

International Network for Alpine
Research Catchment Hydrology

Summary and Overview of INARCH Phase II Activities and Progress

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GEWEX Hydroclimatology Panel (GHP) Meeting, Maynooth, Ireland

July 5–7, 2023

<https://inarch.usask.ca>



Image: Baños de Panticosa, Spain (C. DeBeer)



About INARCH

- A cross-cut project of the GEWEX Hydroclimatology Panel (GHP) 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 56 research scientists, 38 experimental research basins in 18 countries and six continents.
- Phase II, 2021–2026, with refined science questions and activities is well underway.
- UNESCO has recently approved a UNESCO Chair in Mountain Water Sustainability that INARCH can formally contribute to.

INARCH Linkages

- GEWEX Hydroclimatology Panel (GHP) Projects
 - Cold/Shoulder Season Precipitation Near 0°C project
 - Global Water Futures / GWF Observatories
 - Western US RHP & Water for Foodbaskets
 - ANDEX RHP Initiative for the Andes
- Global Cryosphere Watch
- WMO-SPICE and WMO High Mountain Summit
- TPE (Third Pole Environment)
- Future Earth, Sustainable Water Futures Programme (SWFP) and the Climate Impacts on Global Mountain Water Security working group
- International Commission for Snow and Ice Hydrology (ICSIH)
- UNESCO-Intergovernmental Hydrological Programme (IHP) and UNESCO Chair in Mountain Water Sustainability



United Nations
Educational, Scientific and
Cultural Organization



Intergovernmental
Hydrological
Programme

Participants



1st Kananaskis, Canada 2015



2nd Grenoble, France 2016



3rd INARCH Workshop Schneefernerhaus Zugspitze Germany 7. - 9. February 2018



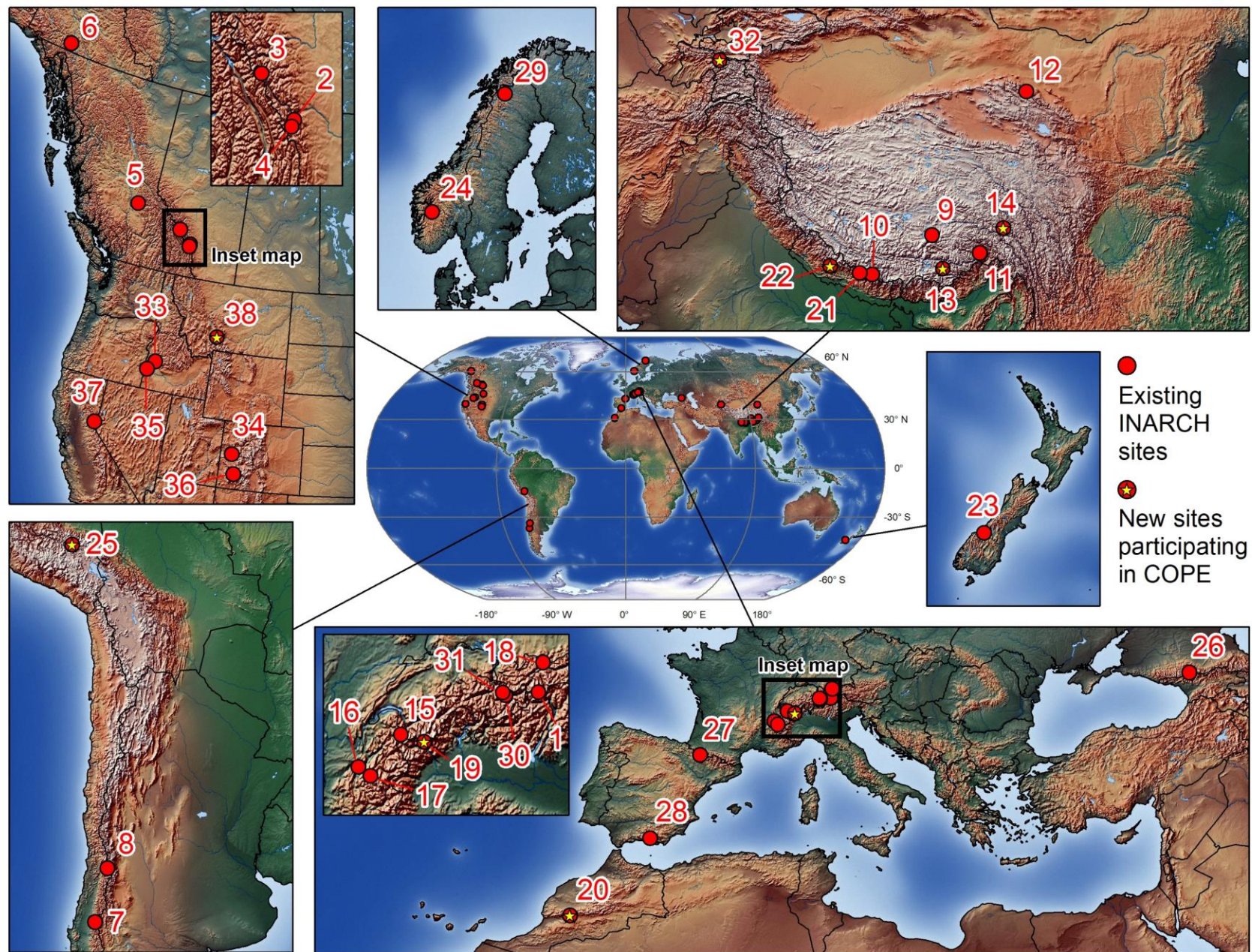
4th Portillo, Chile 2018

- Matthias Bernhardt
- Stefan Achleitner
- Tobias Jonas
- Carlo Maria Carmagnola
- Joseph Michael Shea
- Chris DeBeer
- John Faulner Burkhardt
- Sara McKenzie Skiles
- Georg Kaser
- Rebecca Mott -Grünwald
- Ingrid Reiweger
- Brian Manounos
- Stefan Weishaupt
- Michael Weber
- Ethan Gutman
- Daniel Günther
- Reiner Prinz
- Christopher B. Marsh
- Karsten Schütz
- Vincent Vionnet
- Markus „Wasti“ Weber (photographer)
- Timothy Link
- James McPhee
- John Pomeroy
- Cecile Menard
- Charalampou Charalampidis
- Robert Sandford
- Roy Rasmussen
- J. Ignacio Lopez-Moreno

INARCH Basins

- Austria** 1. Rofental Open Air Laboratory (OpAL);
Canada 2. Marmot Creek Research Basin; 3. Peyto Glacier; 4. Fortress Mountain Snow Observatory; 5. Quesnel River Research Basin; 6. Wolf Creek Research Basin;
Chile 7. Valle Hermoso, Upper Diguillín River Basin; 8. Estero Las Bayas, Upper Maipo River Basin;
China 9. Nam Co Monitoring and Research Station for Multisphere Interactions; 10. Qomolangma Atmospheric and Environmental Observation and Research Station; 11. Southeast Tibet Observation and Research Station for the Alpine Environment; 12. Upper Heihe River Basin; 13. Yala Shampo Cryosphere Hydro-Ecological Station*; 14. Changdu Ecological Monitoring Station*;
France 15. Arve Catchment; 16. Col de Porte Experimental Site; 17. Col du Lac Blanc Experimental Site;
Germany 18. Schneefernerhaus and Research Catchment;
Italy 19. Torgnon Ecosystem Station*;
Morocco 20. Rheraya Catchment, High Atlas Mountains*;
Nepal 21. Langtang Catchment; 22. Hidden Valley, Himalayas*
New Zealand 23. Brewster Glacier;
Norway 24. Finse Alpine Research Centre;
Peru 25. Salcca-Sibinacocha Catchment*;
Russia 26. Djankuat Research Basin;
Spain 27. Izas Research Basin; 28. Guadalfeo Monitoring Network;
Sweden 29. Tarfala Research Catchment;
Switzerland 30. Dischma Research Catchment; 31. Weissfluhjoch Snow Study Site;
Tajikistan 32. Kyzylsu Glacier and Monitoring Sites*;
United States of America 33. Dry Creek Experimental Watershed; 34. Grand Mesa Study Site; 35. Reynolds Creek Experimental Watershed; 36. Senator Beck Basin Study Area; 37. Sagehen Creek, Sierra Nevada; 38. Bridger Range*.

*new sites participating in the Common Observing Period Experiment (COPE)



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

A New INARCH Vision

- Improve mountain hydrometeorological and related observations, understanding and predictions to help adapt to rapid climate change.
- Implement recommendations from the WMO High Mountain Summit—integrated observation and prediction systems. *How can we build up integrated prediction systems around these research basins and apply them to the larger earth systems that derive from mountains, and what does it take to do that?*
- Science for society. *Can we contribute to the development of ‘fit-for-purpose’ hydrological, meteorological and climate information services in high mountain catchments?*
- Mountain systems include human-water interactions and complex ecological interactions – *how can we address this in our models? Can we use these to develop solutions to help achieve water sustainability in high mountain river basins and downstream?*



INARCH Phase II Science Questions



1. How different are the observation and measurement approaches amongst INARCH basins and do we expect distinctive differences in our understanding of basin response and hydrological predictability because of the sampling schemes, and data quality and quantity?
2. How do the predictability, uncertainty and sensitivity of energy and water exchanges vary with changing atmospheric thermodynamics, ecosystem structure and water management in various high mountain regions of the Earth?
3. What improvements to high mountain energy and water exchange predictability are possible through improved physics in, coupling of, and downscaling of models in complex terrain, and improved and expanded approaches to data collection and assimilation?
4. To what extent do existing model routines have global validity, are transferable, and meaningful in different mountain environments for providing service to society?
5. Can mountain systems be predicted and managed to find solutions to help achieve water sustainability in river basins under climate change?

Eventually contribute to answering - How have mountain atmospheric-cryospheric-hydrological-ecosystem-human systems co-evolved to their current states and how will they respond to climate change over the next century?

Common Observing Period Experiment (COPE)

2022–2024

- This initiative provides an opportunity for inter-comparisons across the global network of INARCH research sites and basins, and to coordinate our own efforts and response to some of the observations and data and also coordinate the modelling.
- Plan to take different models, apply them across basins, examine impact of different forcing data and process representations and model structures, calculate snow and ice dynamics and hydrological responses, and look at these diagnostically using observations.
- COPE aims to produce a common, coherent, and well-documented and described dataset of mountain meteorology and hydrology from INARCH basins over the two-year period at a minimum, and longer where possible.

Common Observing Period Experiment (COPE)

2022–2024

- focusing on obtaining high-quality measurements,
- ensure all sensors are working,
- enhance observations at our mountain research basins,
- fly supplementary UAV acquisitions,
- run high resolution models and
- work together for comparison of processes, data sharing, and model testing in challenging environments
- <https://inarch.usask.ca/science-basins/cope.php>



Common Observing Period Experiment (COPE)

2022–2024

- This will allow us to address INARCH Phase II Science Questions #1 and #4, and indirectly address the others:
- 1. How different are the observation and measurement approaches amongst INARCH basins and do we expect distinctive differences in our understanding of basin response and hydrological predictability because of the sampling schemes, and data quality and quantity?
- 4. To what extent do existing model routines have global validity, are transferable, and meaningful in different mountain environments for providing service to society?
- COPE is well underway with active fieldwork, observation campaigns, modelling initiatives, and data management planning.

INARCH Workshop, Baños de Panticosa, Spain, October 18-20, 2022

- ~30 scientists; first in-person workshop since start of pandemic;
- Hosted by Ignacio López Moreno and Institute for Pyrenean Ecology, Spanish National Research Council.
- Topics:
 - Observatories and Measurement Techniques
 - Predictions, Comparisons, and Global Validity
 - Common Observation Period Experiment (COPE) and Data Management
- Meeting report in GEWEX Quarterly https://www.gewex.org/gewex-content/files_mf/1677625320Q12023.pdf



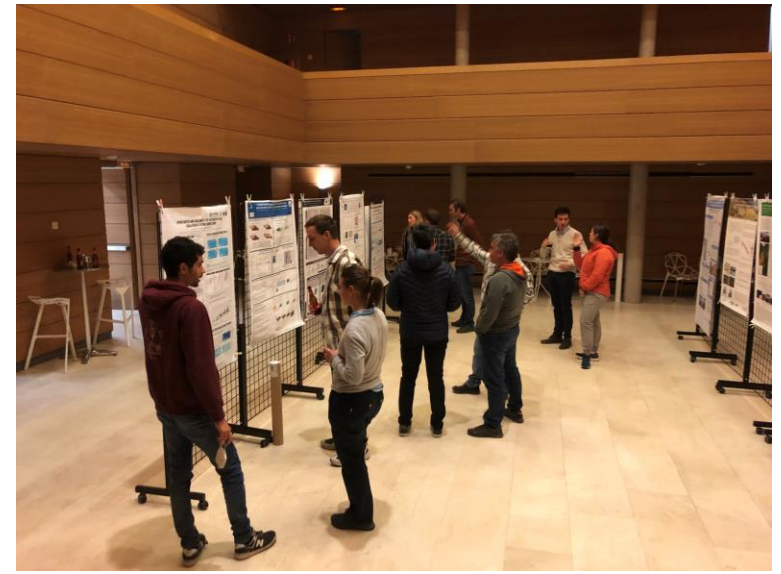
GEWEX QUARTERLY Vol. 33, No. 1 | Quarter 1 2023

GEWEX is a Core Project of the World Climate Research Programme on Global Energy and Water Exchanges

Updates from the International Network for Alpine Research Catchment Hydrology

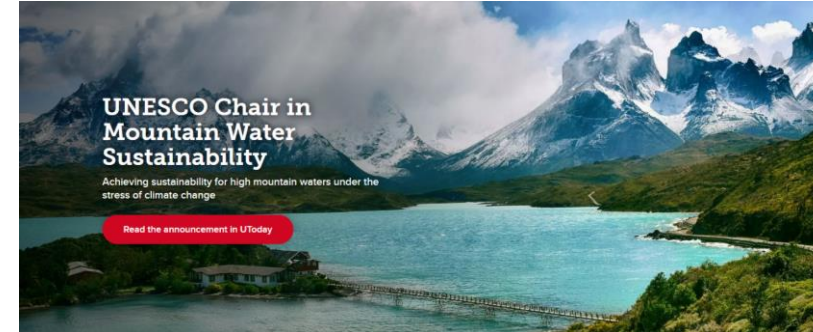
This map of INARCH's instrumented research basins and experimental sites as of 2022 illustrates the network at the center of the cross-cutting activity. These basins and sites serve as testbeds for detailed process studies on mountain hydrology and meteorology, improving our understanding of alpine catchment hydrology. For more, see Pielke et al., page 10.

News and General Interest	General Interest (Cont'd)	Meeting Reports
<ul style="list-style-type: none">• Wetland gained over 30 years of GEWEX (p. 2)• Recent GEWEX SSC and Panel members (p. 3)• New GEWEX initiative on improving groundwater modeling (p. 3)• LSP explores the remote effect of Tibetan Plateau spring temperature and identifies high mountain land temperature as a predictor for the onset of spring precipitation predictability (p. 7)	<ul style="list-style-type: none">• INARCH offers to increase its role in alpine catchment hydrological processes (p. 10)• The Pielke study group sets the stage for a new and larger-scale simulation: interpretations to deliver into rotation (p. 11)	<ul style="list-style-type: none">• INARCH, a GWP Network, meets to work towards a better understanding of earth system processes and their interactions in the Pyrenean Basin (p. 14)• Workshop on the role of early catchment hydrology in contributing to Earth observations and global hydrological data access and availability, technology and technique handling and collaboration during pre-workshop (p. 15)



Other Recent Activities and Updates

- World Meteorological Organization's INFCOM Workshop on Coupling of Cryosphere in Numerical and Earth System Models and First Meeting of the Global Cryosphere Watch Advisory Group in Oslo, Norway in March 2023.
- UN Water Conference: first major water conference in 47 years at UN headquarters in NYC during World Water Week, March 2023
- UNESCO Chair in Mountain Water Sustainability <https://research.ucalgary.ca/unesco-chair-mountain-water-sustainability>
- UN International Year for Glaciers' Preservation - 2025



2025 is declared as the International Year of Glaciers' Preservation

International Year of Glacier Preservation 2025

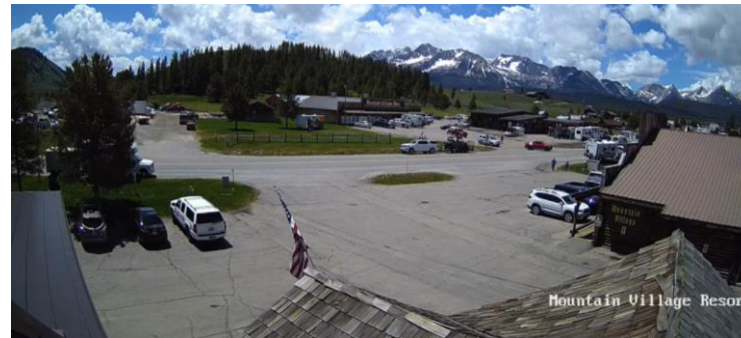
- *To raise awareness of the world community about the intensive reduction of world snow and ice resources and the potential risks of this process,*
- *To give a special impetus to a new movement at the global level to take the necessary measures and actions to protect glaciers from intense melting and disappearance,*
- *To mobilize financial resources from various sources to implement these actions and tasks,*
- *To improve international cooperation and establish an international mechanism to facilitate access to accurate and timely information on the cryosphere.*

Scientific Milestones

- Global assessment of glacier extent and depth, including rock-covered glaciers, seasonal snowpacks and recent rate of change, in light of historical rates of change- update of Randolph Inventory
- Renewal of organization of glacier and snow observation systems in former IHD basins around the world
- Global assessment of historical glacier and snowpack contribution to freshwater supplies delivered to oceans and to hydrological systems in the major river basins of the world
- Global predictions of glacier and snow mass balance and freshwater contributions to oceans and hydrological systems to the end of the 21st C and into the 22nd C.
- Glacier and snowpack information system development and capacity building events to train the next generation of cryospheric scientists and water managers
- Incorporation of Indigenous knowledge systems in managing changing water supplies in high mountain communities

INARCH Workshop, Stanley, Idaho, USA, October 9–11, 2023

- The next in-person INARCH Workshop will be held October 9–11, 2023 in Stanley, Idaho, USA
- Professor James McNamara, Boise State U., and Dr. Andrew Hedrick, USDA Agricultural Research Service, will be our 2023 workshop hosts
- Scientific sessions, posters, discussion, and planning for COPE outputs
- Field trips to Dry Creek and Reynolds Creek Research Basins



Observe, Predict, Protect

