration
   - Mountain hazard risk numerical simulation monitoring platform

◆ Early Warning System Design



- **Sub5:** Risk Warning SYS
  - Risk assessment
  - Risk mapping

→ Forecast to serve different purposes

- **Sub4:** Hazard Process SYS
  - Kinetics index
  - Hazard property
  - Process simulation

→ Process simulation and dynamic risk assessment (Physically-based)

- **Sub3:** Hydro SYS
  - Hydro zone
  - Runoff and flood

→ Hydrological processes and soil mechanics

- **Sub2:** Weather SYS
  - Real time
  - Forecast

→ Real-time weather forecast (climate change and terrain effects)

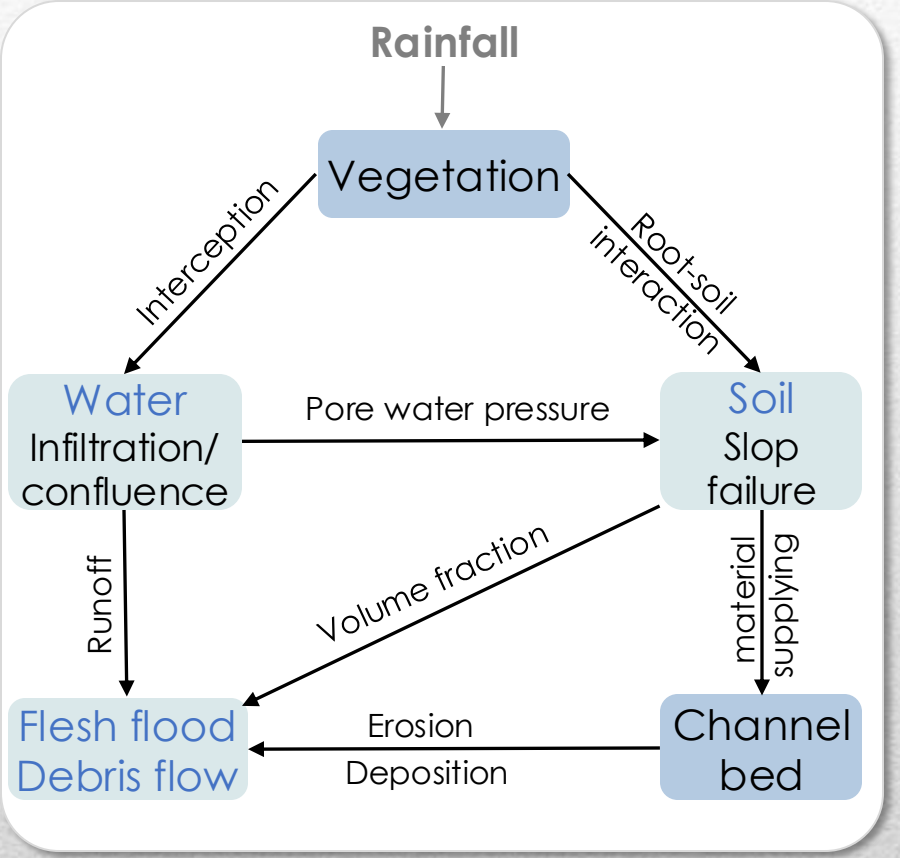
- **Sub1:** Database SYS
  - Environmental background
  - Physical parameter

→ Disaster fostering factors and parameter database

Full Process Simulation

A comprehensive simulation to describe Rainfall → Water-soil coupling → Hazard Formation → Movement → Deposition processes has been developed.

Multi-physical processes



Solid-Fluid interaction model

- Solid-Fluid process

$$\frac{\partial hv}{\partial t}+\frac{\partial huv}{\partial x}+\frac{\partial hvv}{\partial y}=-gh\frac{\partial(h+z_{1bot})}{\partial y}-\frac{(\rho_s-\rho_w)gh^2}{2\rho}\frac{\partial c}{\partial y}-\frac{(\rho_2-\rho)(E-D)v}{\rho(1-p)}$$
$$-\frac{\tau_{1zybot}}{\rho}+\frac{\rho_2 v(z_b)}{\rho}\frac{E-D}{1-p}$$ Momentum

- Evolution of solid-phase volume fraction

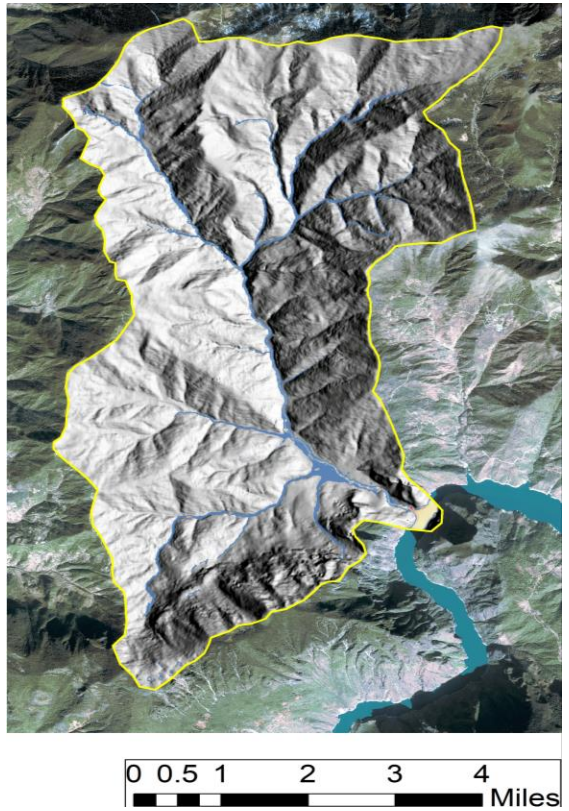
$$\frac{\partial hc}{\partial t}+\frac{\partial huc}{\partial x}+\frac{\partial hvc}{\partial y}=E-D$$ (erosion and deposition)

- Solid-Fluid resistance

$$\tau_b=\max\left[\tau_y+\frac{K\mu V}{8h}+\frac{\rho g n_{td}^2 V^2}{h^{1/3}}, c\tau_{bs}+(1-c)\tau_{bf}\right]$$

Solid Fluid

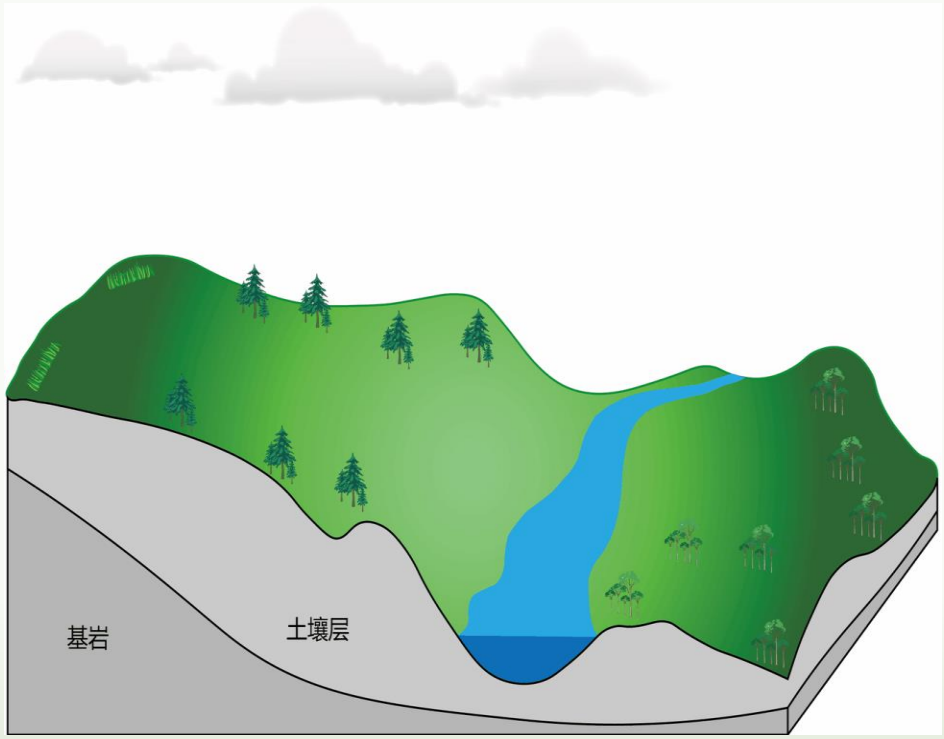
Full process simulation



Establishing the physical-based model and simulating the complex process in small watersheds address the key challenge to **process-based disaster risk forecasting**!

◆ Model integration

A physically based model system integrates disaster formation, initiation, movement, and risk-warning processes.



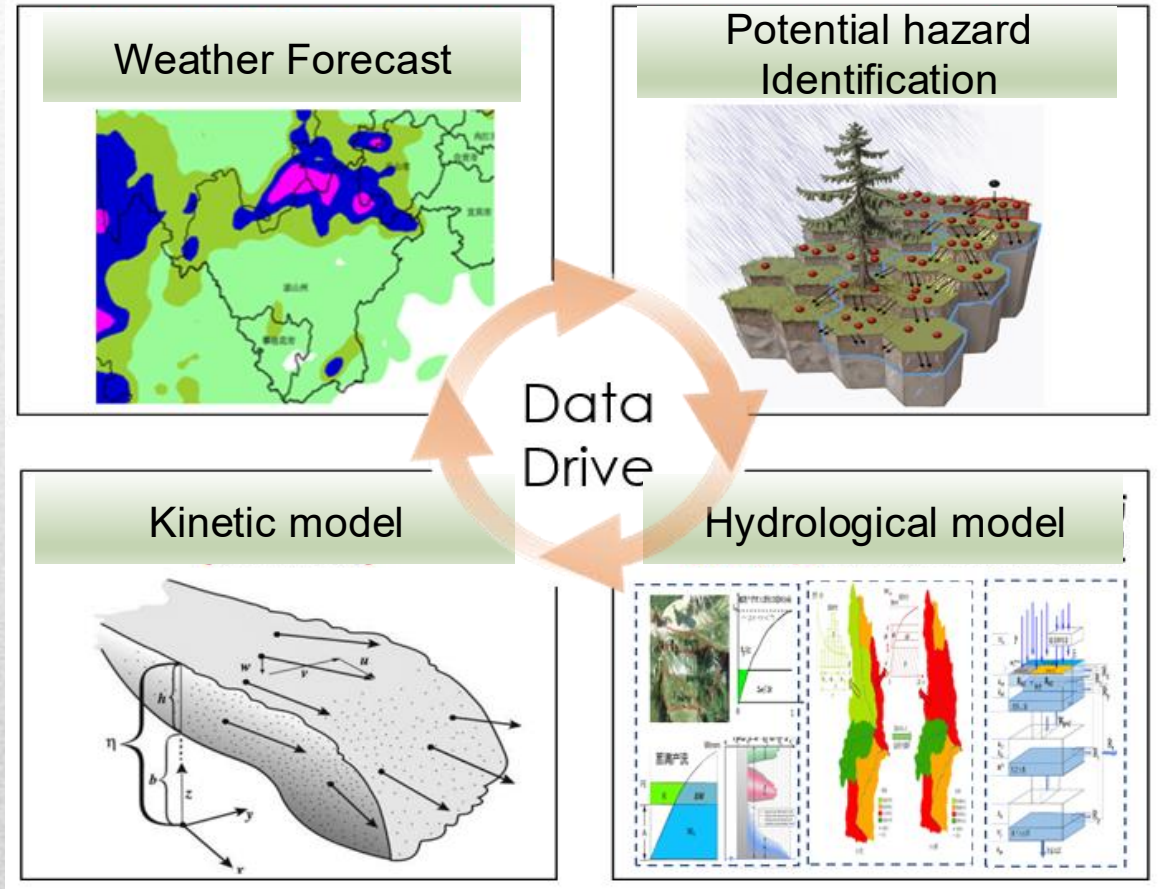
The hazard process

Rain drive

Slope Failure

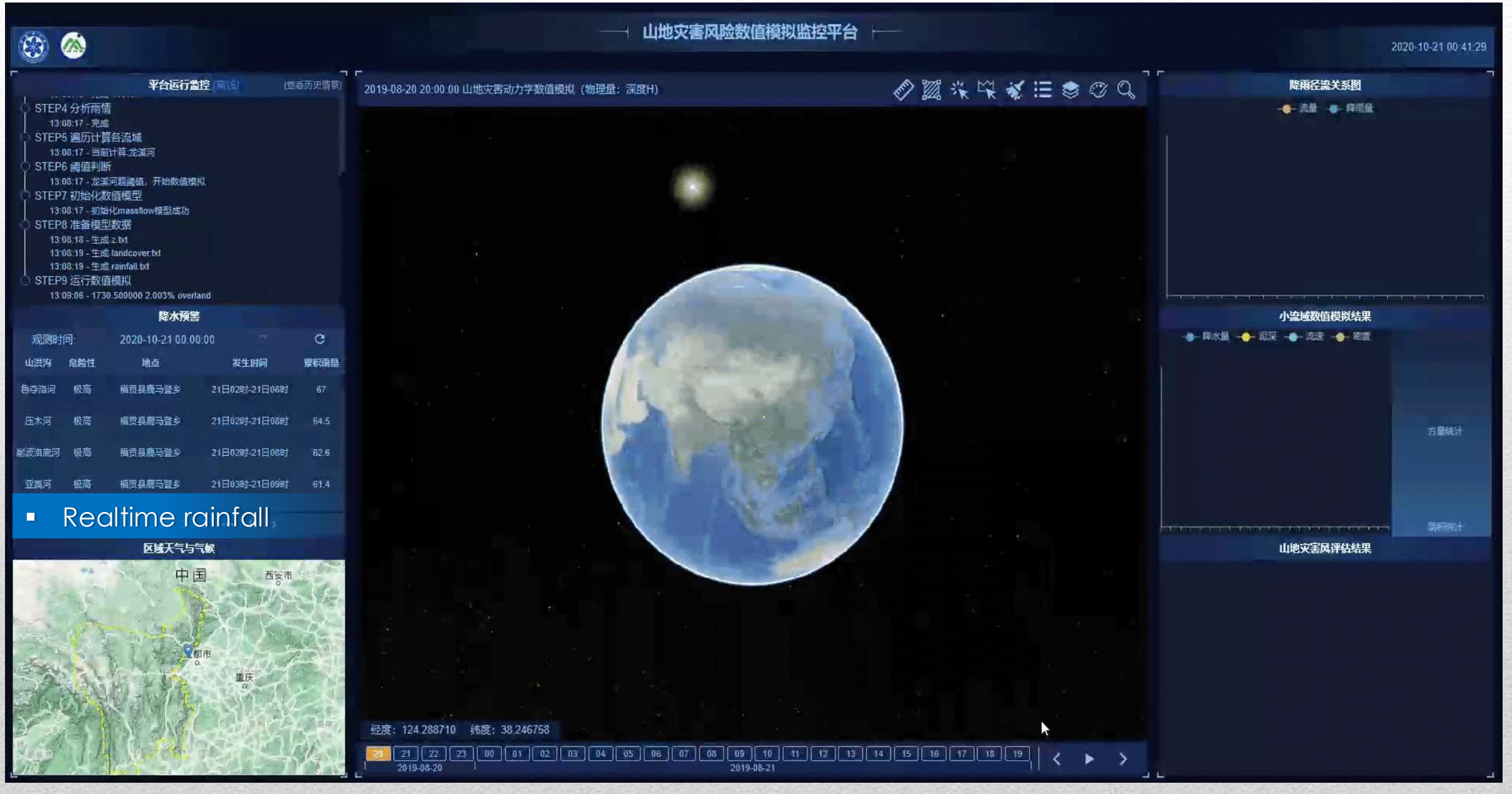
Water/ Soil

Movem ent



Real-time Weather forecast→ Hydrological Model→ Slope Failure → Hazard formation→ Movement→ Risk Warning

◆ Mountain hazard risk numerical simulation monitoring platform



- Realtime rainfall

System Advantages

From threshold-based to process-based system; from hazard prediction to risk forecasting

Existing Warning System	VS	RWS
Threshold-Based		**Process-Based**
Regional prediction: ■ Accurate Location: NO ■ Hazard Process: NO ■ Risk Forecasting: NO		Regional prediction: ■ Accurate Location: YES ■ Hazard Process: YES ■ Risk Forecasting: YES
Early Warning: ■ Accurate Location: YES ■ Ground-based instrument relied : YES ■ Risk information: NO ■ Pre-known location: YES		Early Warning: ■ Accurate Location: YES ■ Ground-based instrument relied : NO ■ Risk information: YES ■ Pre-known location: NO

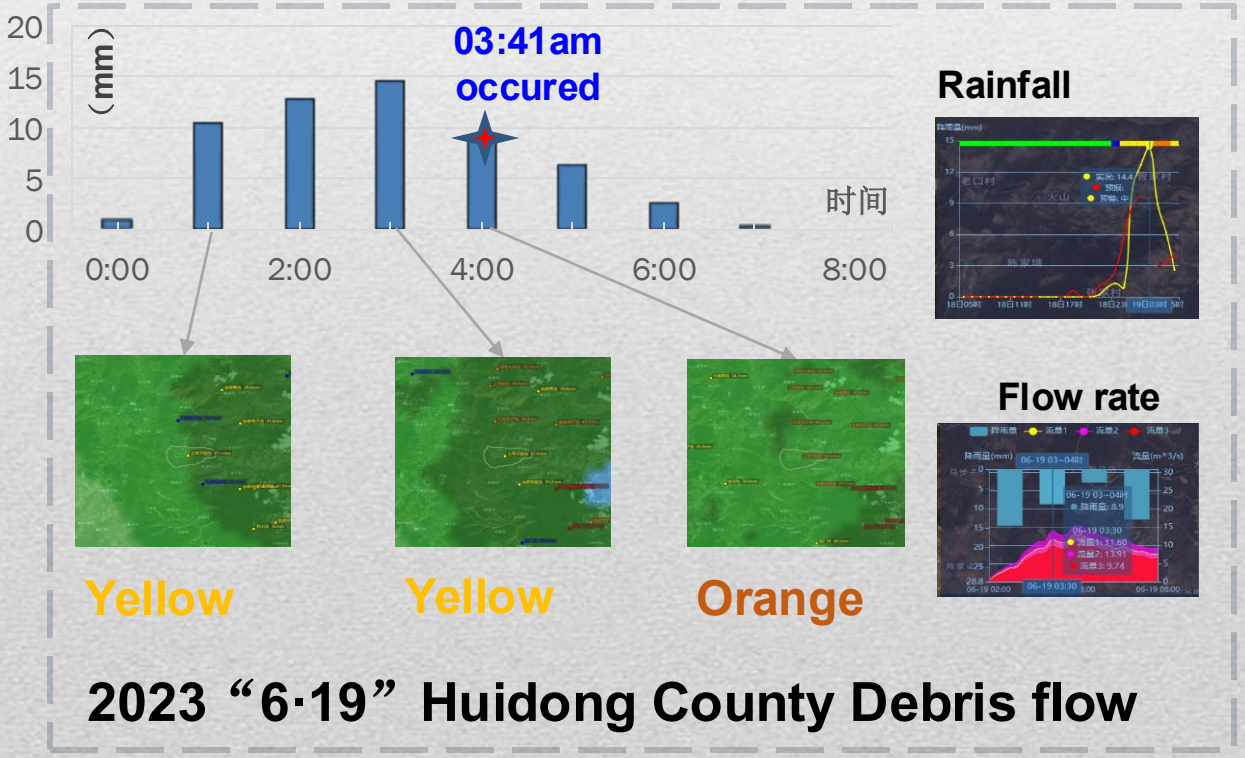
Disasters captured since 2022

Debris Flow

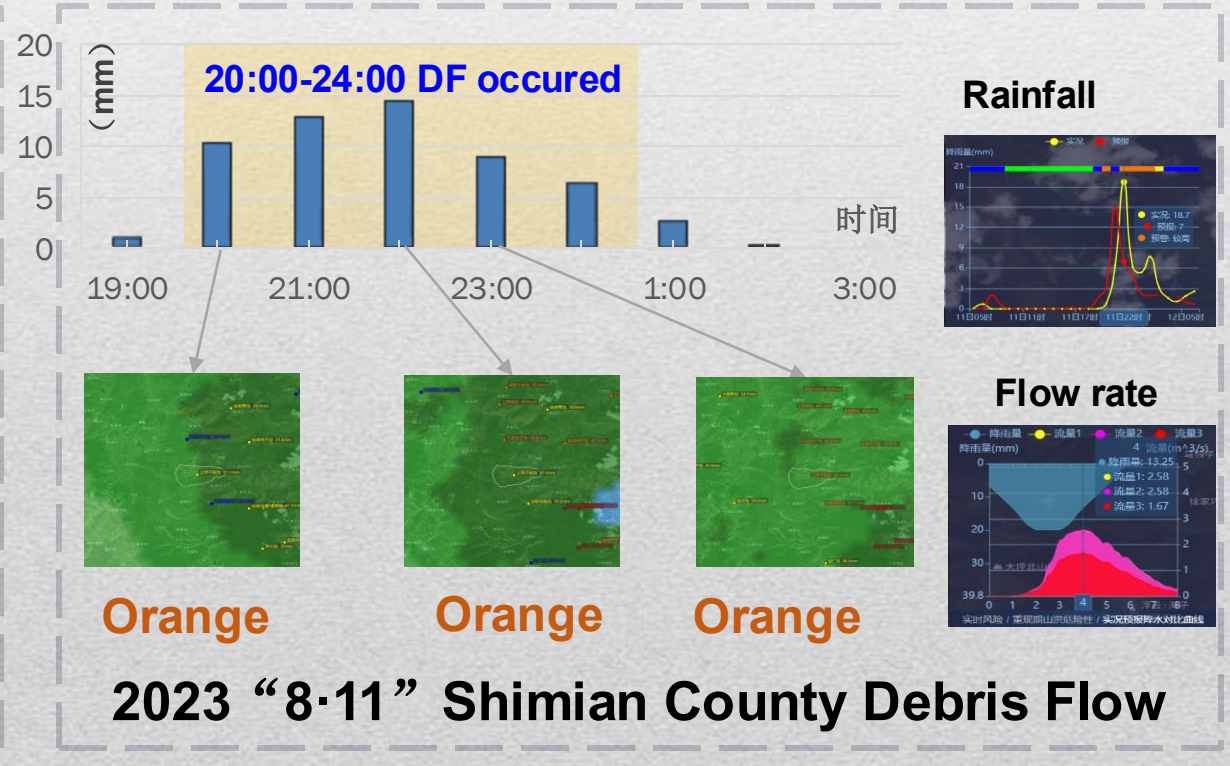
- **27** debris flow events in Liangshan Prefecture were captured;
- **21** successful early warnings were issued, with an accuracy rate of **77.8%;**
- nearly **7,000** casualties were prevented.

Flash flood

- **86** flash flood events in Liangshan Prefecture were captured;
- **63** successful early warnings were issued, with an accuracy rate **of 73.83%;**
- nearly **30,000** casualties were prevented.



2023 “6·19” Huidong County Debris flow



2023 “8·11” Shimian County Debris Flow

Potential Contributions to ICEIDR

Potential Contributions

01
Academic and Personnel Exchanges

Reciprocal visits, conferences, and workshops

02
Collaborative Research

Joint projects and funding applications

03
Joint Graduate Training

Co-supervision and student exchanges

04
Research Platform Sharing

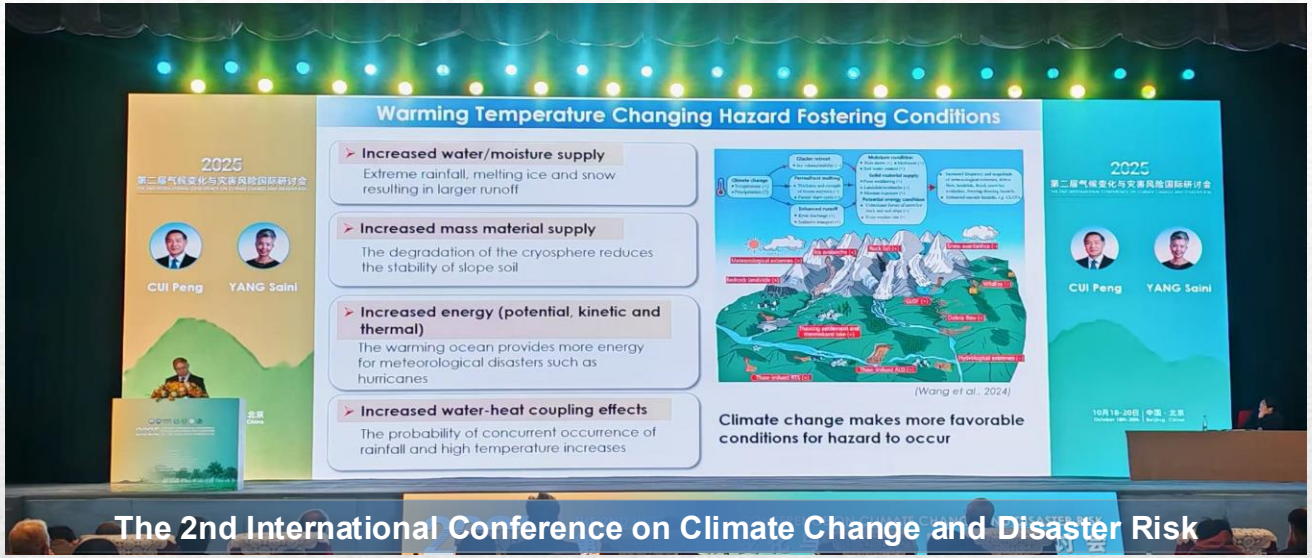
Field sites, laboratories, data, and tools

05
International Research Initiatives

Bilateral and multilateral research programs

Academic and Personnel Exchanges

ANSO-DRR Steering Committee Meeting, Beijing (2025)



The 2nd International Conference on Climate Change and Disaster Risk

2nd Pakistan–China Symposium on Early Warning for Hydrological and Geological Disasters

Key Modes of Collaboration

- Joint academic exchange with partner institutions
- Reciprocal visits and researcher interaction
- Co-organization of international conferences and workshops

Collaborative Research

The Center advances collaborative research through joint laboratories, bilateral projects, and international funding programs.

China–Italy Joint Laboratory

Partner: CNR IRPI, Italy

Channel: Governmental cooperation project

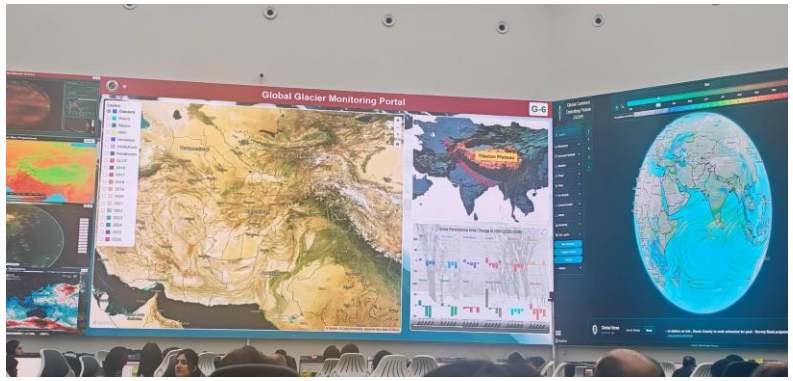
Focus: High-mountain disaster chains and risk management

China–Pakistan Joint Research Center

Partner: Quaid-i-Azam University

Channel: CAS international cooperation program

Focus: Hydrological and geological disaster early warning



China–Serbia Cooperation Project

Partner: Jovan Cvijić Institute, SASA

Channel: International exchange project

Focus: Disaster risk prevention and socio-ecological resilience

Future Collaboration Opportunities

Joint Training

Co-supervision of graduate students and visiting scholars

Short-term exchanges, workshops, and academic mentoring

Platform Sharing

Shared access to field sites, laboratories, data, and analytical tools

Support for collaborative experiments, monitoring, and capacity building

Collaborative Initiatives

Joint proposals for bilateral and multilateral research programs

Coordinated studies on disaster risk, early warning, and climate resilience

Building a long-term partnership through joint talent development, shared research resources, and collaborative innovation.

中国科学院地理科学与资源研究所
Institute of Geographic Sciences and Natural Resources Research, CAS

Jointly promote international collaborative research projects!

Thank you!

Center for Natural Hazard Research
Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences