

Summary and Overview of INARCH Phase II Activities and Progress

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<https://inarch.usask.ca>



INARCH in 2026

- A cross-cut project of the GEWEX Hydroclimatology Panel and a contribution to the UNESCO Intergovernmental Hydrological Programme to:
 - measure and understand high mountain atmospheric, hydrological, cryospheric, biological and human-water interaction processes,
 - improve their prediction as coupled systems,
 - diagnose their sensitivities to climate change and propose how they may be managed to promote water sustainability under global change.
- A network of over 60 research scientists, 43 experimental research basins in 19 countries and six continents.
- Phase II, 2021–2026, is approaching completion. Preparing renewal as a GEWEX Cross-Cutting Project.
- INARCH is supported by Global Water Futures Observatories, and contributes to the UN Decade of Action for Cryospheric Sciences, 2025–2034

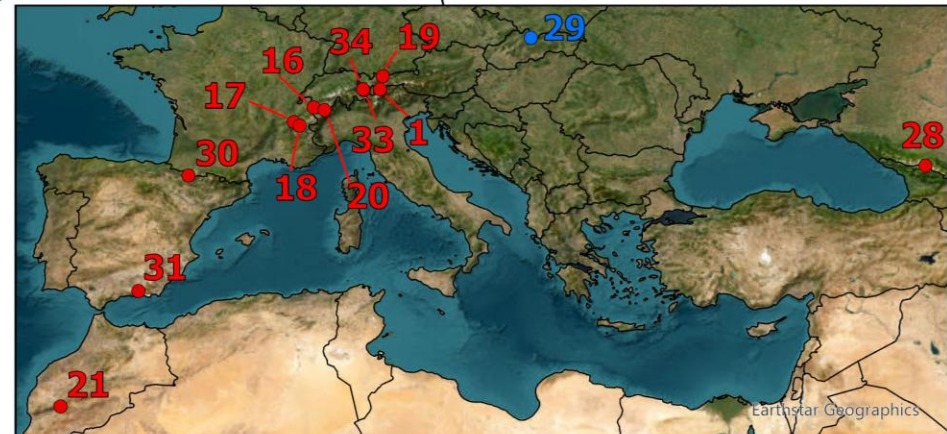
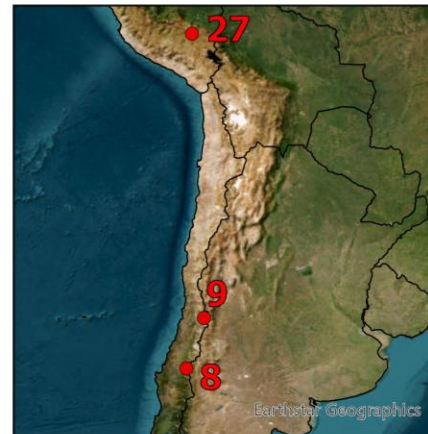
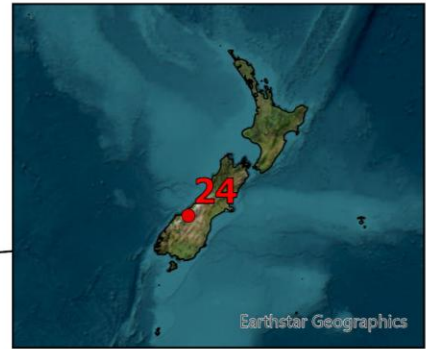
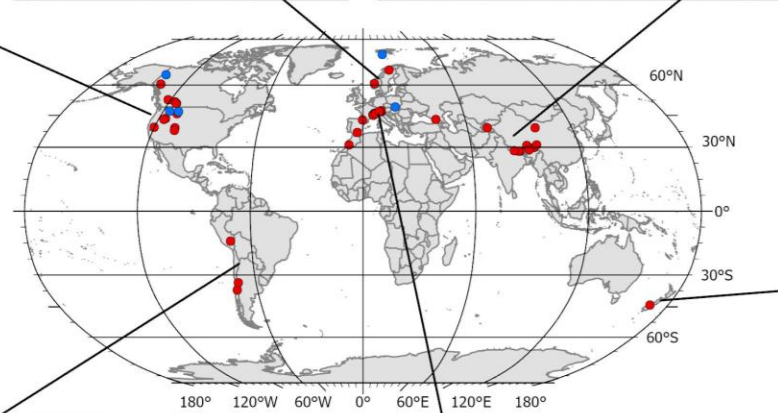
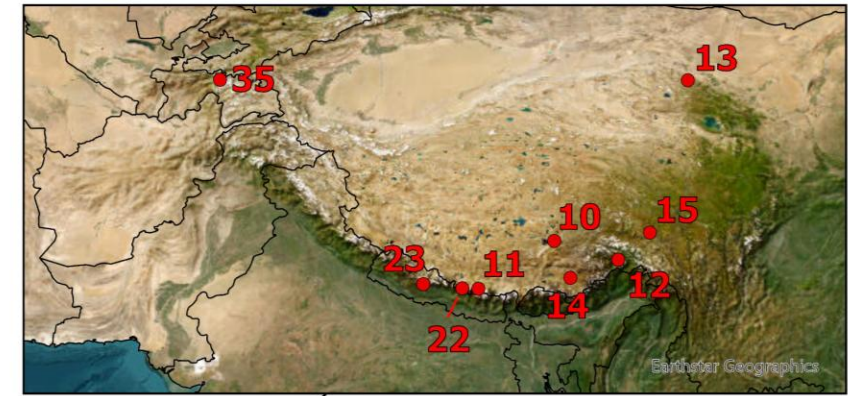
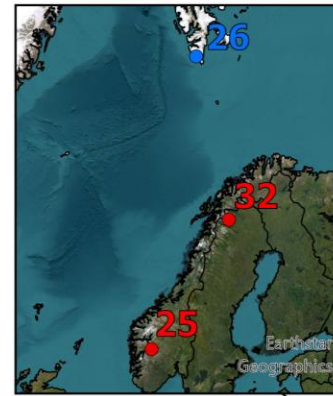
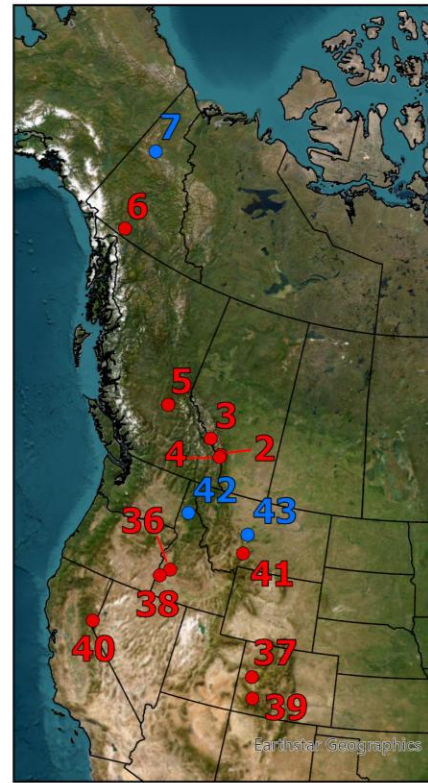
INARCH Linkages

- GEWEX Hydroclimatology Panel Projects
 - TeamX
 - GWF Observatories Regional Hydroclimate Project (RHP)
 - Third Pole Environment-Water Sustainability RHP
 - H2US US RHP
 - ANDEX RHP
- WMO Global Cryosphere Watch
- International Commission for Snow and Ice Hydrology (ICSIH)
- UNESCO-Intergovernmental Hydrological Programme (IHP) and UNESCO Chair in Mountain Water Sustainability
- UN International Year for Glaciers' Preservation – 2025;
- UN Decade of Action for Cryospheric Sciences, 2025–2034



INARCH Basins

Austria **1.** Rofental Open Air Laboratory (OpAL);
Canada **2.** Marmot Creek Research Basin; **3.** Peyto Glacier; **4.** Fortress Mountain Research Basin; **5.** Quesnel River Research Basin; **6.** Wolf Creek Research Basin; **7.** **Tombstone Waters Observatory;**
Chile **8.** Valle Hermoso, Upper Diguillín River Basin; **9.** Estero Las Bayas, Upper Maipo River Basin;
China **10.** Nam Co Monitoring and Research Station for Multisphere Interactions; **11.** Qomolangma Atmospheric and Environmental Observation and Research Station; **12.** Southeast Tibet Observation and Research Station for the Alpine Environment; **13.** Upper Heihe River Basin; **14.** Yarla Shampo Cryosphere Hydro-Ecological Station; **15.** Changdu Ecological Monitoring Station;
France **16.** Arve Catchment; **17.** Col de Porte Experimental Site;
Germany **19.** Schneefernerhaus and Research Catchment;
Italy **20.** Torgnon Ecosystem Station;
Morocco **21.** Rheraya Catchment, High Atlas Mountains;
Nepal **22.** Langtang Catchment; **23.** Hidden Valley, Himalayas
New Zealand **24.** Brewster Glacier;
Norway **25.** Finse Alpine Research Centre; **26.** **Fuglebekken Research Catchment (Svalbard)**
Peru **27.** Salcca-Sibinacocha Catchment;
Russia **28.** Djankuat Research Basin;
Slovakia **29.** **Jalovecký Creek catchment;**
Spain **30.** Izas Research Basin; **31.** Guadalfeo Monitoring Network;
Sweden **32.** Tarfala Research Catchment;
Switzerland **33.** Dischma Research Catchment; **34.** Weissfluhjoch Snow Study Site;
Tajikistan **35.** Kyzylsu Glacier and Monitoring Sites;
United States of America **36.** Dry Creek Experimental Watershed; **37.** Grand Mesa Study Site; **38.** Reynolds Creek Experimental Watershed; **39.** Senator Beck Basin Study Area; **40.** Sagehen Creek, Sierra Nevada; **41.** Bridger Range; **42.** **Mica Creek;** **43.** **Tenderfoot Creek Experimental Forest;**



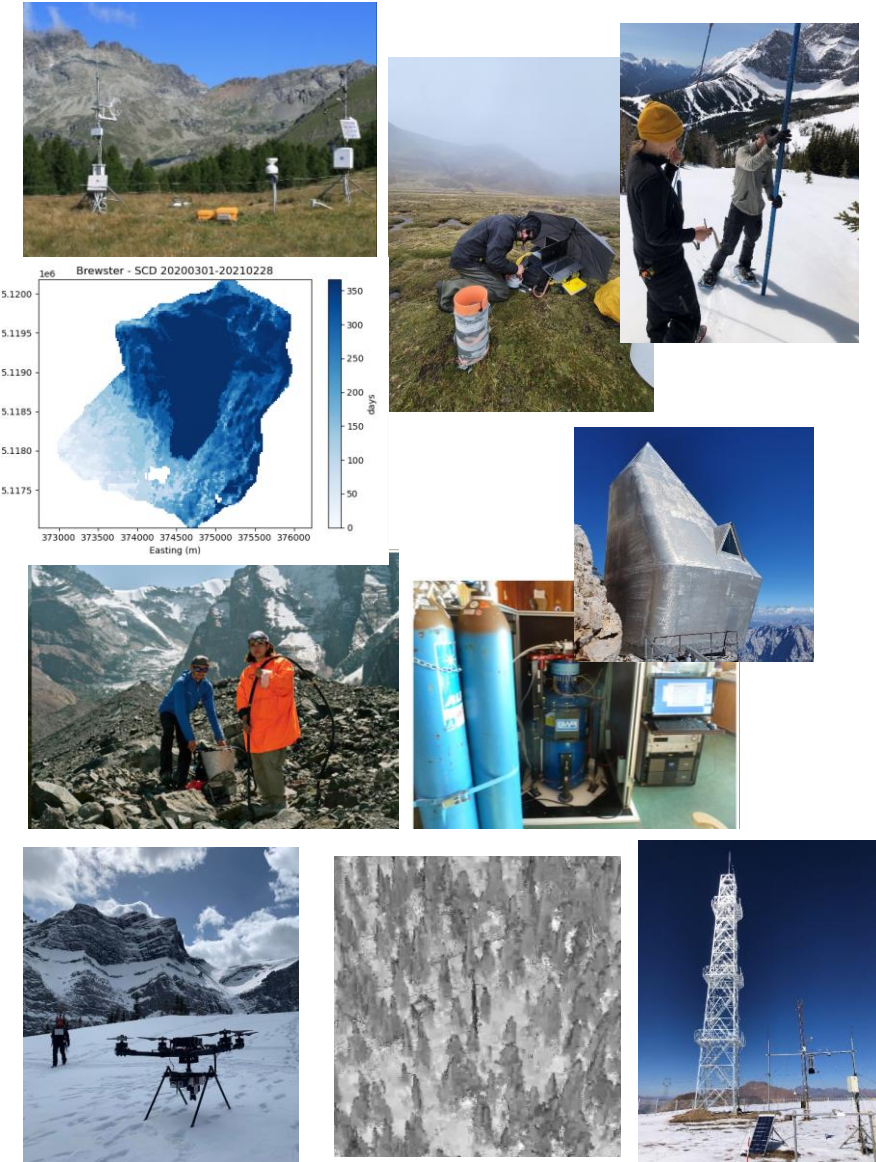
- Existing INARCH basins
- New and prospective INARCH basins

<https://inarch.usask.ca/science-basins/research-basins.php>

Common Observing Period Experiment (COPE) 2022–2024

- 34 basins and instrumented sites participating
- Expanded observations at many existing and new sites; new measurements and technologies
 - Hanging-tree snow interception measurements
 - Eddy covariance towers
 - Cosmic-ray SWE sensors
 - SnowFox sensors
 - GNSS snow measurements
 - Wind profilers
 - Boundary-layer profiling systems
 - Lake-pressure SWE systems
 - Low-cost snow and hydrological sensors deployed across multiple basins.
- Advanced remote sensing campaigns (airborne and terrestrial lidar and multispectral, Sentinel-2 snow-cover products, ESA AlpSnow, AI4Snow - snow parameters from multiple missions)

COPE generated one of the most comprehensive coordinated mountain hydrometeorological observation efforts undertaken globally.

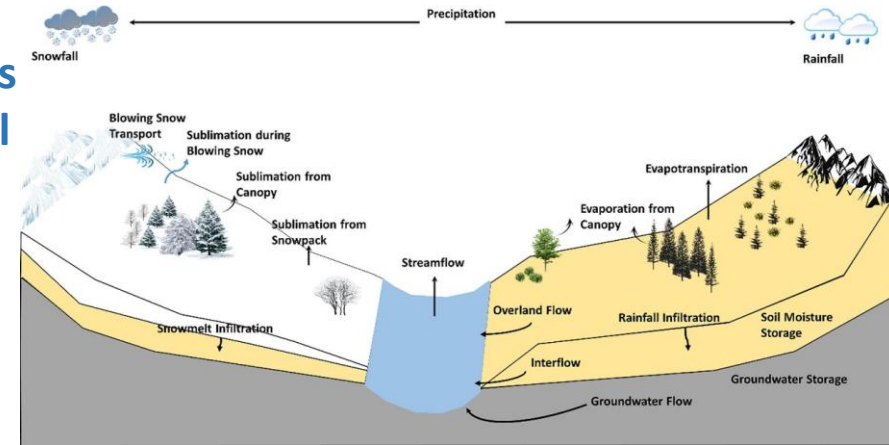


Common Observing Period Experiment

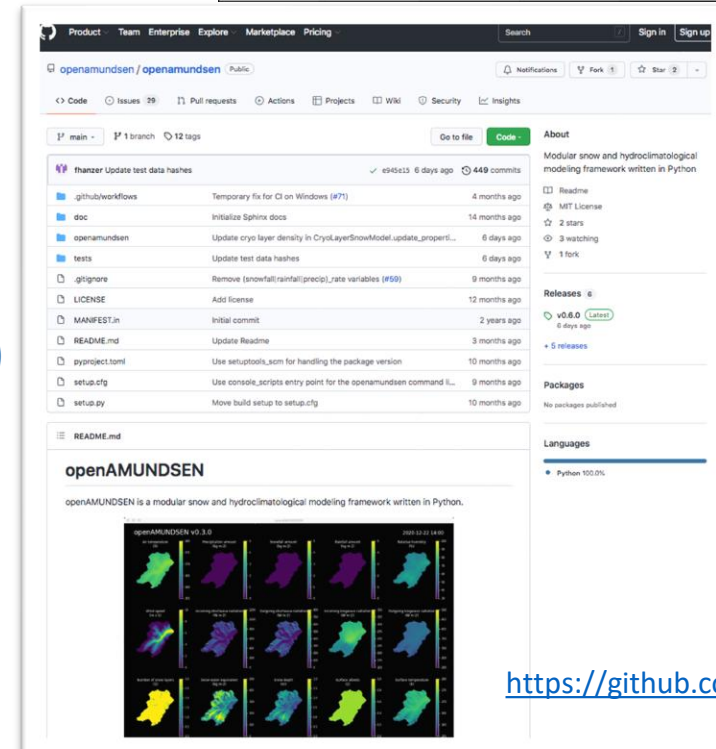
- Global model testbed established
- By 2024–2025 COPE basins were supporting:
 - CRHM
 - CHM
 - openAMUNDSEN
 - OGGM
 - Cosipy
 - SnowModel
 - FSM2
 - FSM-OSHD
 - Alpine3D/SNOWPACK
 - Thethys-Chloris
 - MESH
 - ICAR
 - WRF
 - HMS
 - Amelt
- More than 15 modelling frameworks being applied across common basins.

INARCH is the only mountain initiative to have coordinated both observations and multi-model diagnostics at this scale.

Cold Regions Hydrological Modelling (CRHM) platform



Alpine Multiscale Numerical Distributed Simulation Engine (openAMUNDSEN)

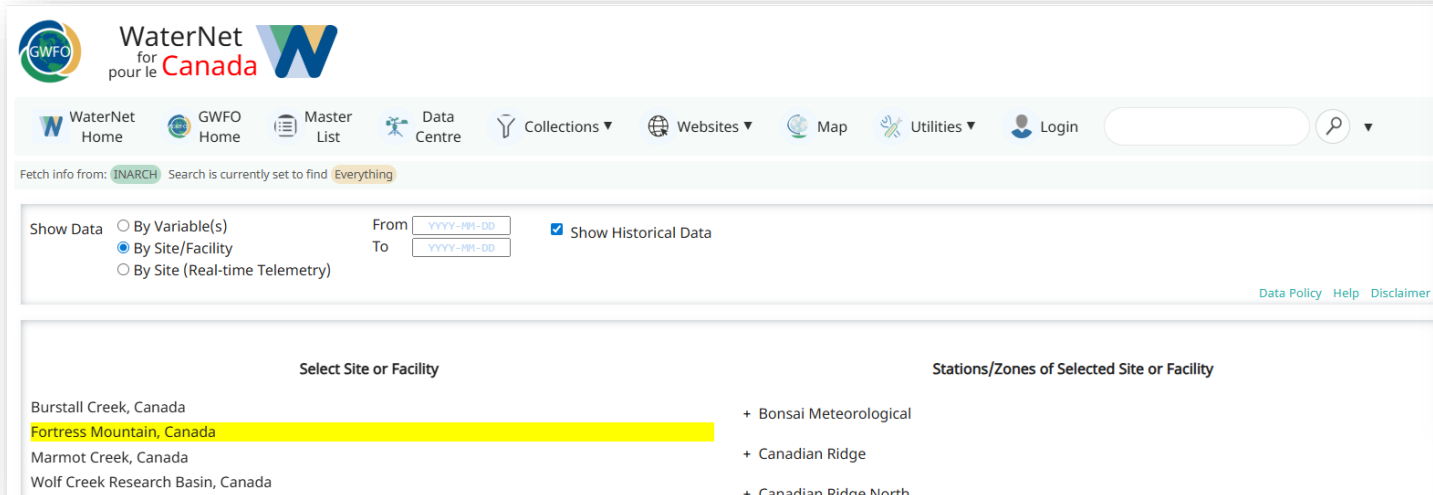
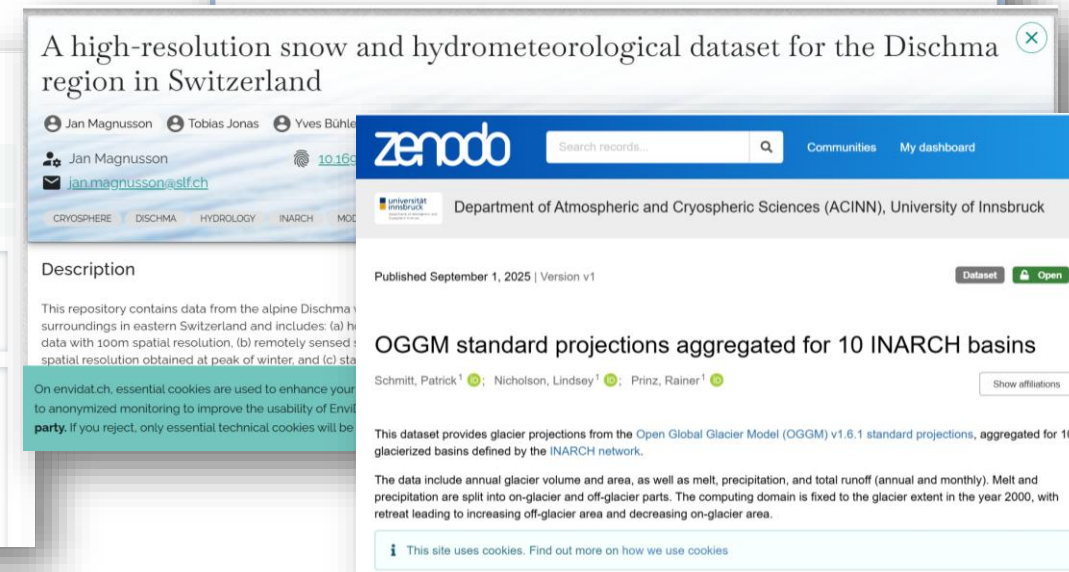


<https://research-groups.usask.ca/hydrology/modelling/crhm.php>

<https://github.com/openamundsen/>

COPE Data Legacy

- Field observation phase of COPE completed as a focal activity to collect a high-quality and coherent observational data set of mountain meteorology and hydrology from around the world
- Current efforts on QA/QC and preparation for data publication—growing inventory of published datasets.
- GWFO support and GWFNet infrastructure for compiling metadata and facilitating data access



Special issue

Articles / Special issue

Search



Hydrometeorological data from mountain and alpine research catchments

Editor(s): John Pomeroy (University of Saskatchewan, Canada), Danny Marks (Retired from Northwest Watershed Research Center, USA), and Ignacio López-Moreno (Instituto Pirenaico de Ecología, Spain)

This ESSD special issue responds to an international need to improve the understanding and modelling of mountain snow and ice hydrological processes. Data sets contributed to the special issue should support and promote research on the effects of mountain snowpacks and glaciers on water supply as well as study of variations in energy and water exchange amongst different high-altitude regions. This initiative arises from a new GEWEX Hydroclimatology Panel cross-cut project – INARCH, the International Network for Alpine Research Catchment Hydrology (www.usask.ca/inarch). The guest editors invite contributions of openly available detailed meteorological and hydrological observational archives from long-term research catchments at high temporal resolution (at least 5 years of continuous data with hourly sampling intervals for meteorological data, daily precipitation and streamflow, and regular snow and/or glacier mass balance surveys) in well-instrumented mountain regions around the world. Contributors and researchers will use this mountain hydrology data publication special issue for the benefit of global alpine hydrological research.

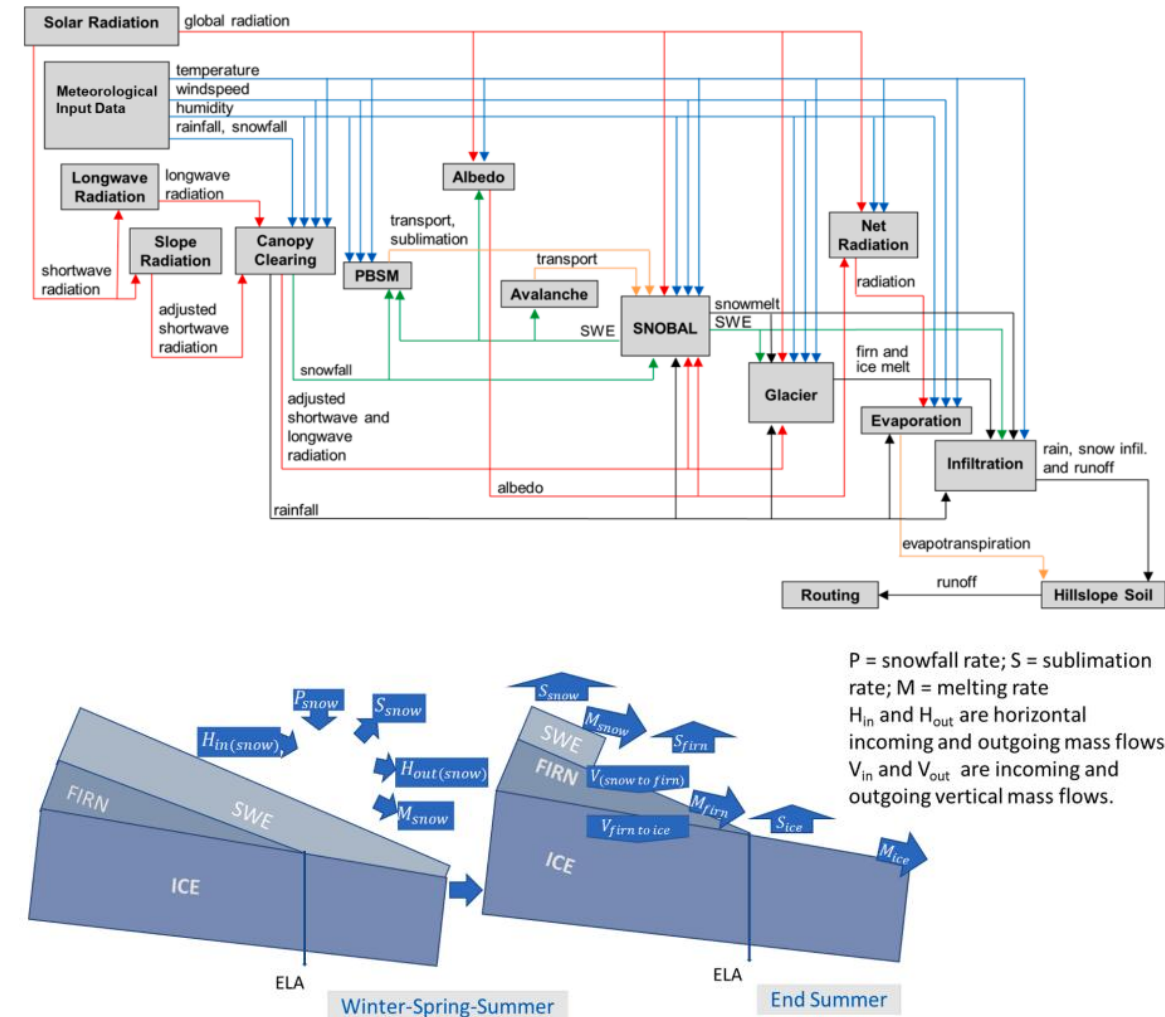
Review process: all papers of this special issue underwent the regular interactive peer-review process of Earth System Science Data handled by guest editors designated by the ESSD chief editors



- 27 papers published. Remains open for data papers
- https://essd.copernicus.org/articles/special_issue871.html

Diagnostic Modelling Framework

- COPE data are being used to address key INARCH science questions and series of hydrological process diagnostic modelling evaluations and analyses.
- Coordination of modelling activities at multiple institutions to make use of the observations to:
 - better understand why models produce various behaviors
 - see if models benchmark various known aspects and regimes of the coupled atmospheric-cryospheric-hydrological system.
- Model diagnostic evaluations emphasize atmospheric, snow, glacier, and water processes in high mountain terrain and include sparse forest, non-needleleaf vegetation, glaciated, and alpine windblown sites.

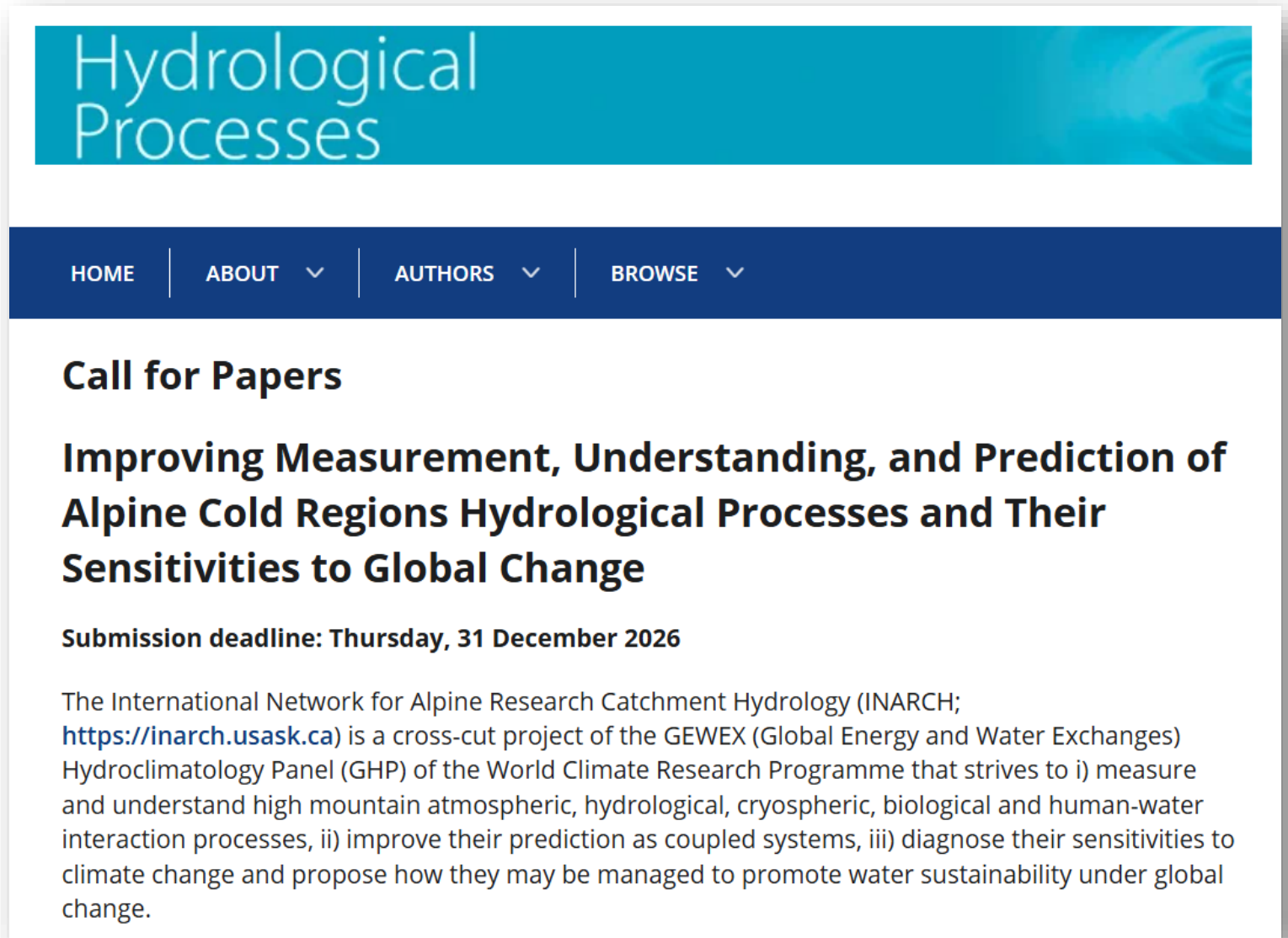


Modular structure and conceptual mass balance of CRHM-glacier (Pradhananga and Pomeroy, 2022)

INARCH HP special issue

8 published so far

- **Guest Editors:**
- **Sean Carey**
McMaster University,
Canada
- **Chris DeBeer**
University of Saskatchewan,
Canada
- **John Pomeroy**
University of Saskatchewan,
Canada
- **Franziska Koch**
University of Natural Resources and Life Sciences (BOKU),
Austria



The screenshot shows the top section of the 'Hydrological Processes' journal website. It features a blue header with the journal title. Below the header is a dark blue navigation bar with links for HOME, ABOUT, AUTHORS, and BROWSE. The main content area is white and contains a 'Call for Papers' section. The title of the special issue is 'Improving Measurement, Understanding, and Prediction of Alpine Cold Regions Hydrological Processes and Their Sensitivities to Global Change'. The submission deadline is Thursday, 31 December 2026. A paragraph of text describes the INARCH project as a cross-cut project of the GEWEX (Global Energy and Water Exchanges) Hydroclimatology Panel (GHP) of the World Climate Research Programme, aiming to measure and understand high mountain atmospheric, hydrological, cryospheric, biological, and human-water interaction processes, improve their prediction as coupled systems, and diagnose their sensitivities to climate change to promote water sustainability.

Hydrological
Processes

HOME | ABOUT ▾ | AUTHORS ▾ | BROWSE ▾

Call for Papers

Improving Measurement, Understanding, and Prediction of Alpine Cold Regions Hydrological Processes and Their Sensitivities to Global Change

Submission deadline: Thursday, 31 December 2026

The International Network for Alpine Research Catchment Hydrology (INARCH; <https://inarch.usask.ca>) is a cross-cut project of the GEWEX (Global Energy and Water Exchanges) Hydroclimatology Panel (GHP) of the World Climate Research Programme that strives to i) measure and understand high mountain atmospheric, hydrological, cryospheric, biological and human-water interaction processes, ii) improve their prediction as coupled systems, iii) diagnose their sensitivities to climate change and propose how they may be managed to promote water sustainability under global change.

<https://onlinelibrary.wiley.com/page/journal/10991085/homepage/call-for-papers/si-2024-001778>

INARCH Workshop, Innsbruck University Center in Obergurgl, Austria, September 12–14, 2025

- 20 participants, scientific updates (13 talks and 7 posters), discussions, a field excursion to local research sites in the Rofental Catchment and surrounding mountain environments, and socializing
- Science topics: progress on observational and modelling activities, remote sensing initiatives, downscaling, progress with INARCH's COPE, and advancing science outcomes and use of COPE data.
- Discussions on next steps for INARCH, publishing data and science papers, and potential contributions to the International Decade of Action for Cryospheric Sciences.
- After the workshop was the International Mountain Conference in Innsbruck, where the INARCH session, ***High mountain hydrology and cryosphere: observations, modelling, prospects*** was attended by ~200 people.

<https://inarch.usask.ca/news-events/inarch-workshop-2025.php>

Thanks to local hosts: Professors Rainer Prinz, Ulrich Strasser, and Lindsey Nicolson from the University of Innsbruck.



INARCH Statement 2025

- INARCH met in Austria for the first time, hosted by the University of Innsbruck
- Alpine catchment studies continue, # of COPE sites are expanding and many are ready to apply for INARCH Research Catchment status. INARCH basins provide essential reduction in uncertainty in precipitation at high elevations and their lapse rates.
- Coupled glacio-hydrological and subsurface hydrological models have been developed and are being applied to diagnose INARCH basins.
- Advanced remote sensing products, surface observing techniques and multi-scale models are being applied to INARCH basins over the COPE period and compared to datasets. More needs to be done and more datasets made available in the GWFNet system. COPE questions need to be addressed. A selection of INARCH catchments will be used to validate new remote sensing products.
- INARCH is delivering new research and novel prediction and monitoring capabilities for IYGP and DACS, including global prediction products through improvement in land surface schemes, microphysics, wind flow and downscaling.
- INARCH is developing new science questions around **downscaling atmospheric forcings, albedo depression from contaminants and bioalbedo, ephemeral snow hydrology, influence of snow and ice on runoff efficiencies, transient vegetation, glacier, surface and subsurface water storage changes with climate, and coupling physically based models with flowpath understanding from isotopes**. This could lead to globally coordinated studies comparing cryospheric-hydrological responses in mountains around the world.
- Inter-institutional collaborations including community of practice, workshops, lab exchanges could accelerate collaborations and comparative outputs.
- INARCH will reapply as a GEWEX crosscut project in 2026.

INARCH Workshop, Kananaskis, Alberta, Canada, September 8–10, 2026

- Completing INARCH's Common Observing Period Experiment (COPE): model trials at various sites, testing algorithms, various structures, forcing data and the need for dynamical downscaling or other solutions;
- Major advances in observing systems that we will want to document;
- Issues of how to upscale hydrological, cryosphere, and meteorological models from INARCH sites to regional products and predictions of various types; and
- Plan renewal of INARCH as a Cross-Cutting project in GEWEX and priority science questions and themes.

We will tour the Fortress Mountain Research Basin



Global Water Futures Observatories (GWFO): Canada's Water Observation and Prediction Infrastructure

- GWF ended in 2025
- GWFO now supports the next generation of hydroclimate science
- National infrastructure for observations, data, and prediction support
- Supported by the Canada Foundation for Innovation's Major Science Initiatives Fund (CFI-MSI), 2023–2029, and renewable thereafter



GWFO Vision

To operate a national freshwater research facility that supports critical water research to safeguard Canadian water resources in an era of rapid change.



GWFO Mission

- Operate as **Canada's premier national freshwater research facility** in support of national water management through governments, industry and communities
- Provide **essential data** for researchers and others to develop sustainable water resource management solutions
- **Inform development** and evaluation of computer modelling and analytical tools for water-related disaster warning and water quantity and quality predictions
- **Support prediction** of future water flows and quality and quantitative support for adaptation to climate change and risk management
- **Disseminate freshwater data** to provincial, territorial and federal government agencies, industry, agriculture, communities and other researchers
- **Support finding solutions** to user-defined questions that will help Canada and the world achieve water sustainability in a time of rapid global change.
- **Provide deep water data** from water observations, managed using a state-of-the-art system, to a wide range of users

GWFO leads and supports the Canadian RHP

Predictions

- Forcing, validation, and benchmarking datasets for hydrological and land-surface models.
- Development and evaluation of models such as MESH, CHM, CRHM, SUMMA and related systems. Recent future hydrology predictions for Mackenzie (Elshamy et al., 2025) and Saskatchewan (Yassin et al., 2026) river basins
- Field verification of new hydrometeorological process algorithms - snow interception (Cebulski and Pomeroy, 2026), permafrost thaw (Elshamy et al., 2025), complex terrain evapotranspiration (Rohanizadegan et al., 2025), depression storage effects on variable contributing area for runoff (Shook & Pomeroy, 2025)
- Diagnostic model evaluation and prediction experiments.

Community Coordination

- Support INARCH, DACS, WMO, UNESCO-IHP, and other international initiatives.
- Coordinate academic researchers, government agencies, and operational users.
- Provide training, workshops, and technical expertise.

Applications

- Support water forecasting, drought monitoring, flood preparedness, wildfire risk assessment, and water resources management through data and infrastructure services.

GWFO's contribution to GEWEX is to provide the sustained observations, data management, and modelling infrastructure along with resulting hydroclimate science, prediction, and services.

Research Enabled by GWFO

Canadian Challenge

What GWFO Enables

Floods, drought & water supply

Continuous hydroclimate observations and improved prediction

Changing snow, glaciers & permafrost

Long-term mountain and northern observations

Water quality & ecosystem health

Lakes, rivers, groundwater and Great Lakes monitoring

Agriculture, cities & land-use change

Prairie agricultural, groundwater and emerging urban observatories



GWFO does not fund these science programs—the infrastructure and data make them possible.



GLOBAL WATER FUTURES
OBSERVATORIES

Awarded
\$ 15.25 M



over 6 years

2023-2029

from

INNOVATION
Canada Foundation
for Innovation / Fondation
canadienne pour l'innovation

Brought in by GWFO

65.4 M
leveraged in research grants,
partnerships, and in-kind support

Nationwide Network



75

Freshwater
Observatories



18

Water
Laboratories



15

Deployable
Systems

Partner Institutions



By The Numbers

(2023-2026)

Current Data & Facility Users

2025 - 2026



65,231

data & facility users



38

facility leads



37

major research
data users

Scientific Outputs

2175



650

peer-reviewed
publications



1136

conference
presentations



72

databases,
code,
software



120

newsletter and
magazine articles



11

conference
proceedings



19

technical /
consultancy
reports



21

books/chapters



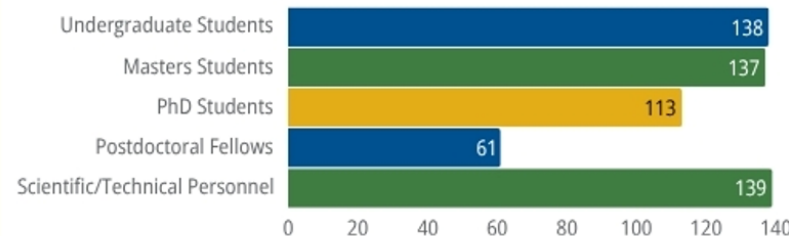
146

student theses

Currently Supports

588

Highly Qualified Personnel
2025 - 2026



Outreach



200

courses, workshops, training



311

stakeholder or public events



382

media interviews, broadcasts, podcasts

External Collaborators



United Nations



2025
International Year of Glaciers
Preservation



2025
2034 Decade of Action
for Cryospheric
Sciences

INARCH and the UN Decade of Action for Cryospheric Sciences 2025–2034

INARCH Contributions to World Glacier Day 2026 and DACS Launch

- **UNESCO Headquarters, Paris (18–19 March 2026)**
 - INARCH played a central role in the World Glacier Day and World Water Day celebrations at UNESCO Headquarters in Paris.
 - Events brought together UNESCO, WMO, UN agencies, scientists, and policy leaders to close the International Year of Glaciers' Preservation (IYGP) and launch the Decade of Action for Cryospheric Sciences (DACS), 2025–2034.
- **INARCH-Led Side Event “Integrated Observation and Prediction Systems”**

The INARCH side event focused on:

 - Gaps in mountain and polar cryosphere observations.
 - Challenges in monitoring snow water equivalent, glacier mass balance, and permafrost.
 - Integration of observations with prediction systems.
 - Improving hydrological and cryospheric forecasts through coordinated international observing networks.

INARCH is becoming a major scientific coordination mechanism for mountain observations and prediction within DACS



INARCH and the Decade of Action for Cryospheric Sciences 2025–2034

INARCH Contributions to World Glacier Day 2026 and DACS Launch

Two Scientific Panels

- **Monitoring Panel**

- Examined spatial and elevational gaps in mountain observations.
- Evaluated emerging technologies and observing strategies.
- Discussed global needs for snow, glacier, and permafrost monitoring.

- **Prediction Panel**

- Addressed limitations in mountain hydrological and cryospheric prediction.
- Highlighted the need for integrated observation–modelling systems.
- Discussed priorities for improving predictive capability across mountain regions.

Outcomes

- Demonstrated INARCH's role as a global coordinator of mountain observation and prediction activities.
- Elevated COPE as a framework for international cryosphere-hydrology observations.
- Strengthened connections among GEWEX, UNESCO-IHP, WMO Global Cryosphere Watch, and DACS.
- Positioned INARCH to contribute directly to DACS implementation over the coming decade.



DACS Overarching Challenges and Milestones



2025
2034
Decade of Action
for Cryospheric
Sciences

OC1 Global Cryosphere Monitoring

Build a Global
Cryosphere
**Monitoring
Inventory.**

Enhance **Monitoring
Capabilities.**

Make **Observations
Actionable**

OC2 Actionable Cryosphere Prediction

Cryosphere
**Modelling for
Decision Making.**

**Inclusive Cryospheric
Prediction**

Creation of a
**Decision and
Outreach Toolkit**

OC3 Cryospheric Risk Management Solutions

Global **Cryosphere
Risk Assessment**

Cryosphere Loss
**Vulnerability
Assessment**

**Operationalise
Cryosphere Risk
Management
Solutions**

OC4 Adaptation to Cryosphere Loss

Incorporate
Cryosphere Loss into
Adaptation Strategies

**Co-develop
Adaptation Strategies**

Establish a Global
Cryosphere
**Adaptation
Knowledge Hub.**

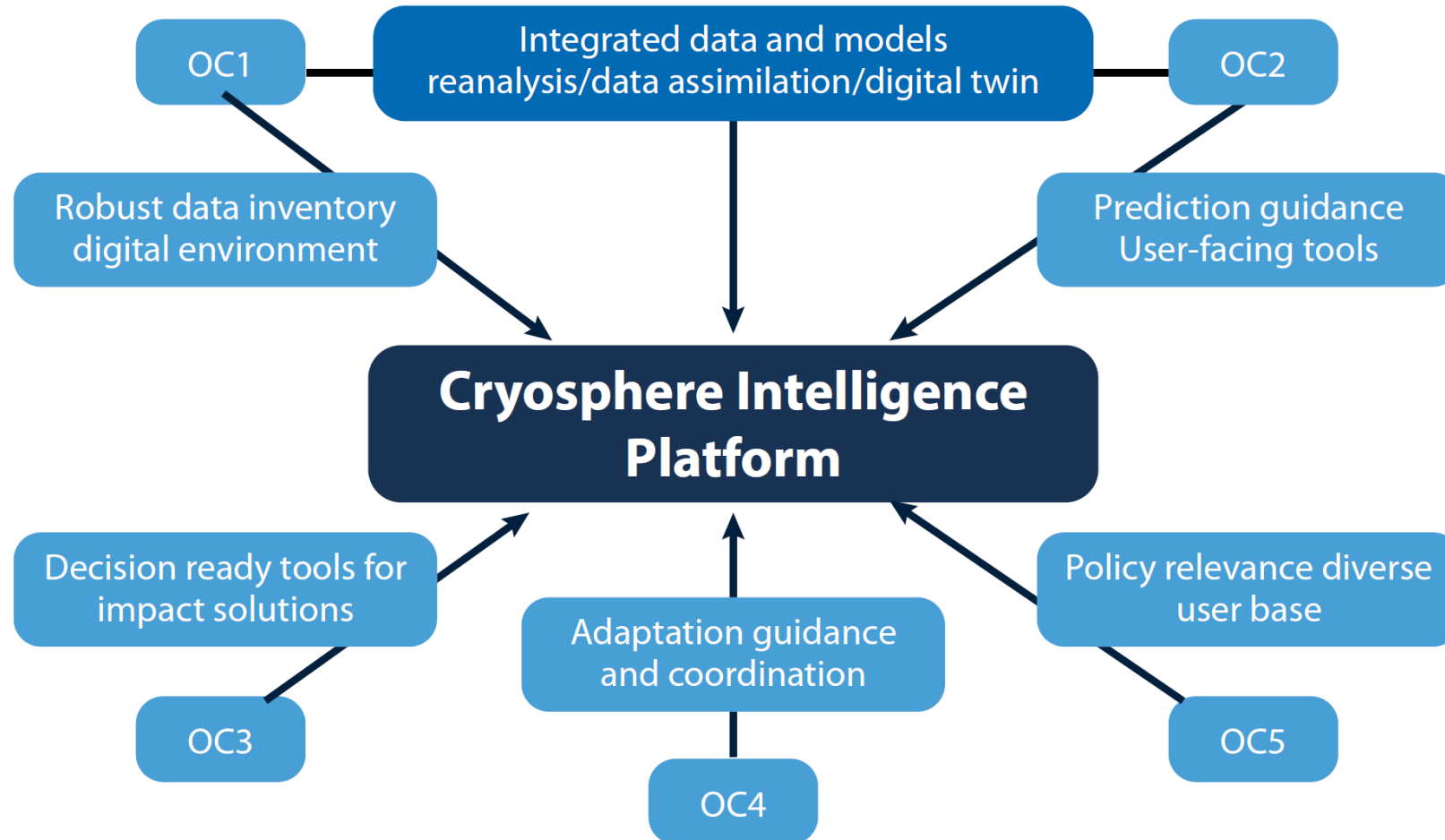
OC5 Amplify the Impact of Cryosphere Science

**Policy Integration
and Engagement**

Global Cryosphere
**Outreach and
Communication**

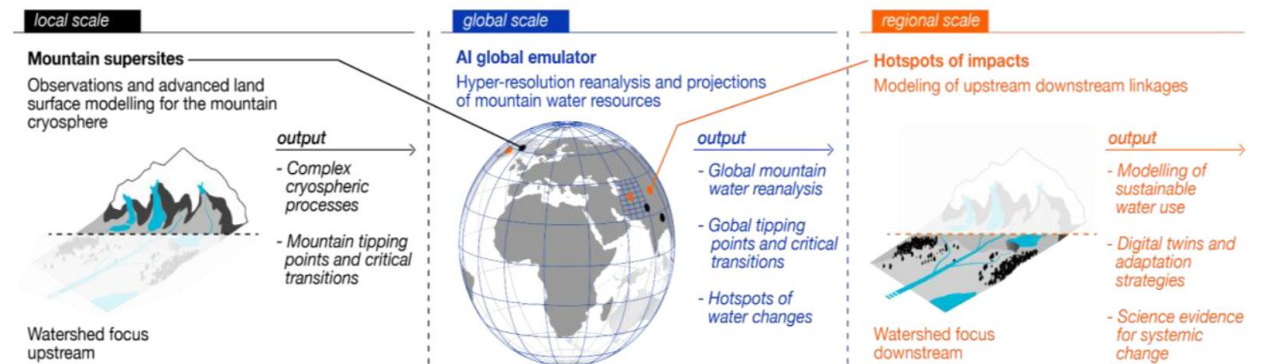
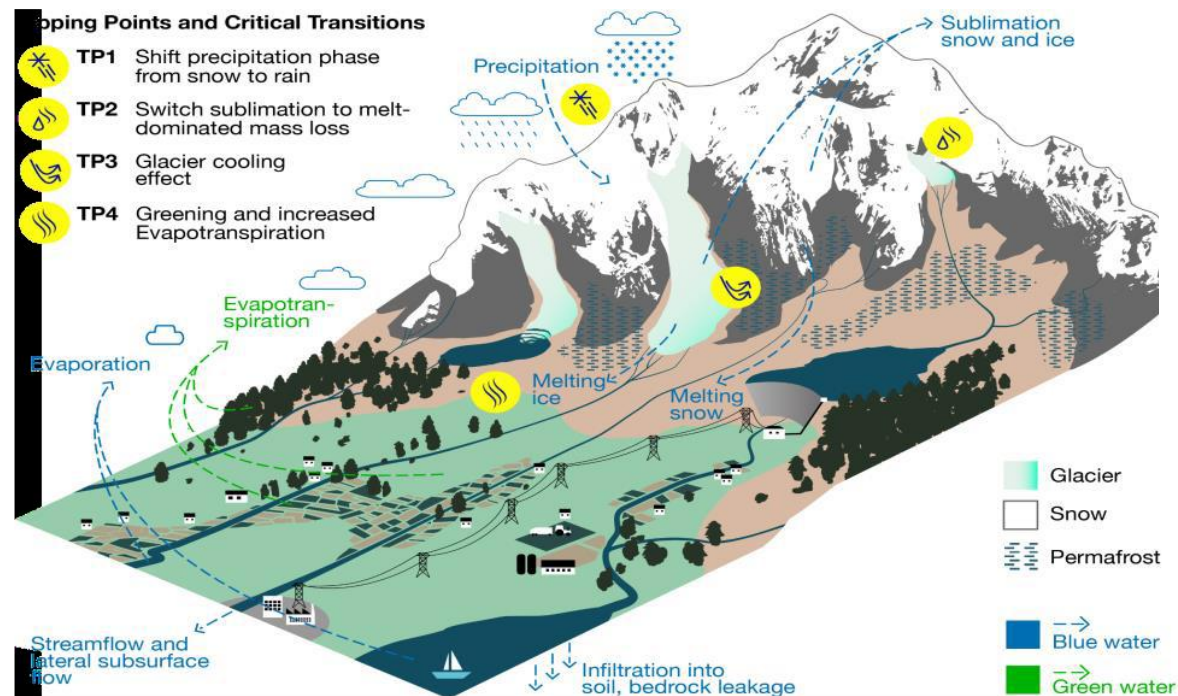
**Education and
Capacity Building**

Cryospheric Intelligence Integrates the Decade



Schmidt Sciences: Virtual Institute for the Earth's Water

- Water from the mountains: global reanalysis and future tipping points (MountAInWater) – project led by Francesca Pellicciotti (ISTA Austria) and Walter Immerzeel (U Utrecht) 2026-2031
 - Austria: ISTA, Canada: University of Saskatchewan, Netherlands: Wageningen University, FutureWater, Climate Adaptation Services Foundation, Switzerland: University of Zurich, Lausanne University, Norway: Oslo University, Germany: Technical University of Munich



4 Work Packages

WP1. Supersites of advanced knowledge on the mountain cryosphere

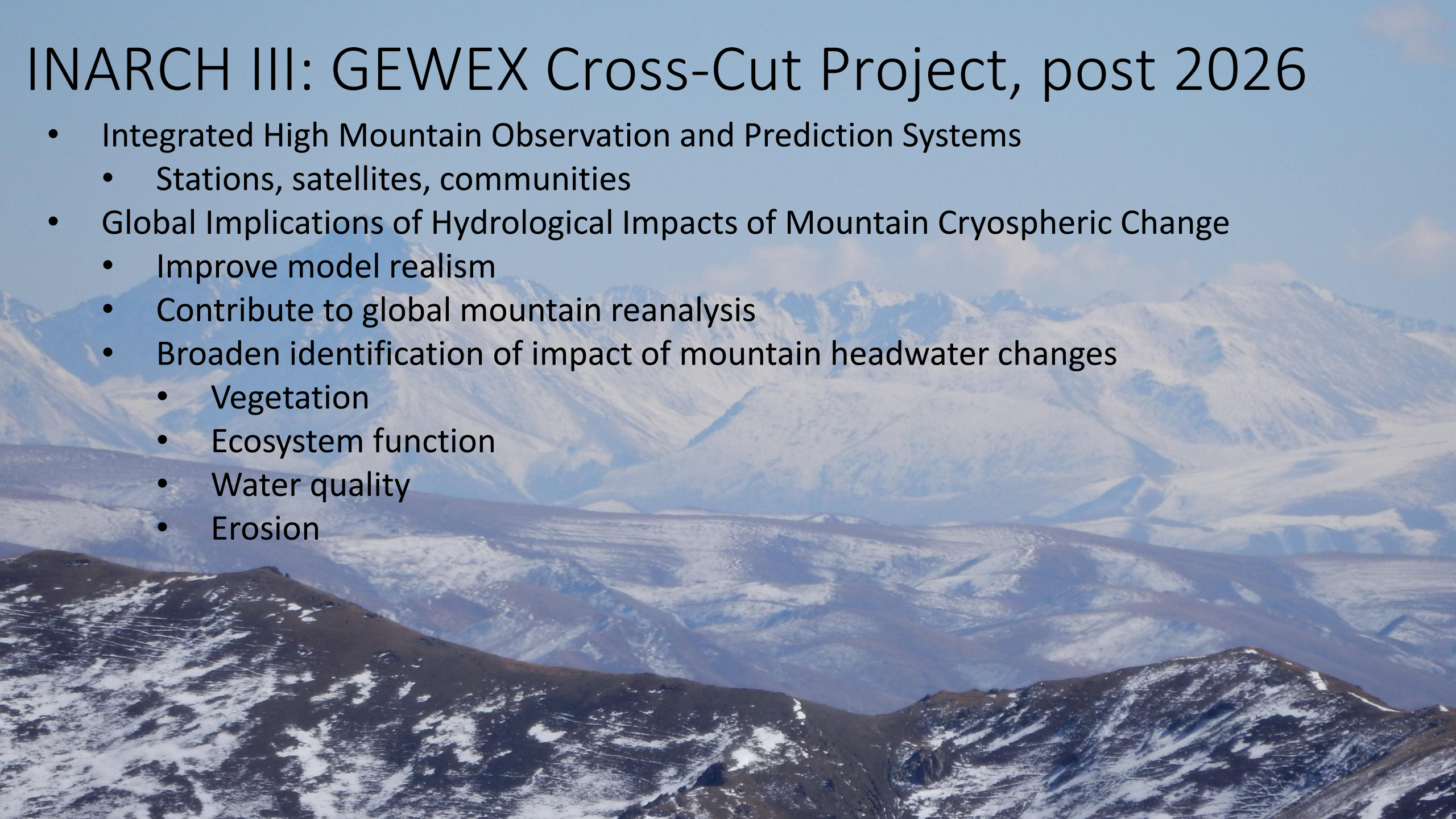
WP2. Global mountain water reanalysis and future projections

WP3. Hotspots of impacts and water management

WP4. Responsive science

INARCH III: GEWEX Cross-Cut Project, post 2026

- Integrated High Mountain Observation and Prediction Systems
 - Stations, satellites, communities
- Global Implications of Hydrological Impacts of Mountain Cryospheric Change
 - Improve model realism
 - Contribute to global mountain reanalysis
 - Broaden identification of impact of mountain headwater changes
 - Vegetation
 - Ecosystem function
 - Water quality
 - Erosion



Carry on the Distinctive Tradition of Innovative Mountain Hydrology Observations

