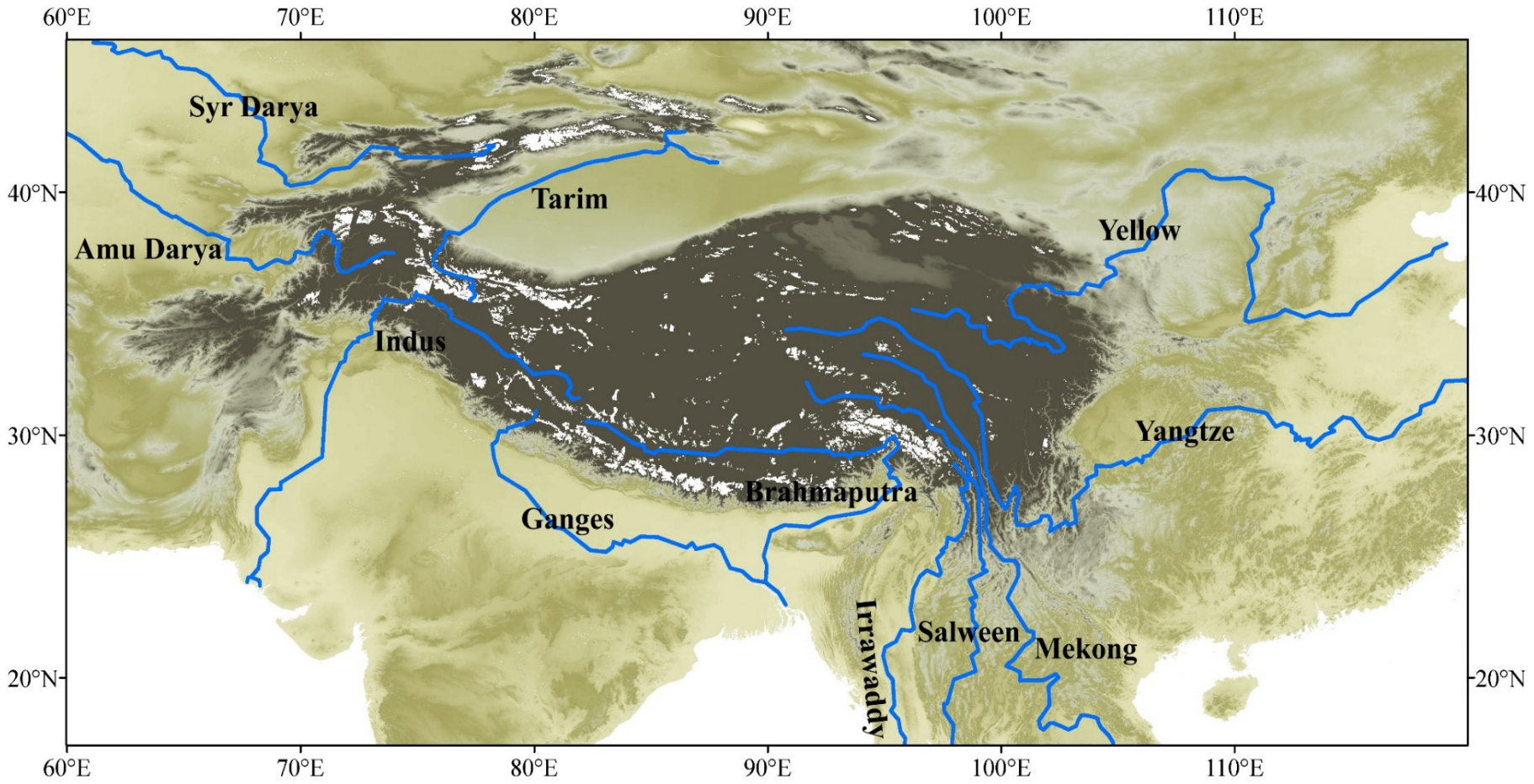
# Third Pole Glacier Melt and Earth System Adaptation (TPGE)

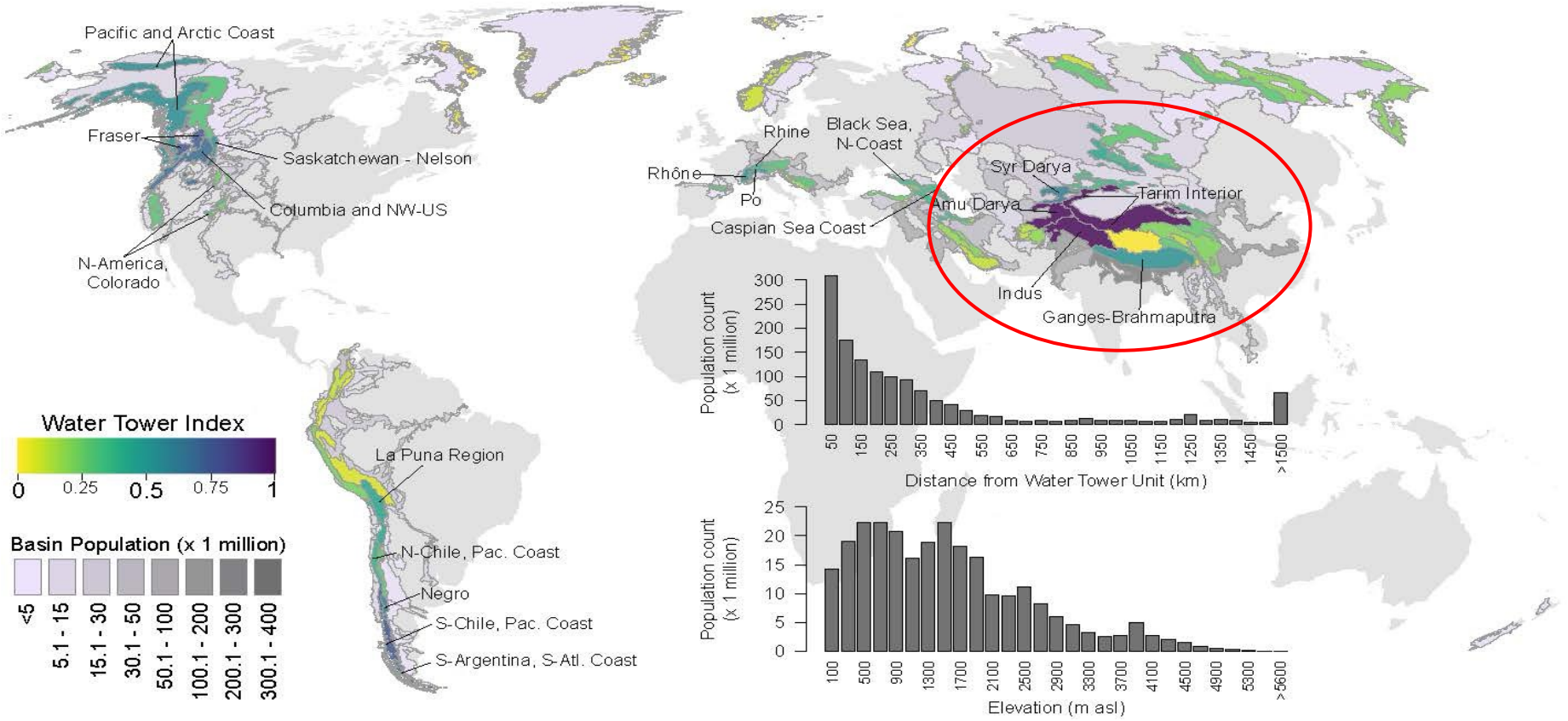
Tandong Yao
Third Pole Environment (TPE) program

# Tibetan Plateau and its surroundings, also called as Third Pole or Asian Water Tower, accommodate the largest ice mass outside polar regions



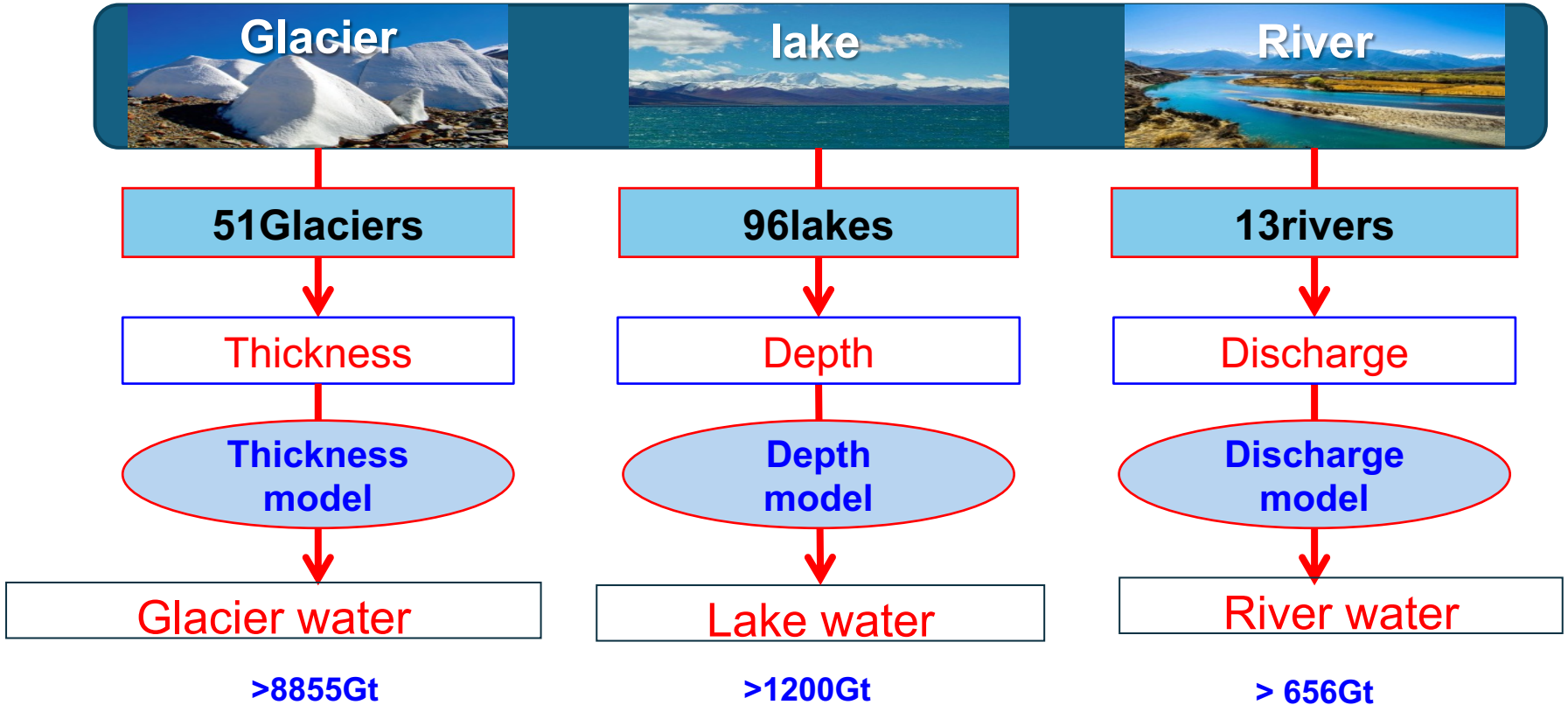

The Asian Water Tower is the origins of tens of major Asian rivers

# The Asian Water Tower is most important water tower in the world



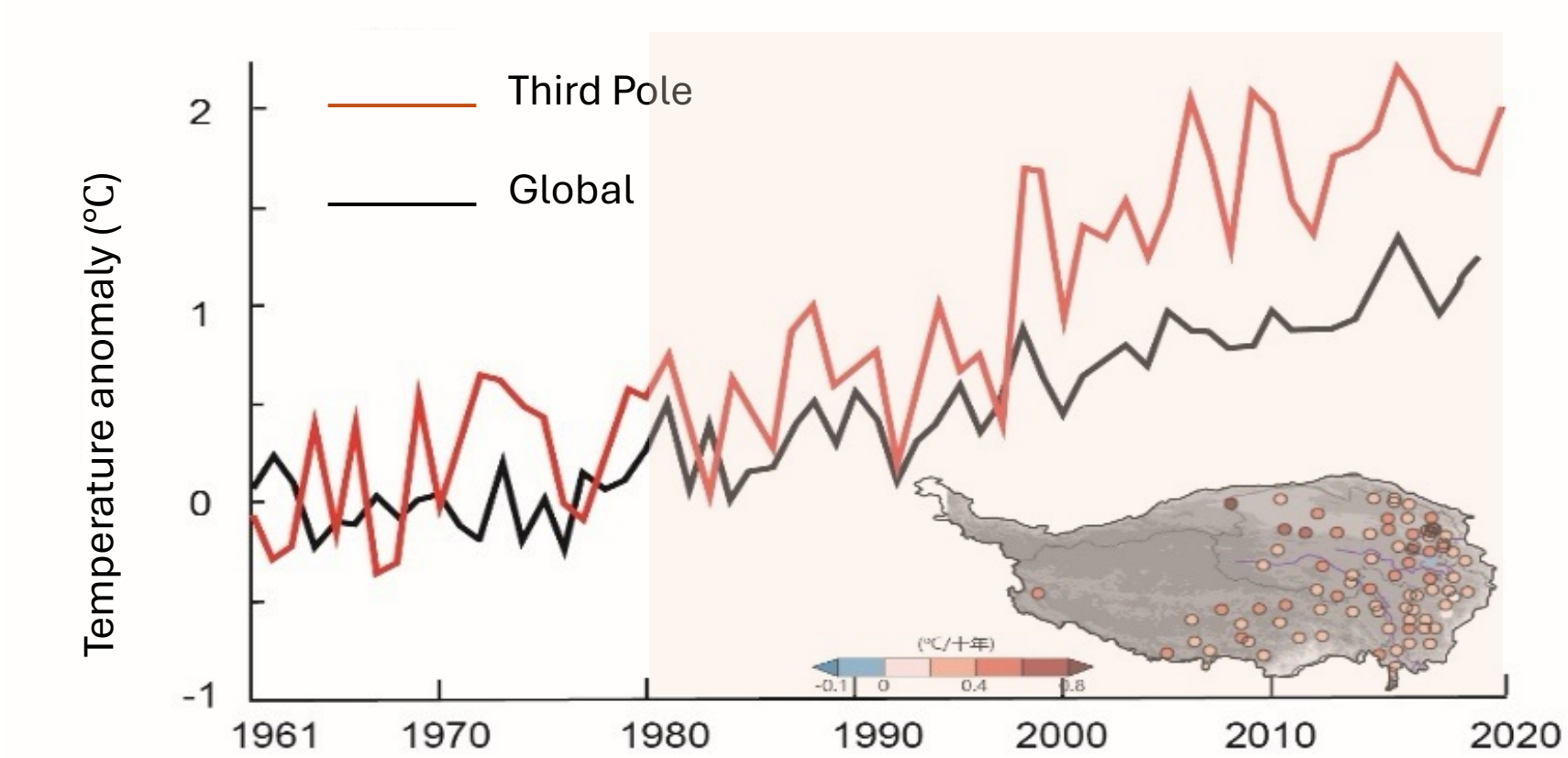

Among 78 water towers in the world, the most important water tower is the Asian Water Tower since it provides water resources for 2-3 billon people on the earth.

# Asian Water Tower stores huge water for the downstream rivers



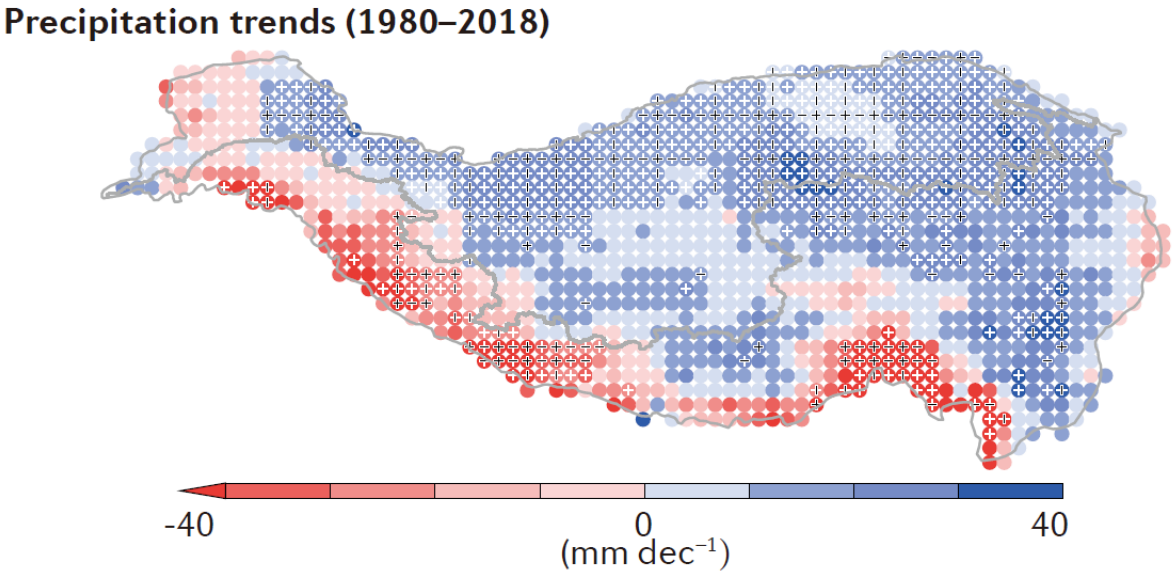

**Totally >10,000Gt, which is more than 200 year's annual discharge of the Yellow River**

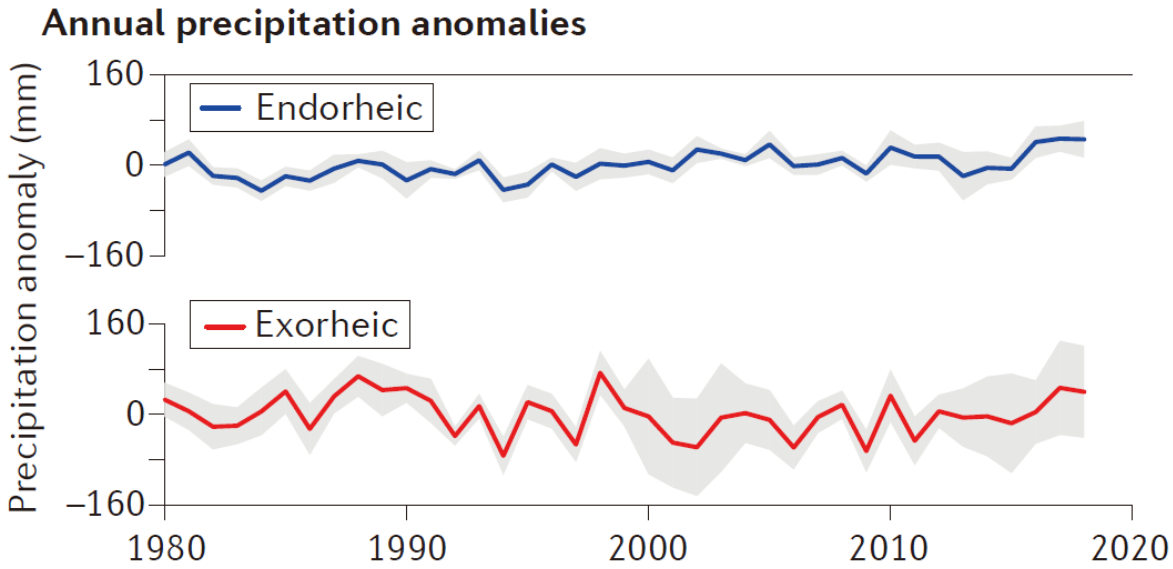
# Warming in the Asian Water Tower




Warming rate of 0.37ºC per decade during 1960–2020 and accelerate to 0.42ºC per decade during 1980–2020, almost doubling the global average (0.19ºC per decade )

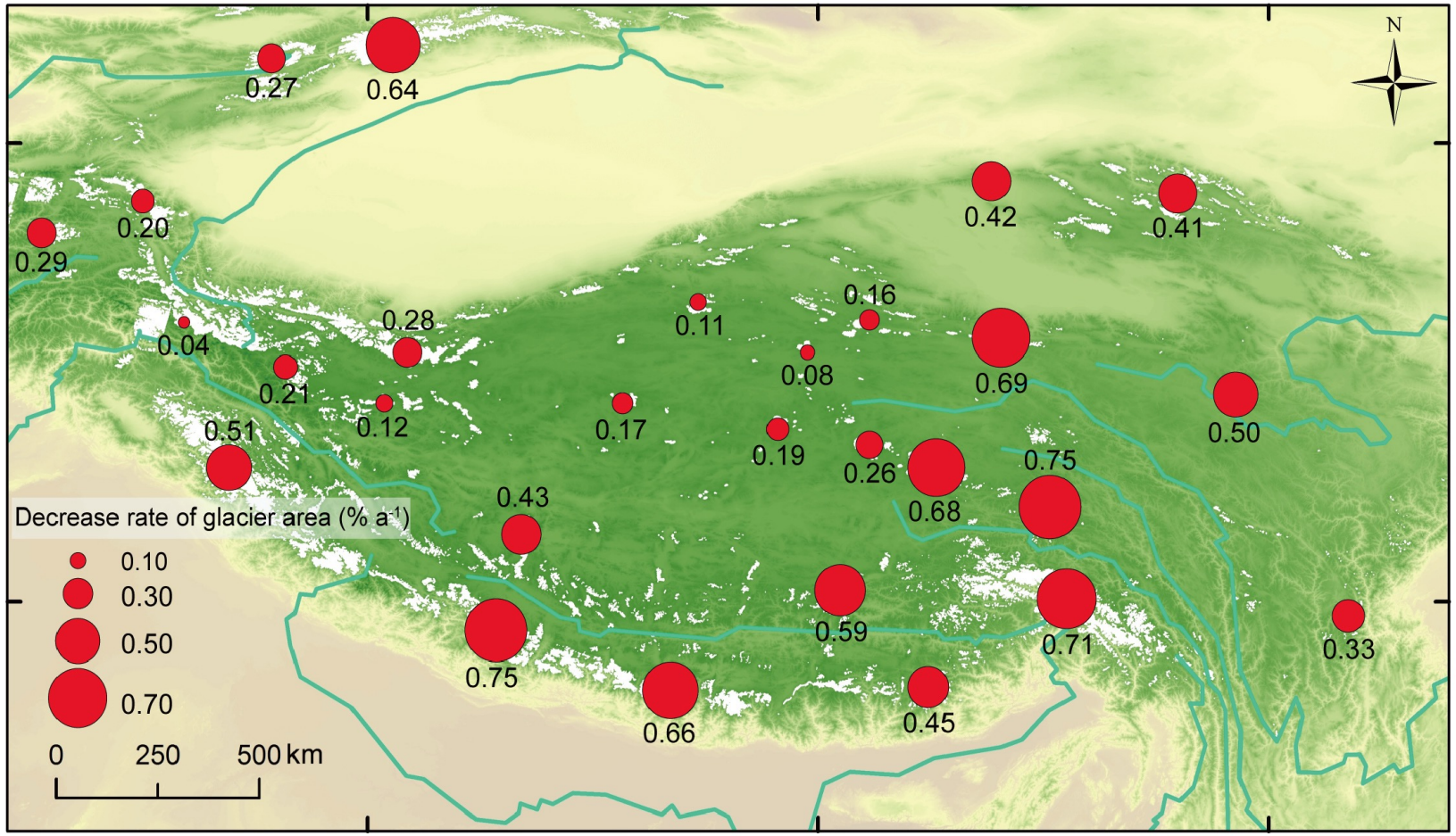
# A north–south dipole pattern in precipitation trends




Substantial precipitation increases have been observed in both the endorheic basins of the northern AWT and the exorheic basins of the northern AWT. By contrast, the exorheic basins of the southern AWT exhibited a statistically significant decrease in annual precipitation over the same period.

# Glacier area has substantially decreased

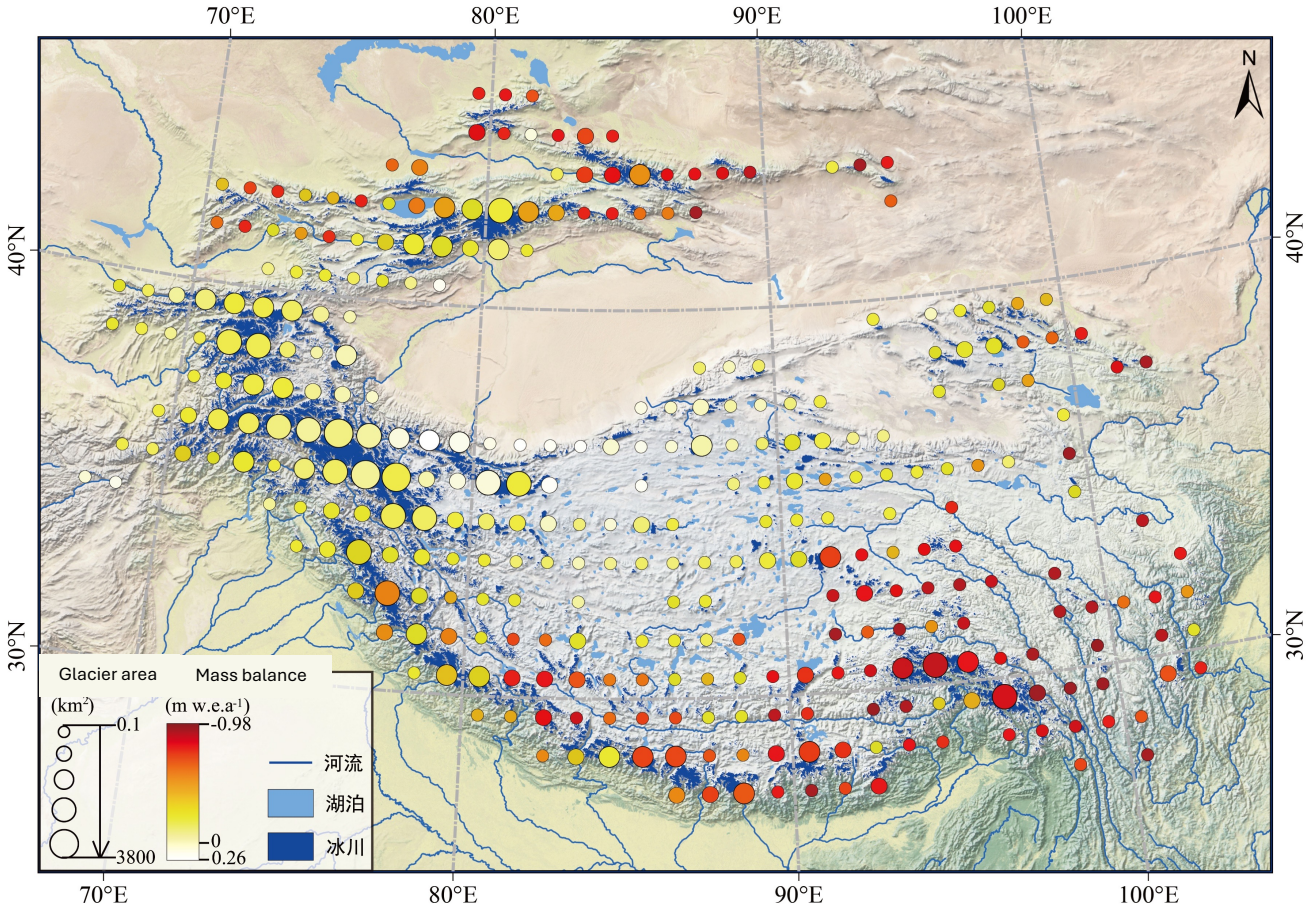


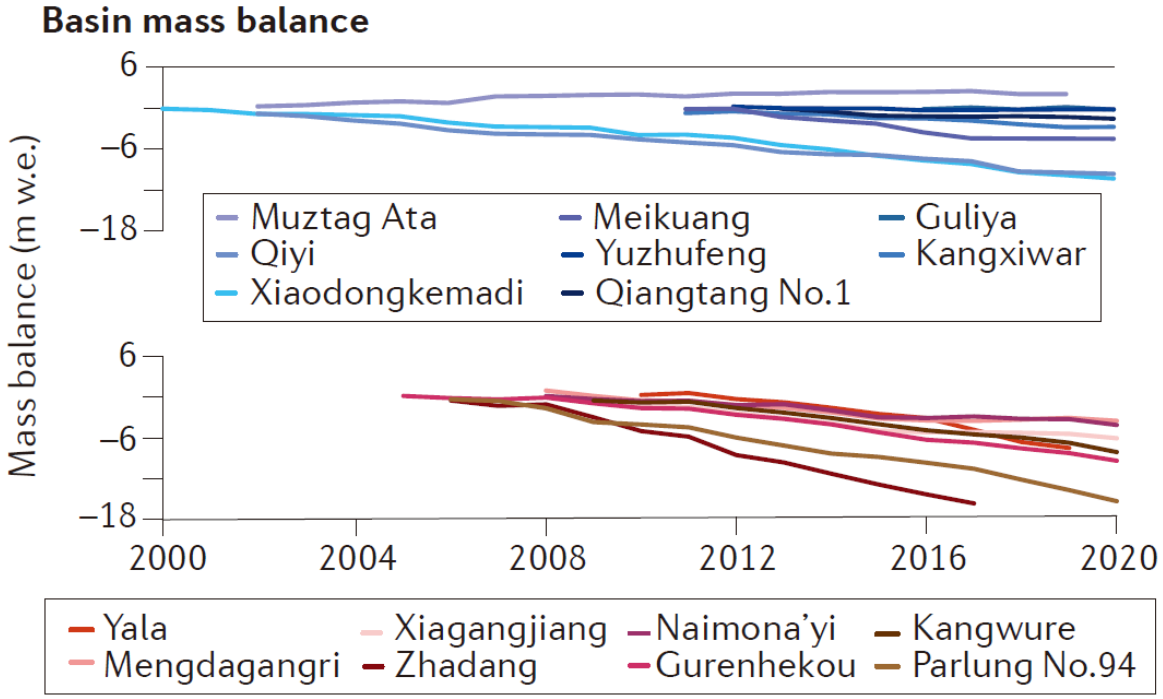

Glacier area has decreased about 20% in the last 40 years


**Mt. Cho Oyu**
Glacier shrinkage and the formation of proglacial lake at the Kyetrak glacier


**Central Tibetan Plateau**
The terminus retreat and disconnection of Dongkemadi and small Dongkemadi Glacier

# Glacier mass balance is more negative in the southern part



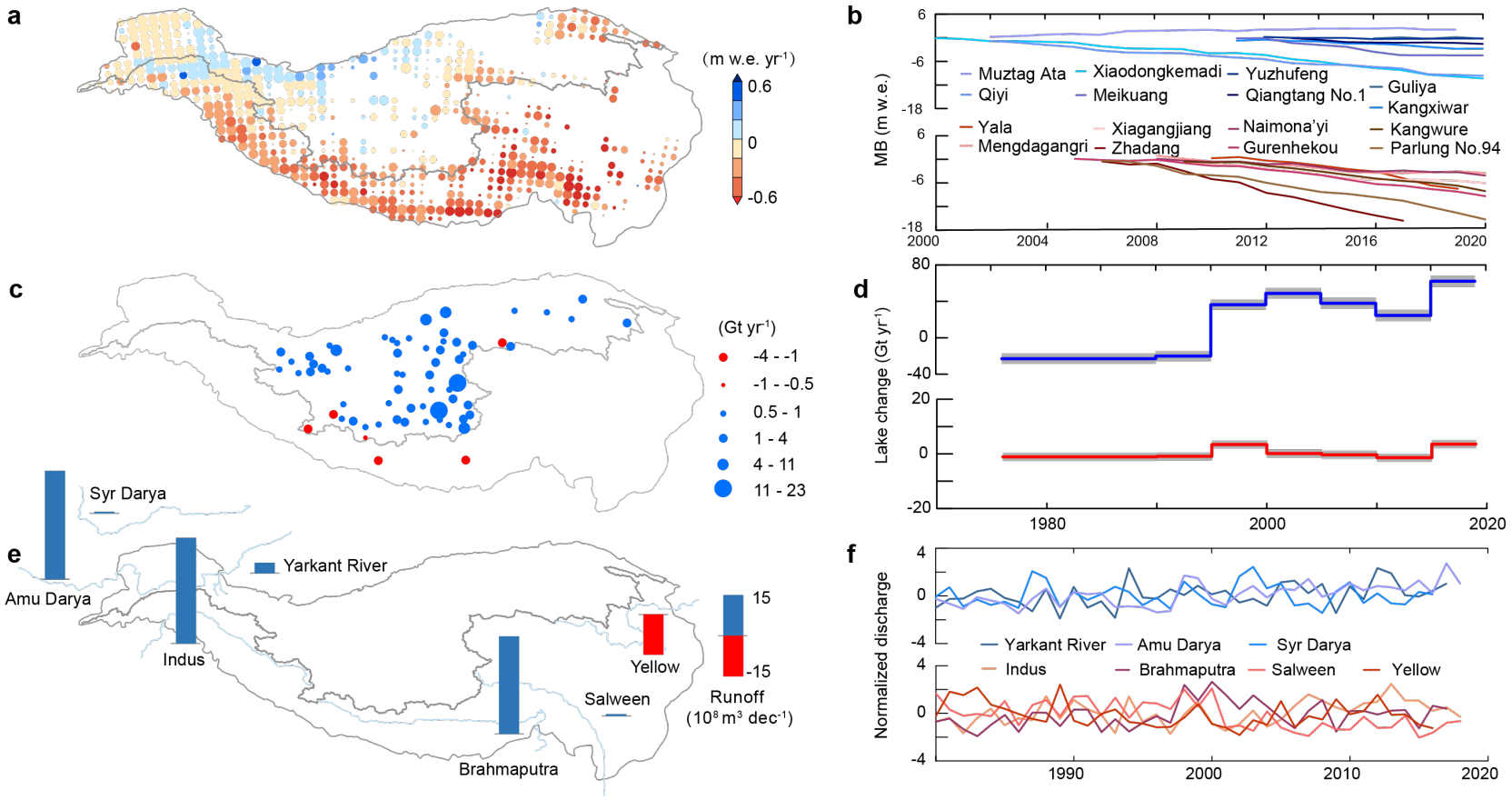

The total glacier mass loss across the whole Asian Water Tower during 2000−2018 is about 340 Gt. It means that the annual rate of glacier mass loss is about 19 Gt per year.

# Imbalance of spatial distribution of water resources in the AWT

**Glaciers**

**Lakes**

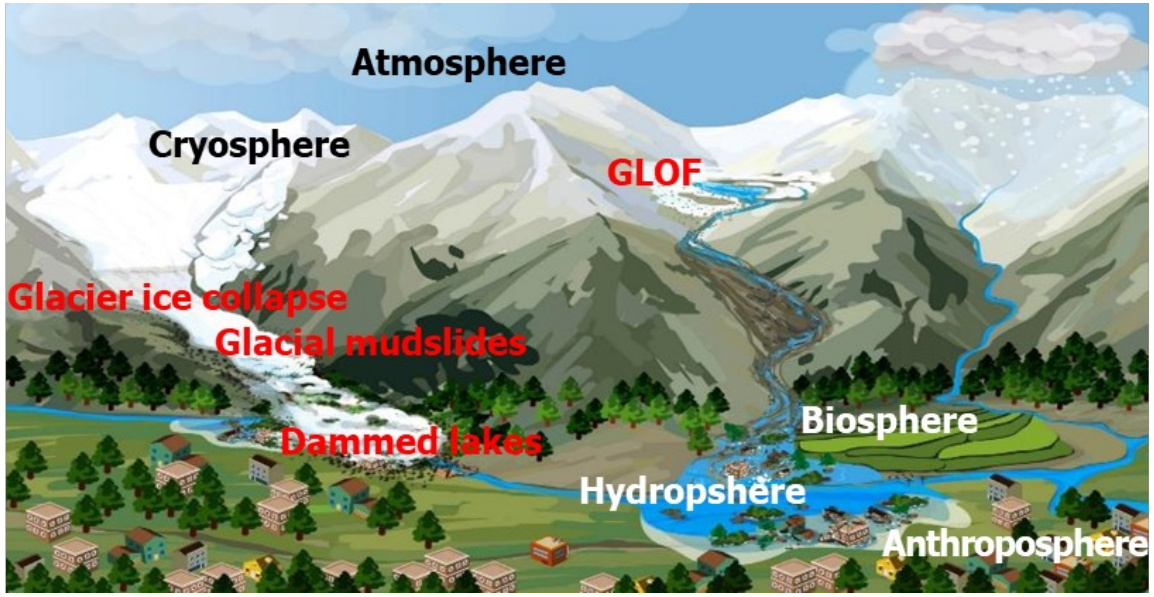
**River run-offs**




Endorheic Basins: generally lower losses of solid water but large gains in liquid water

Exorheic Basins: substantial losses of solid water and smaller gains in liquid water

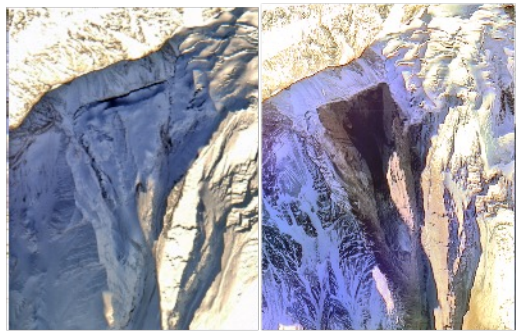
# AWT imbalance triggers chain response to Third Pole earth system, intensifying environmental hazards and jeopardizing regional security





Secondary effects of glacier hazards will trigger chain responses in the lithosphere, hydrosphere, biosphere and anthroposphere, and results in possible extension and amplification of hazards consequences.

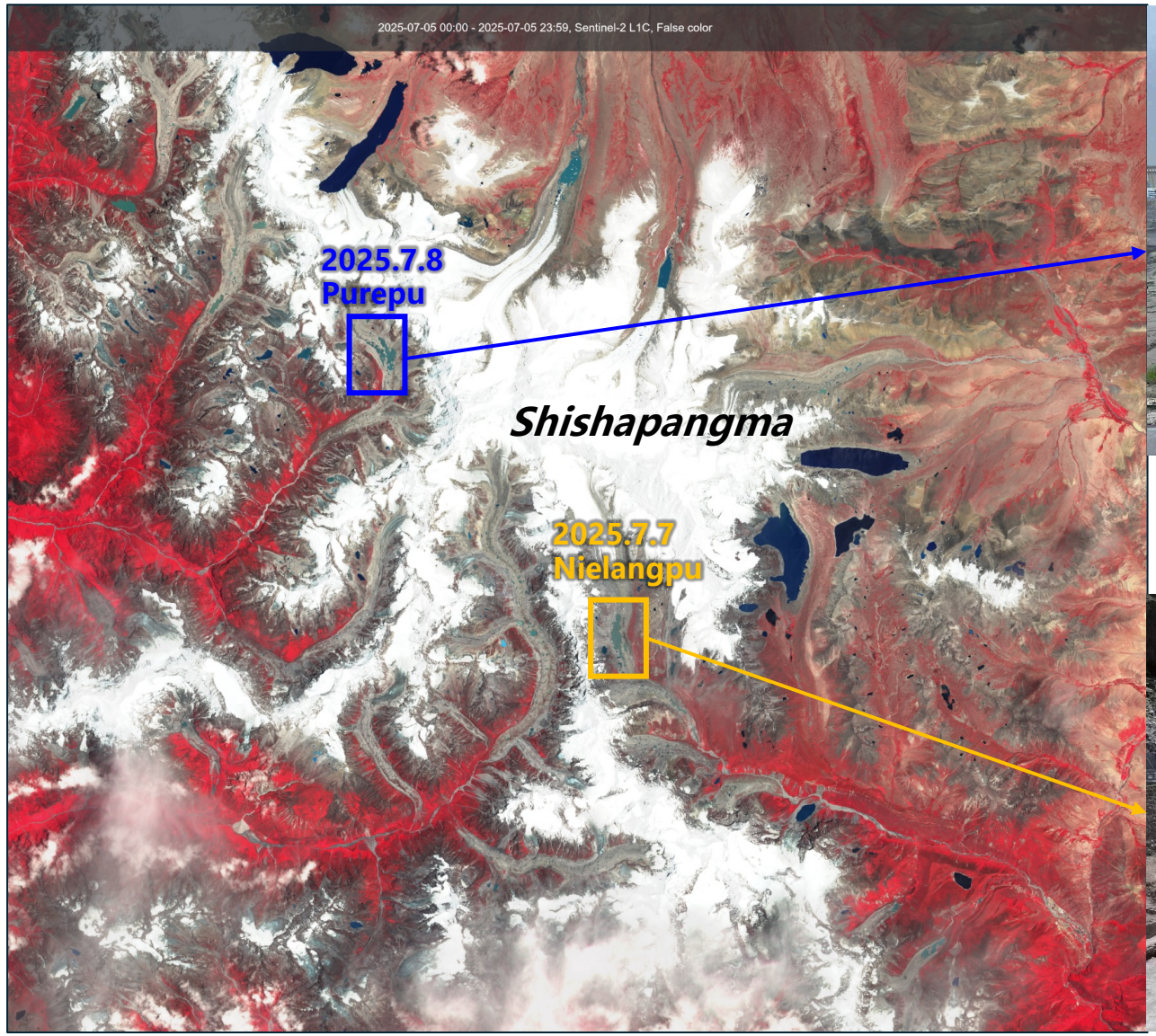
Glacially dammed Yarlung Zangbo River, Oct, 2018



Glacier ice collapse, India, Feb 8, 2021

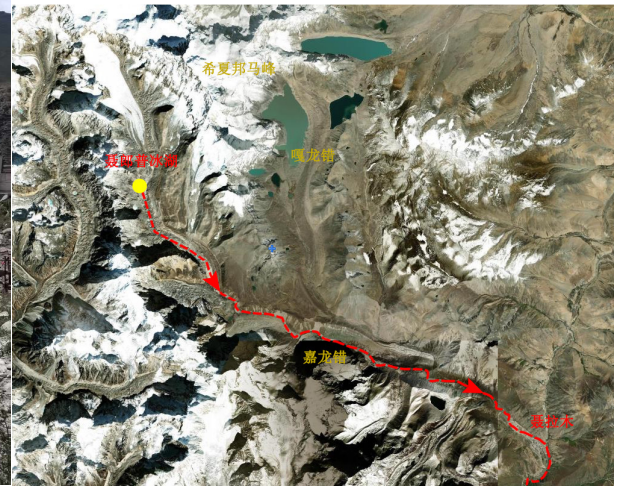
GLOF in Zhangzangbo, Jul, 2016

# Supraglacial lake outburst flood is a new type of GLOF in the TP



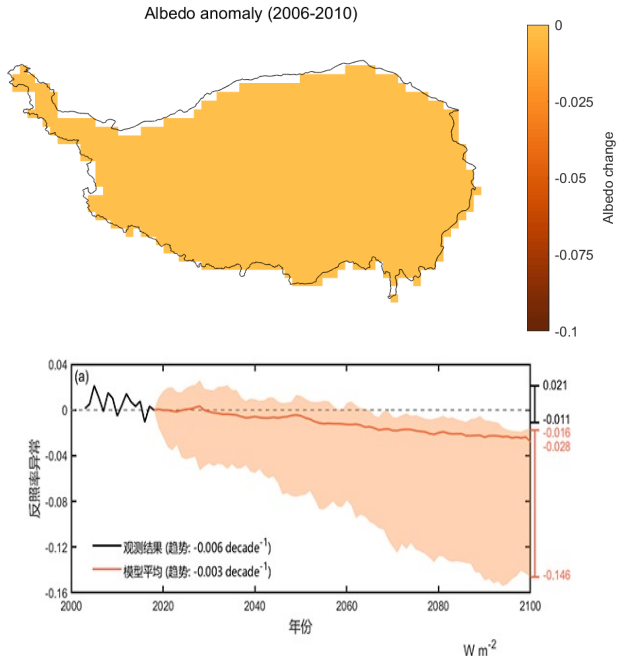






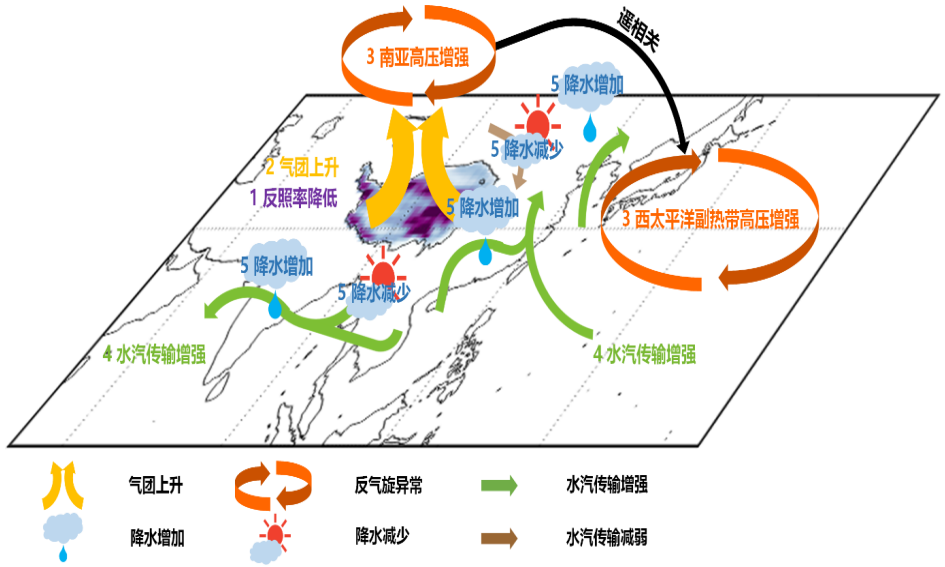
# Shrinking glaciers contributes to the darkening in the AWT and results in modulation of the Asian monsoon circulation pattern


## Shrinking glaciers




## Land surface darkening (decrease in albedo)

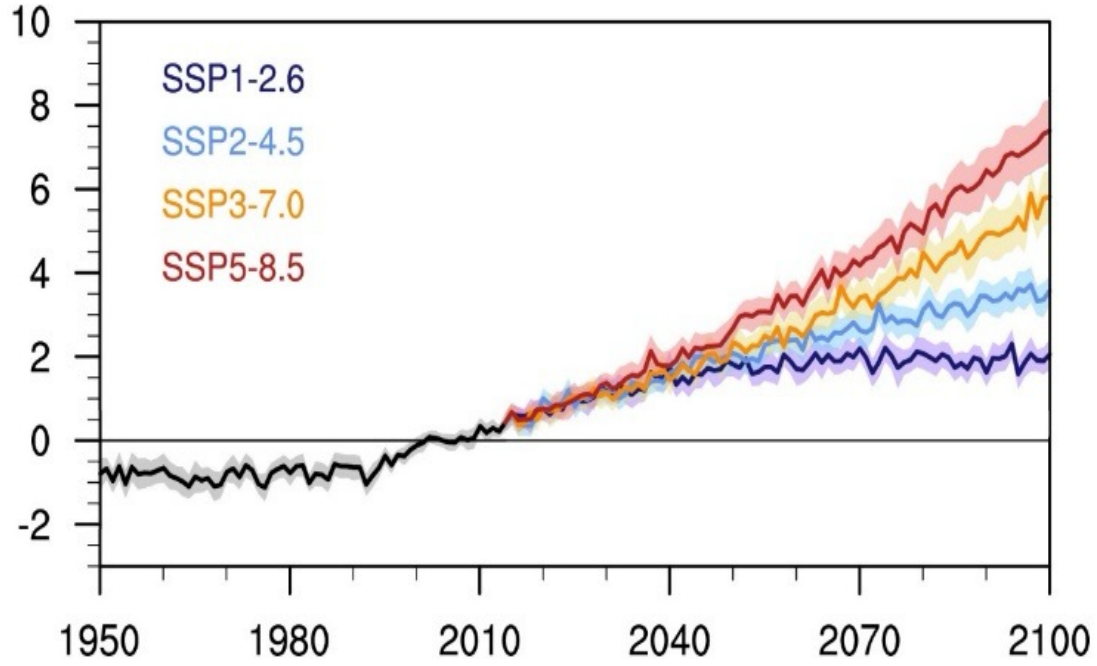
- Under the high emission scenario, surface albedo on the plateau is expected to decrease by 10.5% by the end of 21st century
- Land surface darkening may alter the energy balance, and contribute to a regional warming by 0.24℃



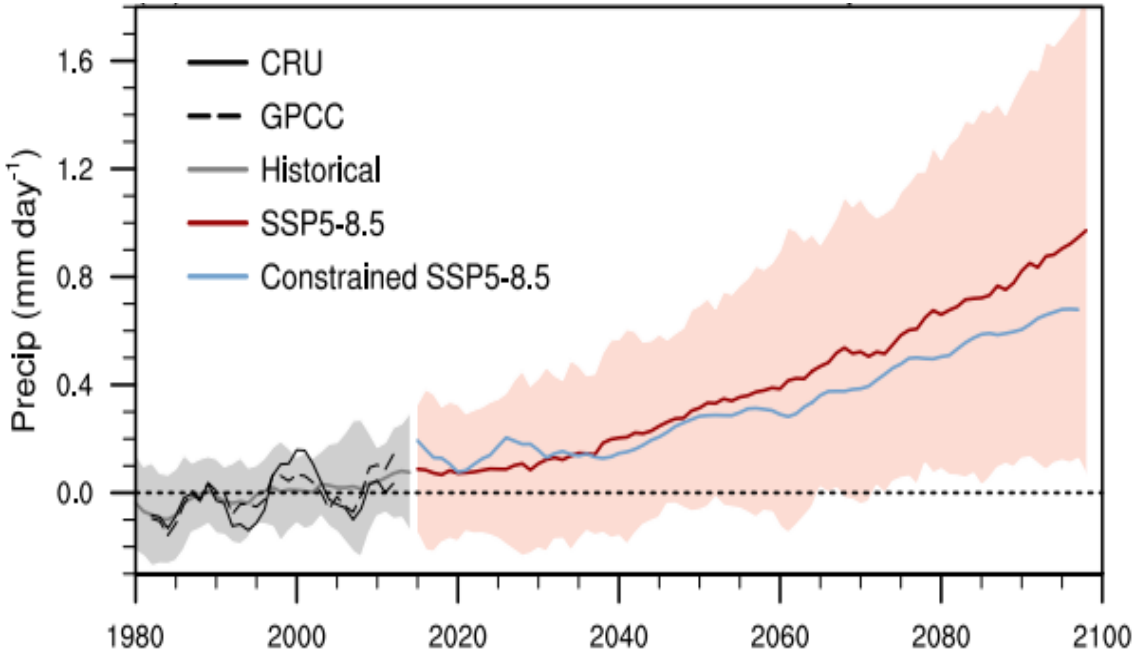

## Exacerbate the southern flood-northern drought pattern (SFND) in East China

Land surface darkening results in sensible heat increase, thus intensifying uplift of atmospheric air mass, and enhancing the South Asian High and West Pacific Subtropical High, which ultimately increases summer precipitation in South Asia and exacerbates the SFND pattern.

# Future climate projections

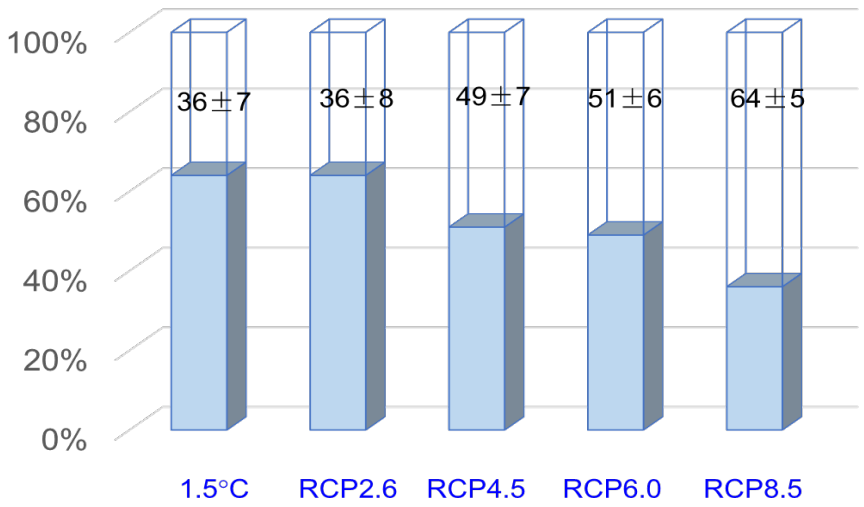



Air temperature is projected to increase in the late 21st century by 1.4-5.6ºC relative to the 1995–2014 reference period

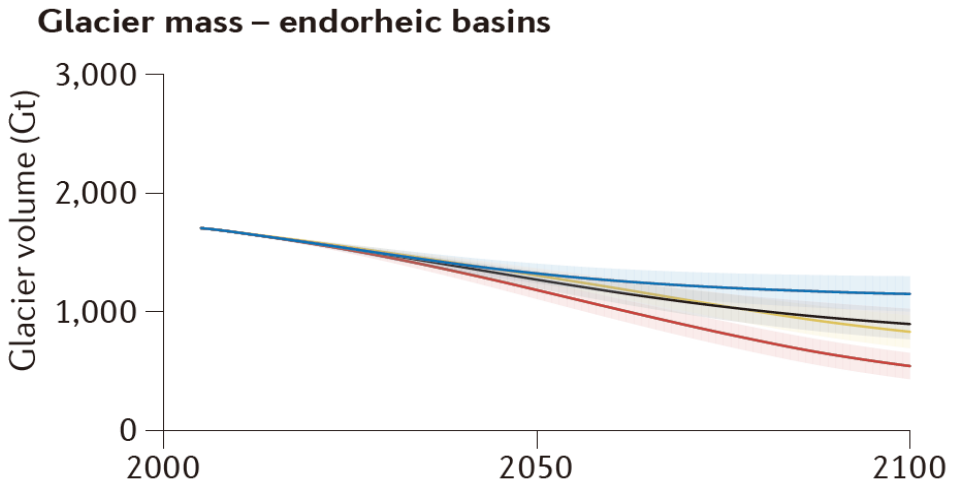


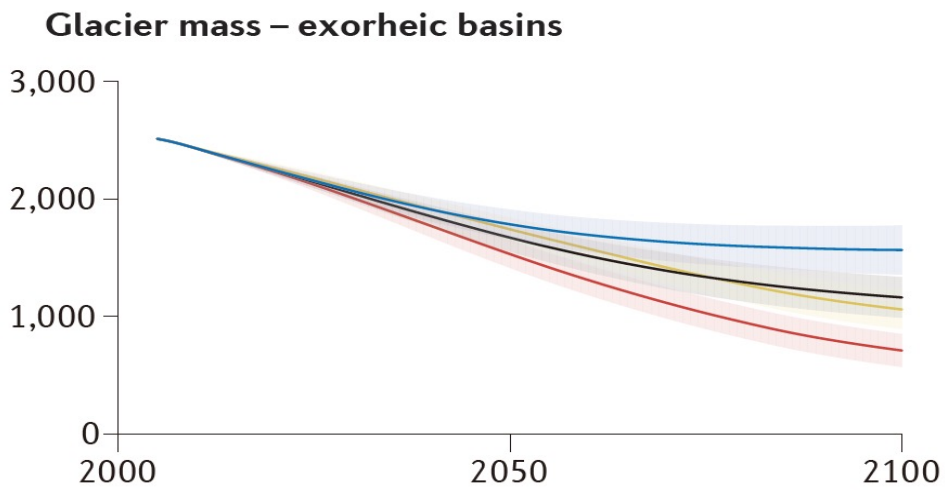

Precipitation is expected to increase by 6-15% by the end of the 21st century but with regional and seasonal variations

# Future projections for glaciers

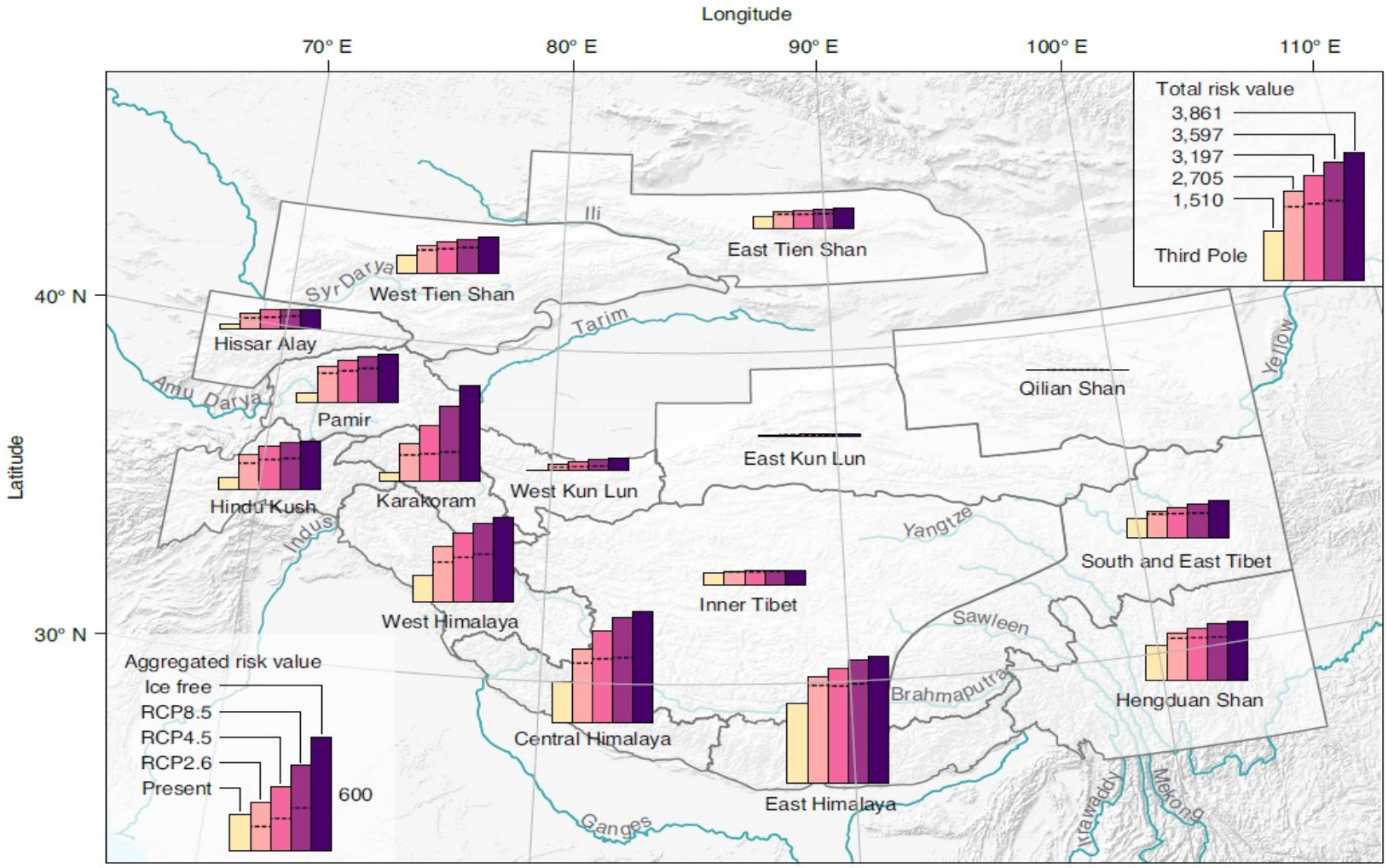



**Glaciers are projected to lose 36-64% of the mass under different scenarios**




# GLOF and ice collapse risks are expected to almost tripled in the future



# International effort - The Third Pole Environment (TPE)

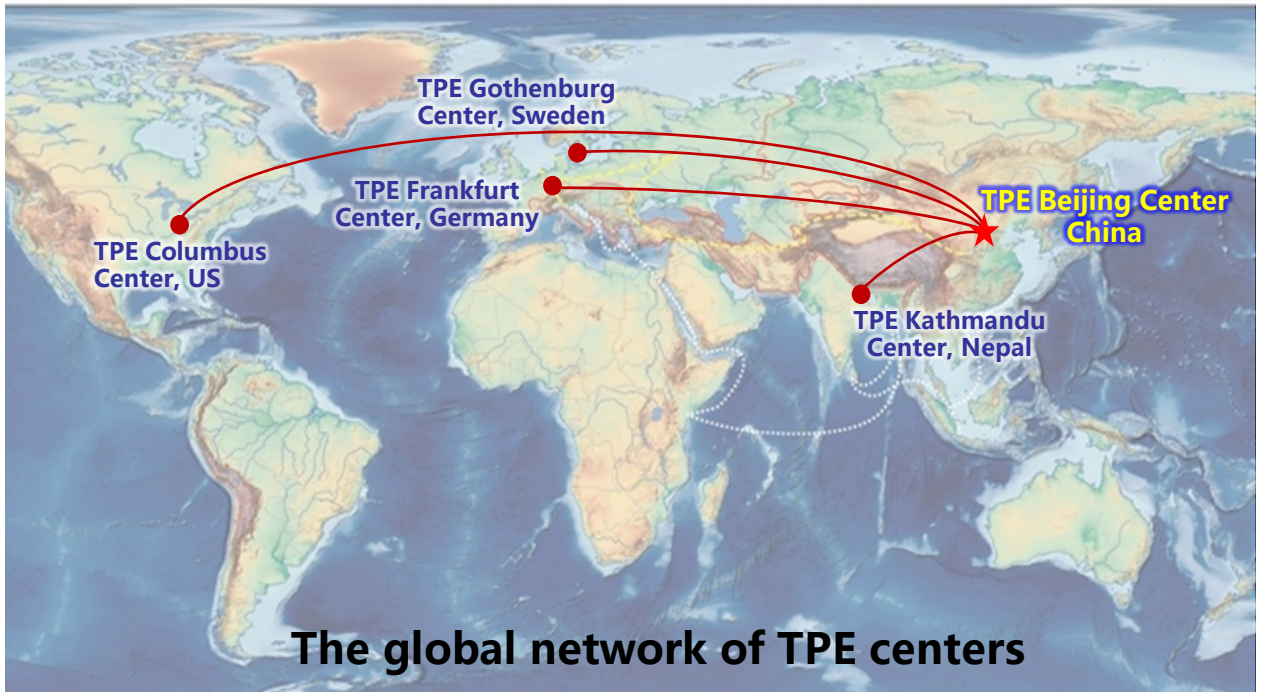
**TPE** is an international program for the interdisciplinary study of the relationships among **water, ice, air, ecology and society**, to address the environment changes in this region and beyond.






TPE was initiated in 2009 by **Prof. Tandong Yao, L.G. Thompson, V. Mosbrugger. Prof. Deliang Chen, Shilong Piao, Philippe Ciais** later joined TPE and became co-chairs.

# TPE aims at regional water issues with a global vision




**2009**
TPE Beijing Center

**2013**
TPE Kathmandu Center

**2016**
TPE Columbus Center

**2018**
TPE Gothenburg Center

**2019**
TPE Frankfurt Center

# TPE workshops facilitate international academic exchanges and communications











# TPE is developing Third Pole Glacier Melt and Earth System Adaptation (TPGE) for UN Decade of Action for Cryospheric Sciences



TPGE aims to better understand glacier dynamics and its impacts on climate change, water resources and ecosystem, and to better support regional and global sustainability in an ice-vanishing Third Pole.

# Main objectives

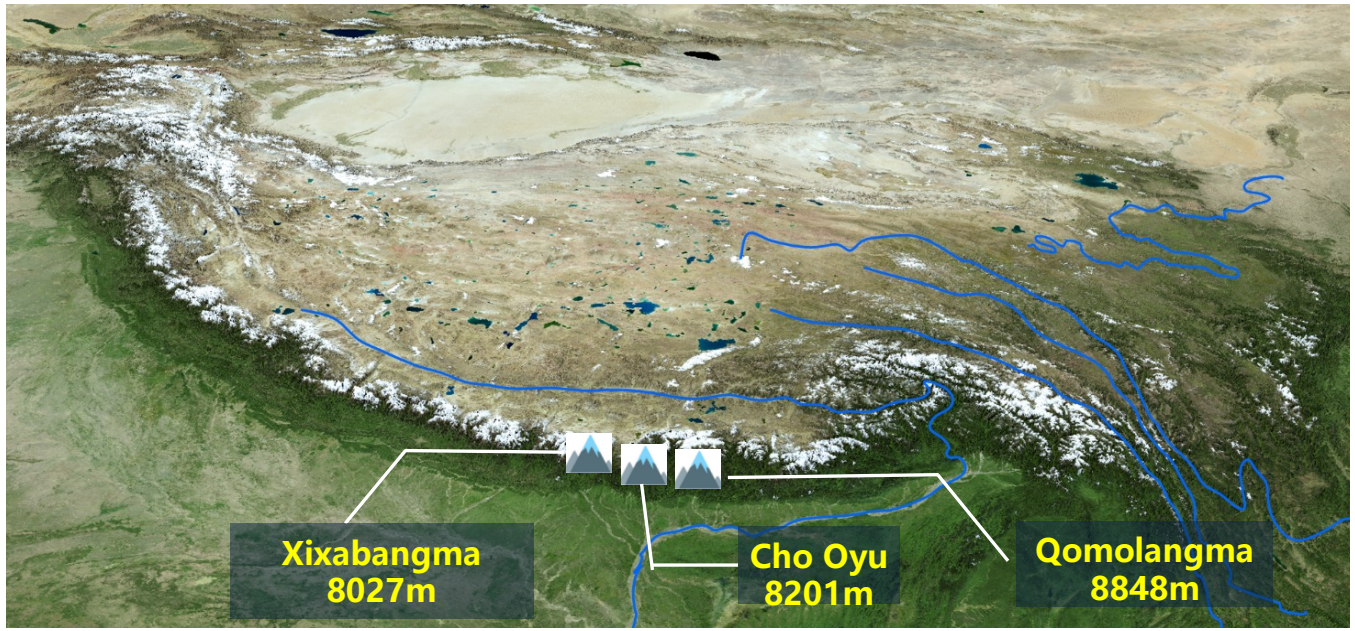
1. Establish Earth Summit transects and enhance Earth system observations.

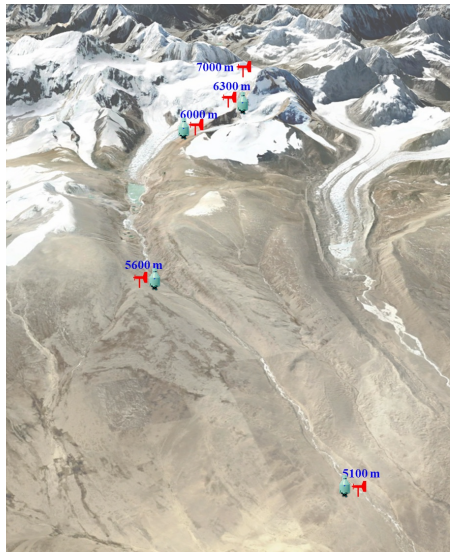
2. Build a platform to predict tipping points of glacier melt and their effects on water security, hazards, and ecosystems.

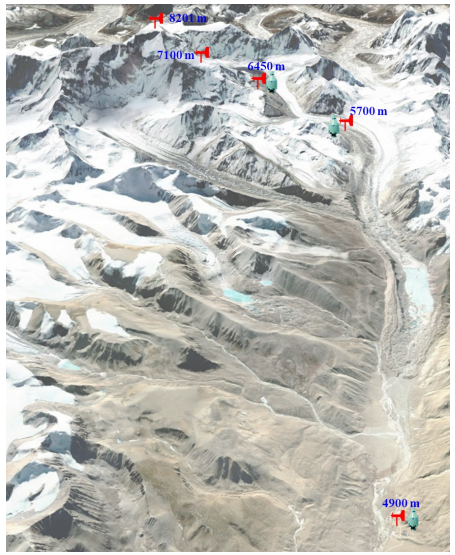
3. Bridge science and policy, supporting glacier preservation, ecosystem management, and sustainable development.

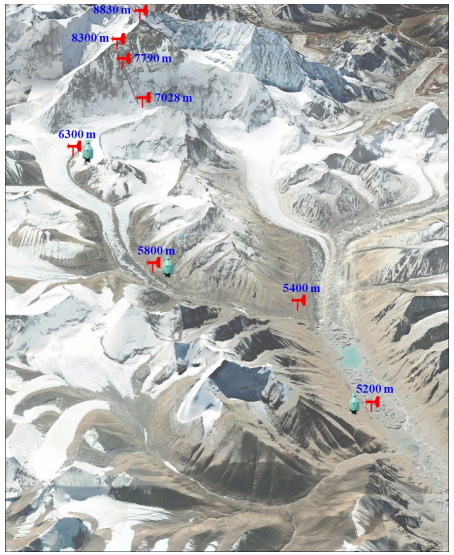
4. Raise public awareness and strengthen regional and global collaboration.

# Task I: Earth Summit Observation Transect



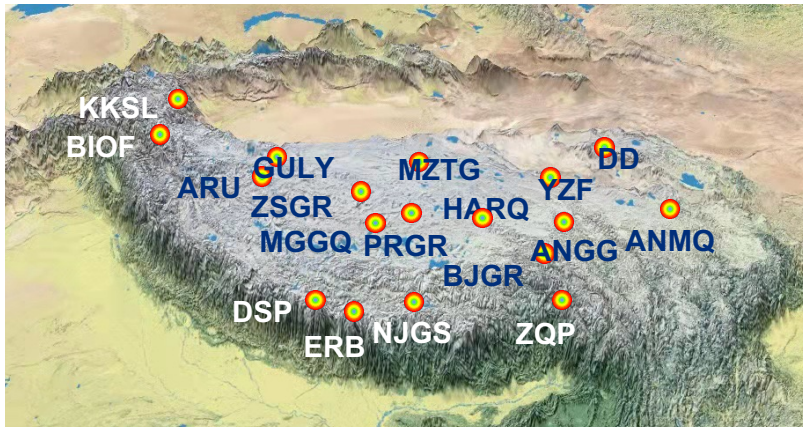

RESEARCH HIGHLIGHT | 14 July 2023

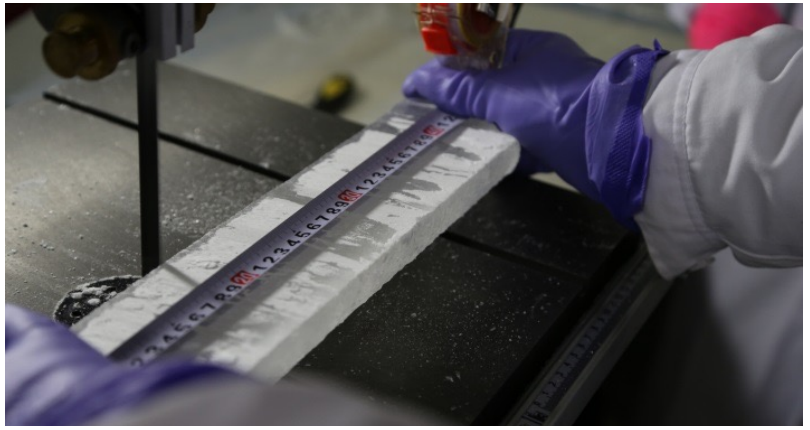
## How much snow is on Mount Everest? Scientists climbed it to find out

**Researchers who summited the world's tallest peak found much more snow there than expected.**

Researchers aiming to measure the snow depth on Mount Everest climb an ice wall at 7,208 metres. Credit: Wei Yang

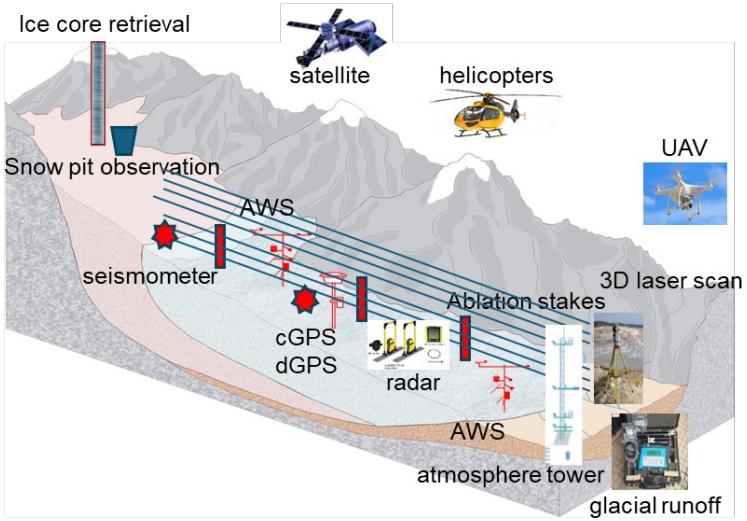


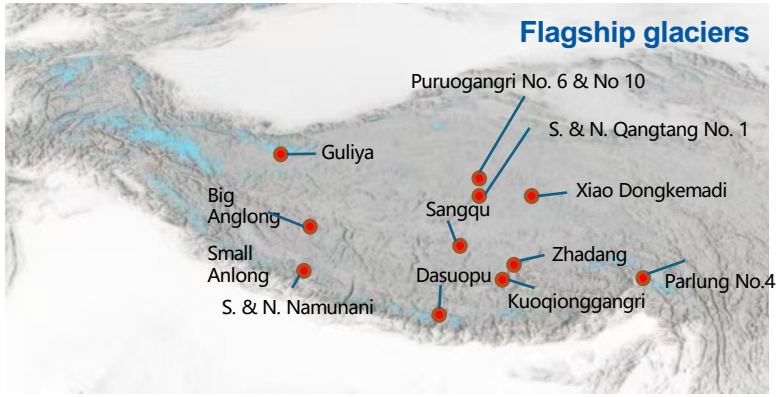


Third Pole ice core bank

# Task II: “Ice-Water-Vapor” transition and glacier melt tipping points

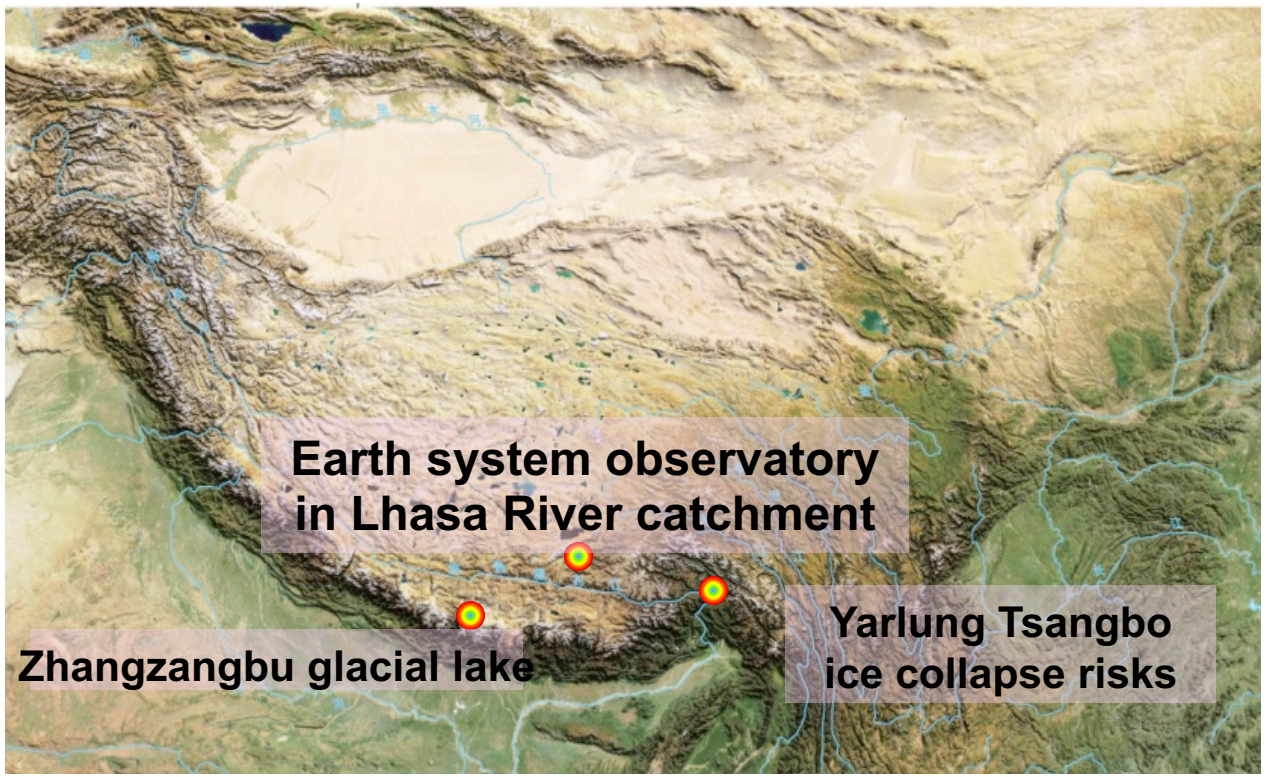


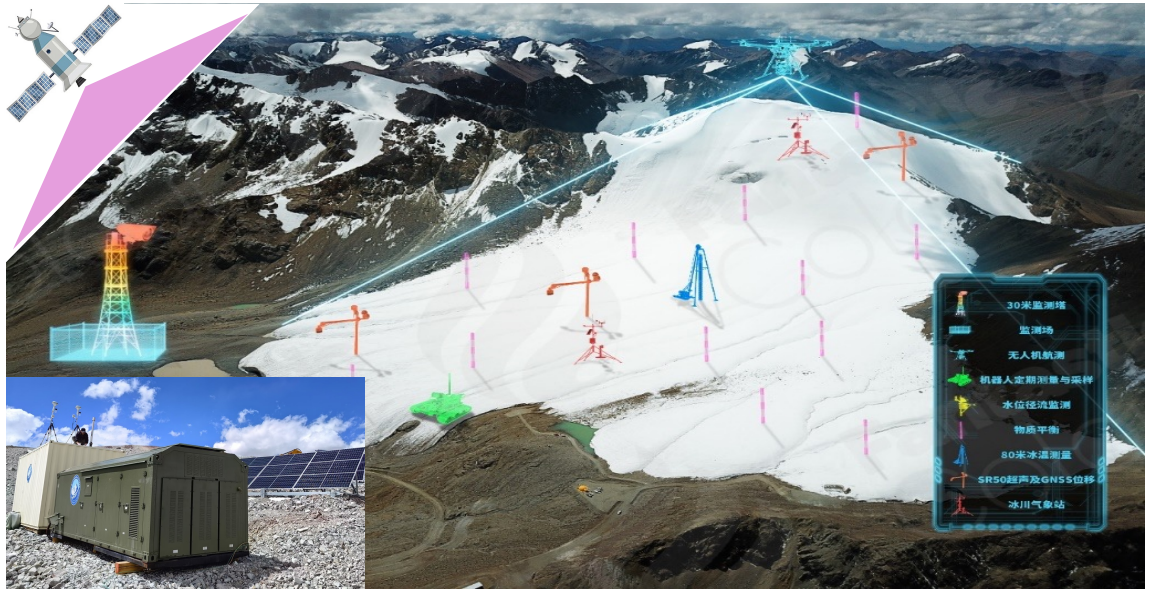



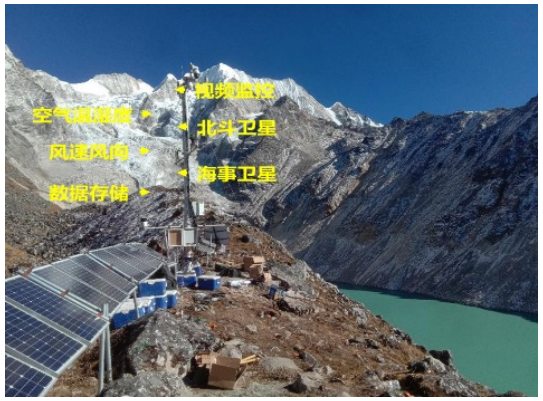

Multi-dimensional and -approach observations of glacier mass balance at altitudes >5000 m ASL.

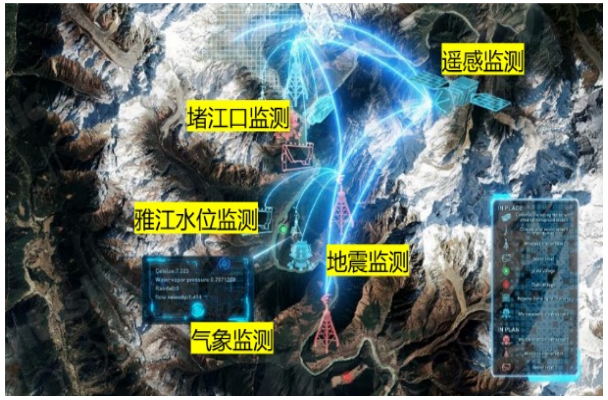
Track air flow to understand moisture supply to Third Pole glaciers and their dynamics.

# Task III : Earth system observatory and early warning platforms

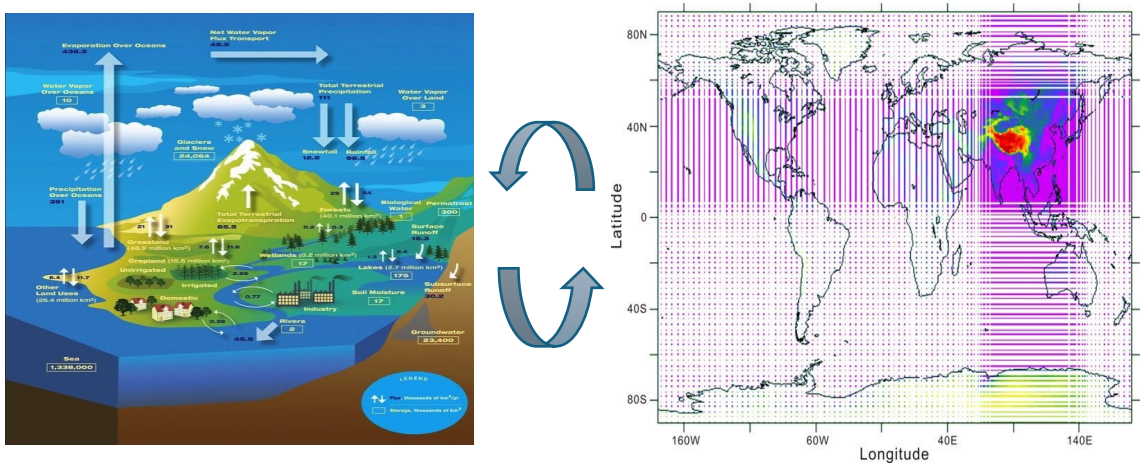


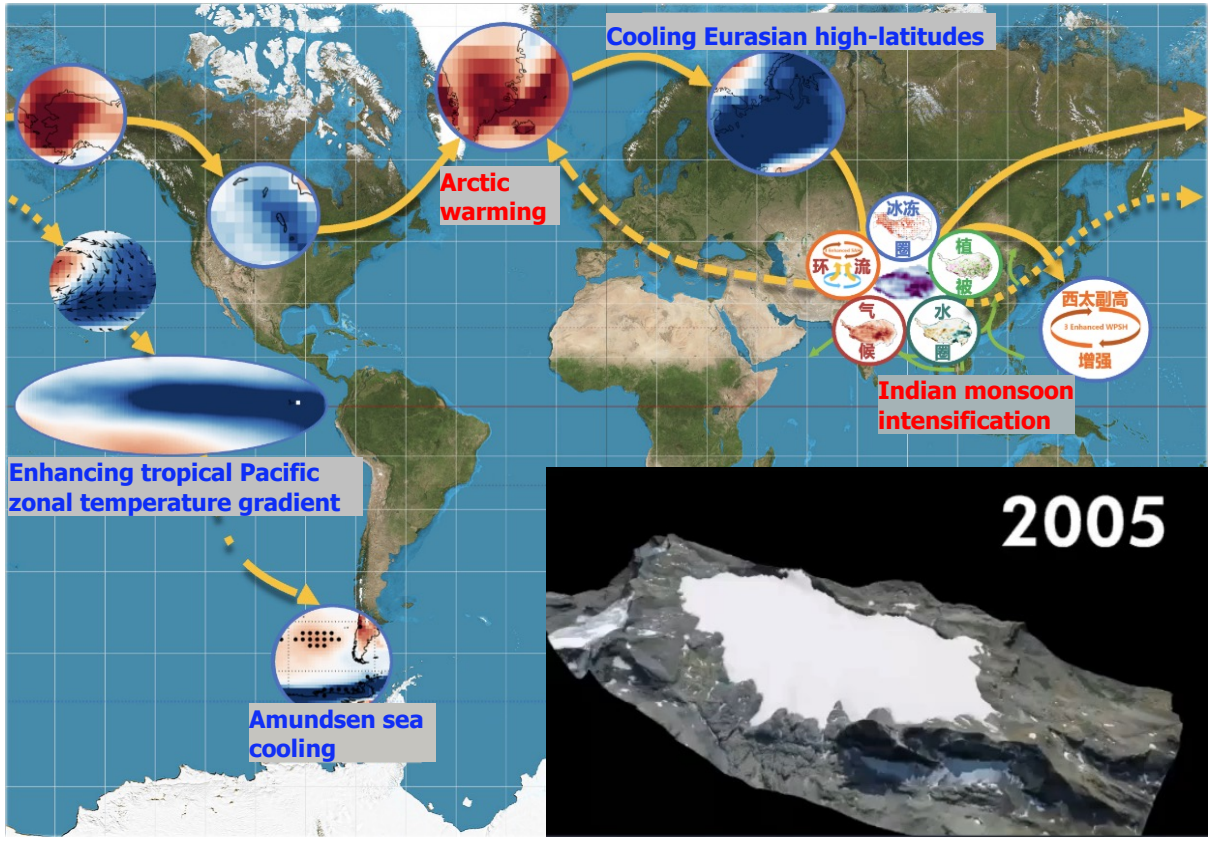



# Task IV: Development of next-generation modeling platform with AI for glacier-climate interactions

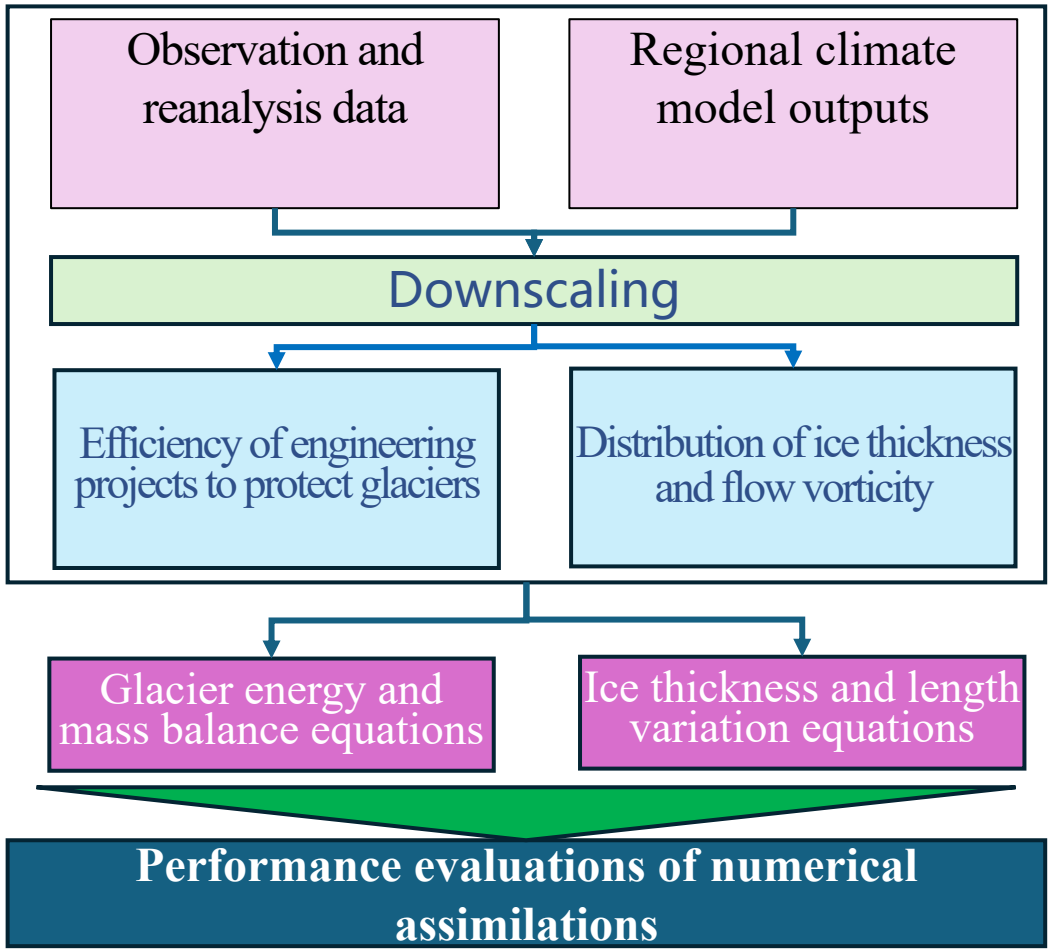



Coupled atmosphere-land surface model to unravel glacial-climate interactions



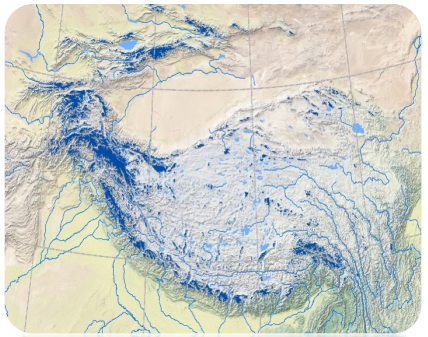

To predict potential effects of Third Pole vanishing glaciers on the heat pump effect of the region and climates beyond through teleconnections

# Task V: Technology innovation on glacier heritage preservation

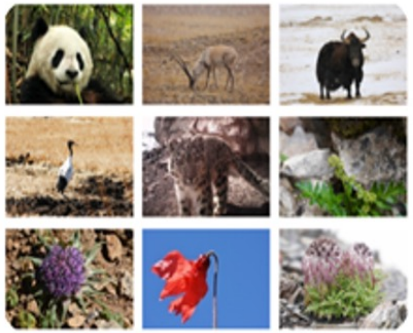
# Task VI: Advance research on the Tran-Himalaya Earth system science as one of the scientific initiatives of ATH

**International Association for Trans-Himalaya Earth System Science (ATH)**



**TPGE**

**Carbon**



**Biodiversity**


**Far-reaching effects**


**Disaster**

**Tans-Himalaya Earth System Science**

# Take-home message

**We are developing a global campaign for IYGP 2025 and Decade of Action for Cryospheric Sciences by focusing on glacier melt and earth system adaptation over Third Pole.**