International Network for Alpine Research Catchment Hydrology

Summary and Overview of INARCH 2023

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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 I, 2015-2000, implemented a network of mountain research basins, developed mountain hydrometeorological models and published openly shared observations.
- 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 0ºC 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

GEWEX

ANDEX

TPE THIRD POLE ENVIRONMENT

WORLD METEOROLOGICAL ORGANIZATION

waterfuture Sustainable Water Future Programme

IAHS AISH

UNESCO United Nations Educational, Scientific and Cultural Organization

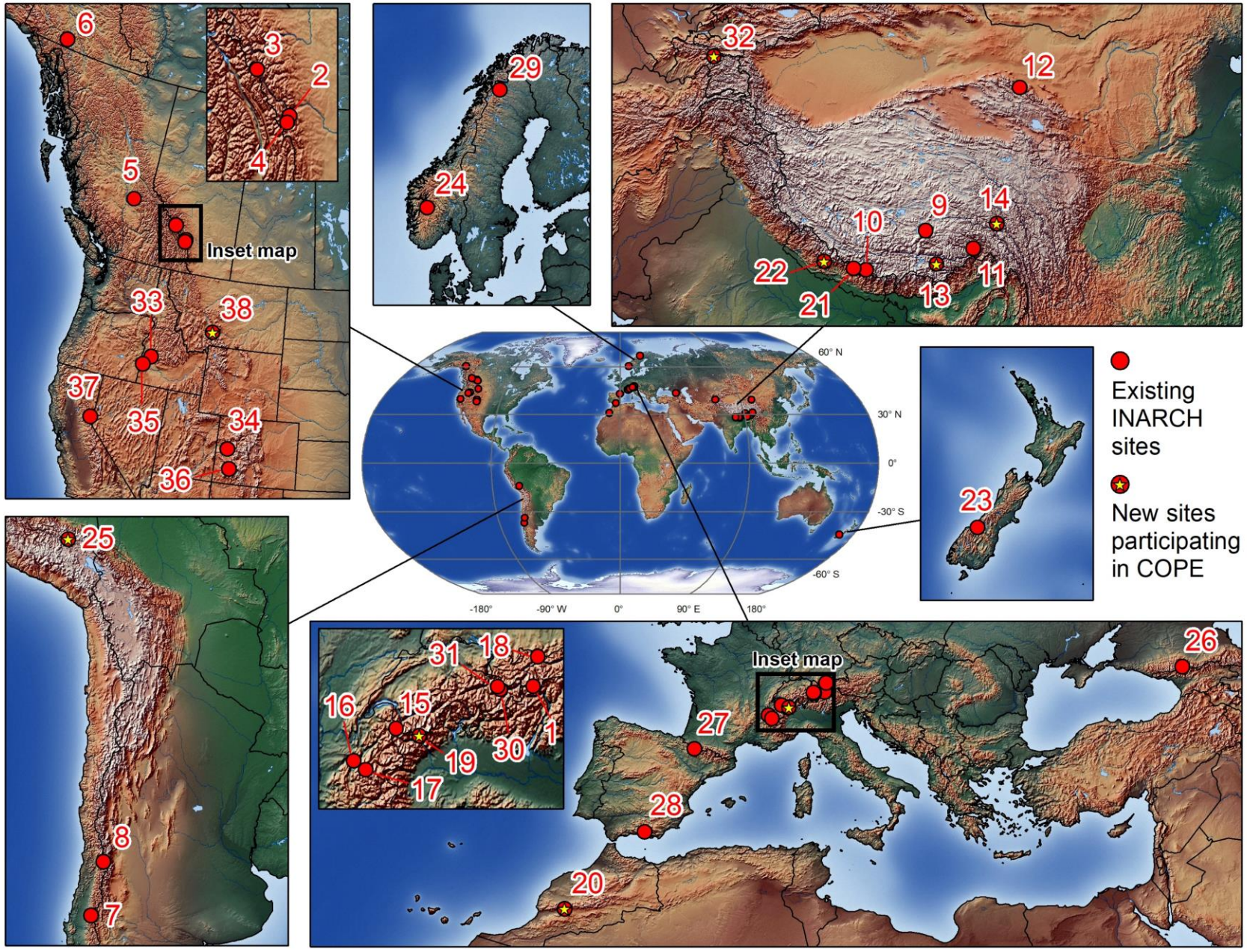
Intergovernmental Hydrological Programme

Participants

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 Catchement; **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?

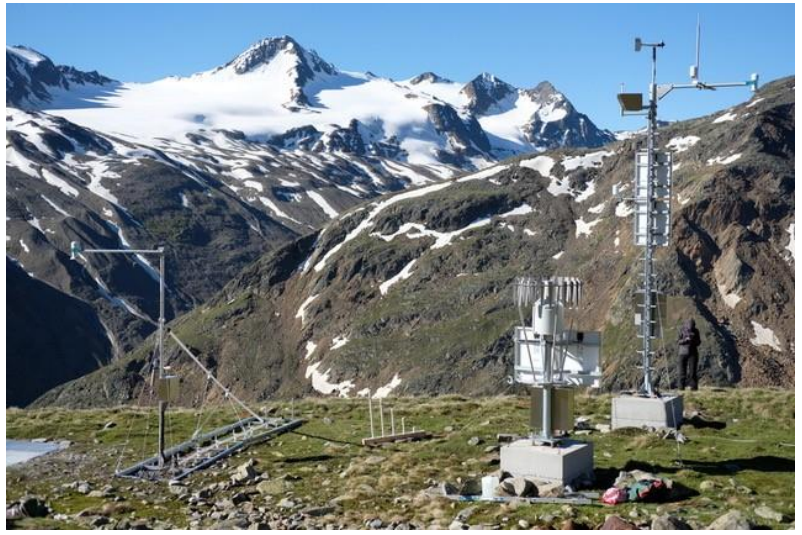
Eventually contribute to answering - How have mountain atmospheric-cryospheric-hydrological-ecosystem-human systems co-evolved to their current states and how will they respond to climate change over the next century?

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

WCRP

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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

Inside This Edition

News and General Interest

General Interest (Cont'd)

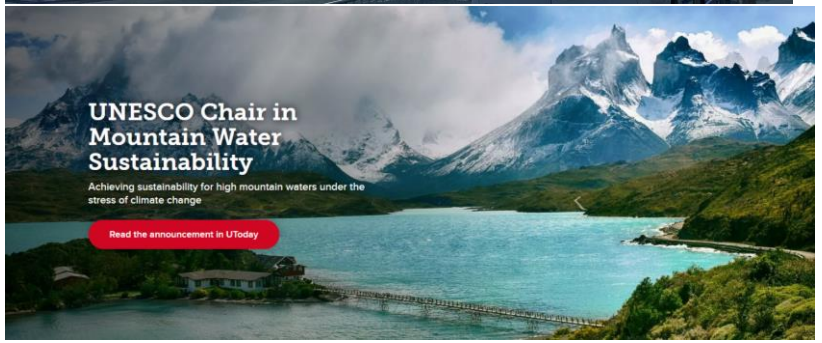
Meeting Reports


VENTA SANCHO
SOUVENIRS
ALIMENTACION
TABAC - BAR
TAPAS-GRILL


Status and Prospects for MARCH

Other Recent Activities and Updates

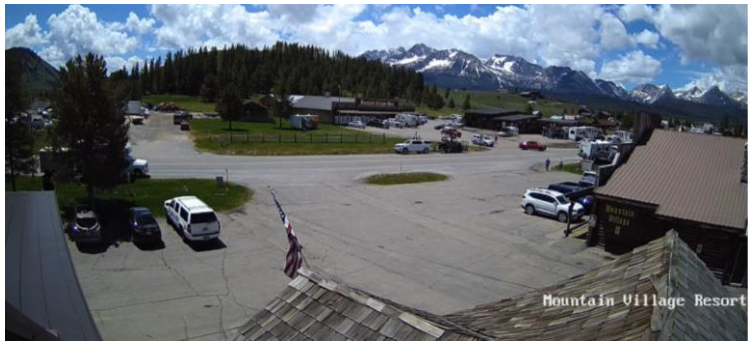
- World Meteorological Organization's INFCOM Workshop on Coupling of Cryosphere in Numerical and Earth System Models and First Meeting of the Global Cryosphere Watch Advisory Group in Oslo, Norway in March 2023.
- UN Water Conference: first major water conference in 47 years at UN headquarters in NYC 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

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

- Stanley, Idaho, USA
- Professor James McNamara, Boise State U., and Dr. Andrew Hedrick, USDA Agricultural Research Service, are our 2023 workshop hosts
- Scientific sessions, discussion, and planning for COPE supported science



MOUNTAIN VILLAGE RESORT
STANLEY, IDAHO

What is on the Horizon?

UN 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

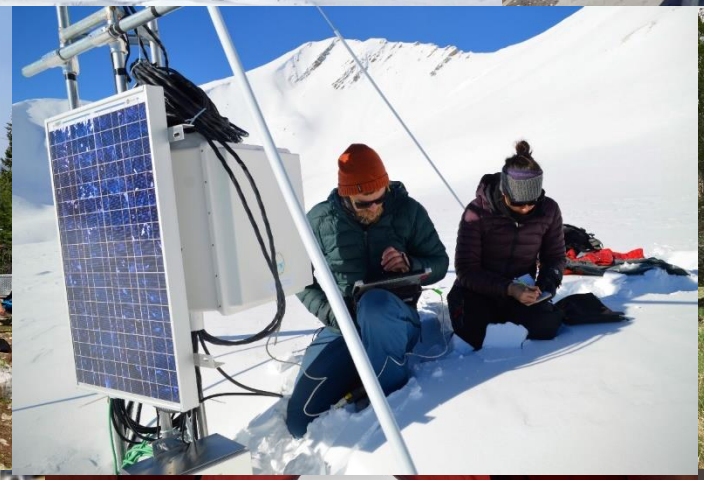
- **Global assessment of glacier** extent and depth, including rock-covered glaciers, seasonal snowpacks and recent rate of change, in light of historical rates of change- update of Randolph Inventory
- Renewal of **organization of glacier and snow observation systems** in former IHD basins around the 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

Global Water Futures Observatories (GWFO)

Solutions oriented network of world class observation sites and laboratories









Global Water Futures Observatories 2023-2029

INNOVATION

Canada Foundation for Innovation

Fondation canadienne pour l'innovation

UNIVERSITY OF SASKATCHEWAN
Global Water Futures
GWF.USASK.CA

CANADA FIRST RESEARCH EXCELLENCE FUND

APOGÉE CANADA FONDS D'EXCELLENCE EN RECHERCHE

University of Saskatchewan

University of Waterloo

McMaster University

Laurier Inspiring Lives.

Carleton University

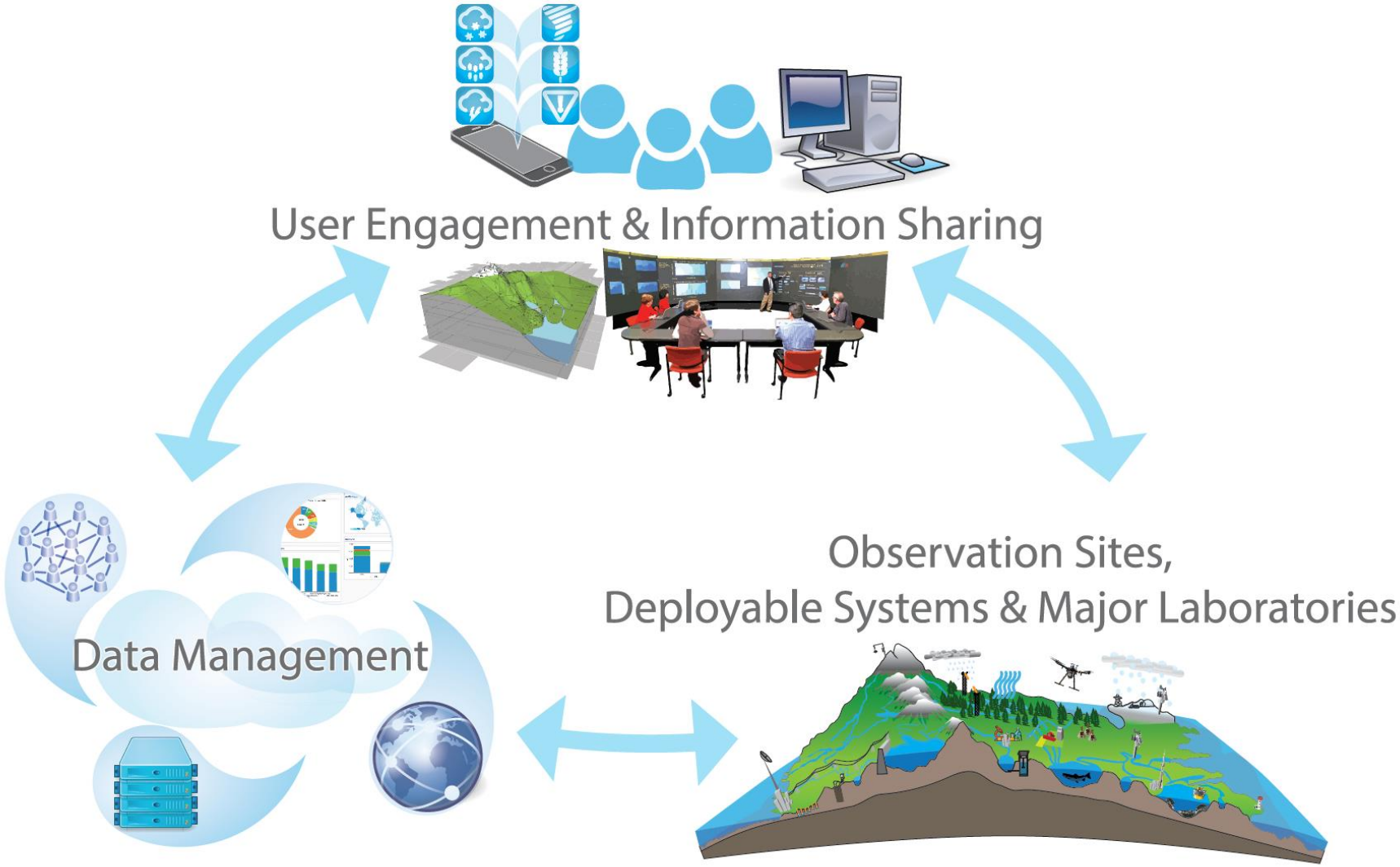
University of Toronto Scarborough

Trent University

Western University · Canada

University of Windsor

GWFO: Big Data for Water Sustainability Solutions



National and Global Need for GWFO

- GWFO research basins, systems and laboratories support development of solutions for
  - Great Lakes health
  - Mountain climate change
  - Irrigation and agriculture
  - Flood and drought prediction
  - Climate change adaptation
  - Water sustainability

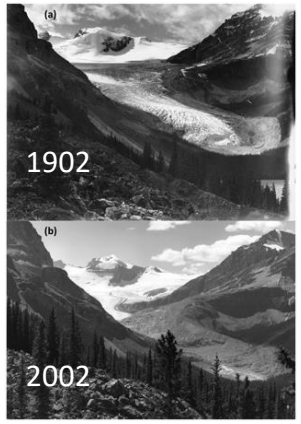
- Nearly 500 groups across Canada use our information

- Model developments used around the world.

- GWF and CFI legacy will disintegrate without technical teams to operate and integrate observational infrastructure

GWFO Progression

Peyto Glacier, Banff NP, AB



Trail Valley Creek, NT

Global Water Futures Observatories (GWFO) brings universities and others together from across Canada to modernize observations and infrastructure

- Models become globally applicable
- Pan-Canadian collaborations are developed
- Information support for water management

Water monitoring installations by provincial and federal agencies

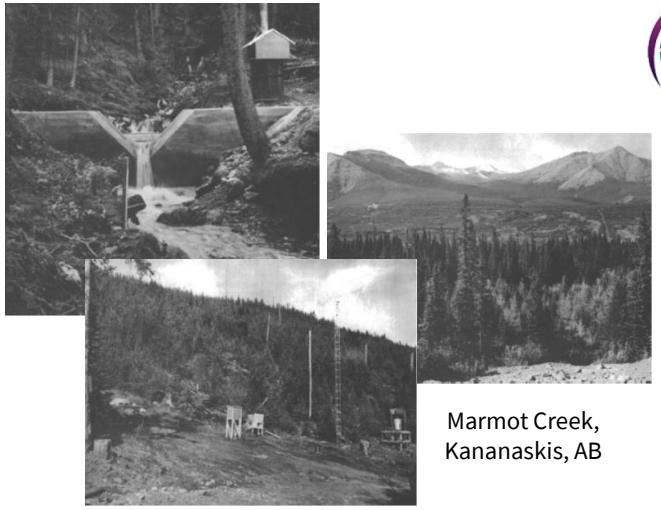
Water monitoring infrastructure assumed by universities; data amalgamated; process understanding generates early models

1960's

1980's

2000's

2020's



Marmot Creek, Kananaskis, AB

Academic – government partnerships and research networks thrive, but are limited in scope/duration

Researchers are brought together and the infrastructure becomes **GFWO**

GWFO provides National and Global solutions for the water crisis

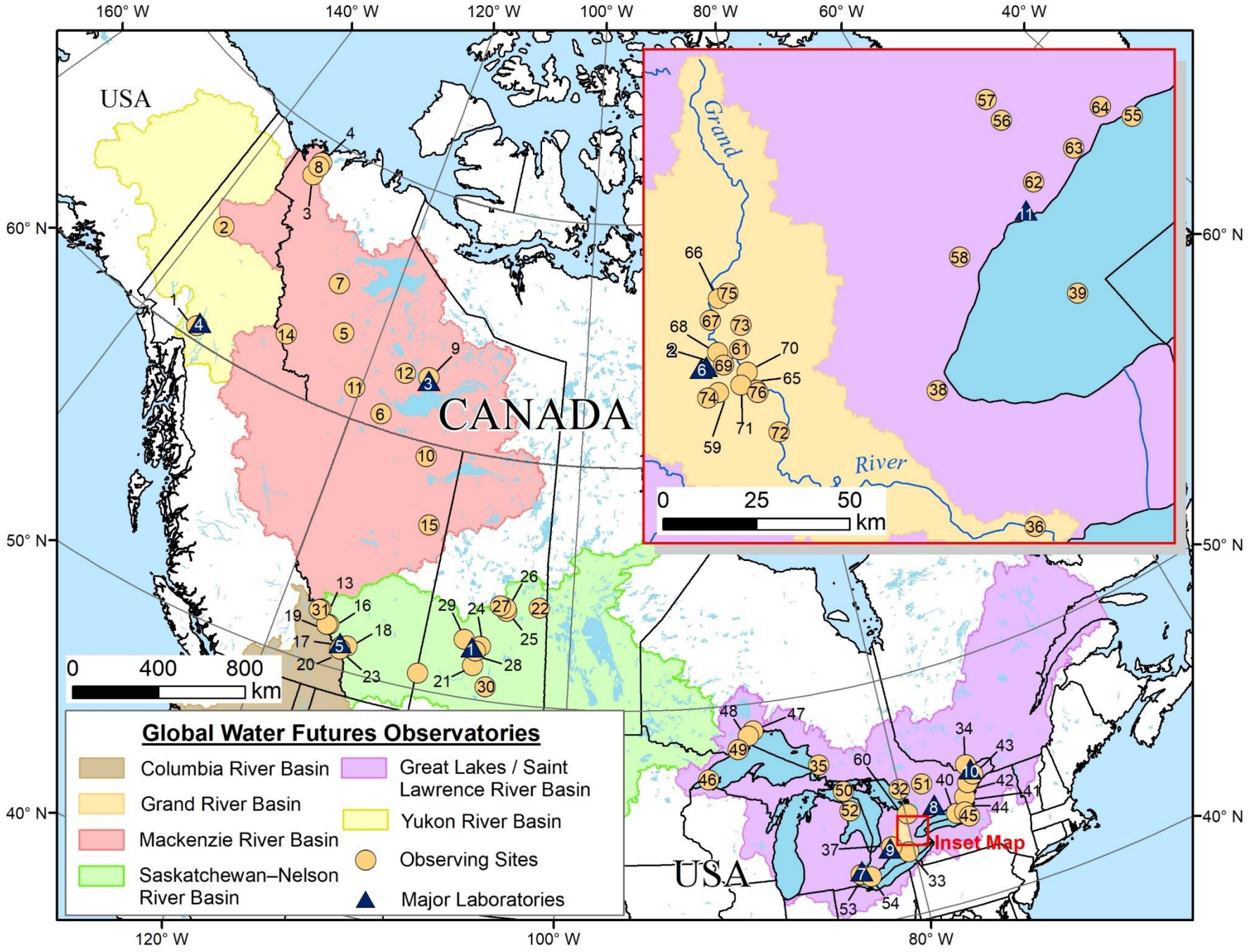
Innovations and new policy in water science, agriculture, engineering and social science implemented across Canada and globally

Canada achieves water sustainability, and adapts to climate change

Global Water Futures Observatories (GWFO)

Transboundary – Provincial & International

64 instrumented basins
15 deployable systems
18 major water laboratories
5 major river basins
50 HQP



GWFO Priority Research Support Directions 2023-2029

Foundations for the development of the Canada Water Agency

Develop and deliver computer models and analytical tools for water-related disaster warning, prediction of future water flows and risks to water quality

Solutions for adaptation to climate change and associated risk management across Canada.

Next-Generation water prediction models that will produce fine scale gridded outputs over all of North America. Eventually the world

Deliver tools to support the information needs of a wide range of data users across Canada

GWFNet – a standard for disseminating water data from water observations over Canada to provincial and federal government agencies, industry, agriculture, communities, and other researchers

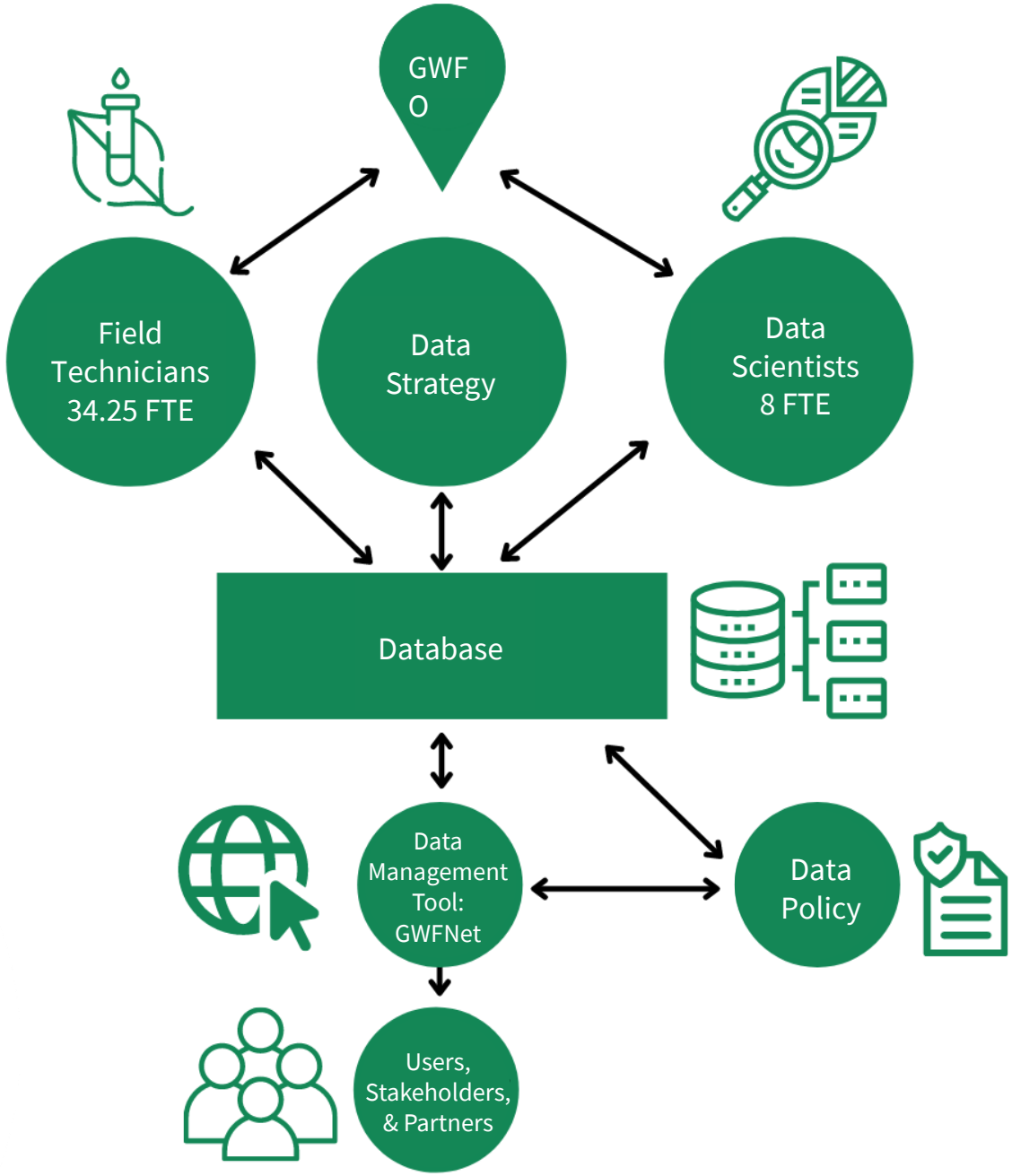
GWFO Vision

Vision: To operate a national water observatory consisting of a network of instrumented water observing sites, supported by deployable observing systems and major laboratories, that provides open access water data and the necessary infrastructure to collect supplementary data, which informs the development and testing of water prediction models, monitors changes in water sources, underpins diagnosis of risks to water security and helps design solutions to ensure the long-term sustainability of Canadian water resources.

Principles of Operation

- provide unique water data of interest to characterizing and monitoring the water conditions of Canadian river basins
- contribute to a critical baseline of water data to the benefit of multiple users
- support the data collection from, and analysis of water from the network of instrumented water observing sites
- adhere to the principles of open access.

Data Management



Observe, Predict, Protect