

INARCH: International Network for Alpine Research Catchment Hydrology

John Pomeroy, Chris DeBeer, and INARCH colleagues

Centre for Hydrology & Global Institute for Water Security,
University of Saskatchewan, Canada

www.usask.ca/inarch



GHP Annual Meeting, Santiago, Chile, 24 October, 2018

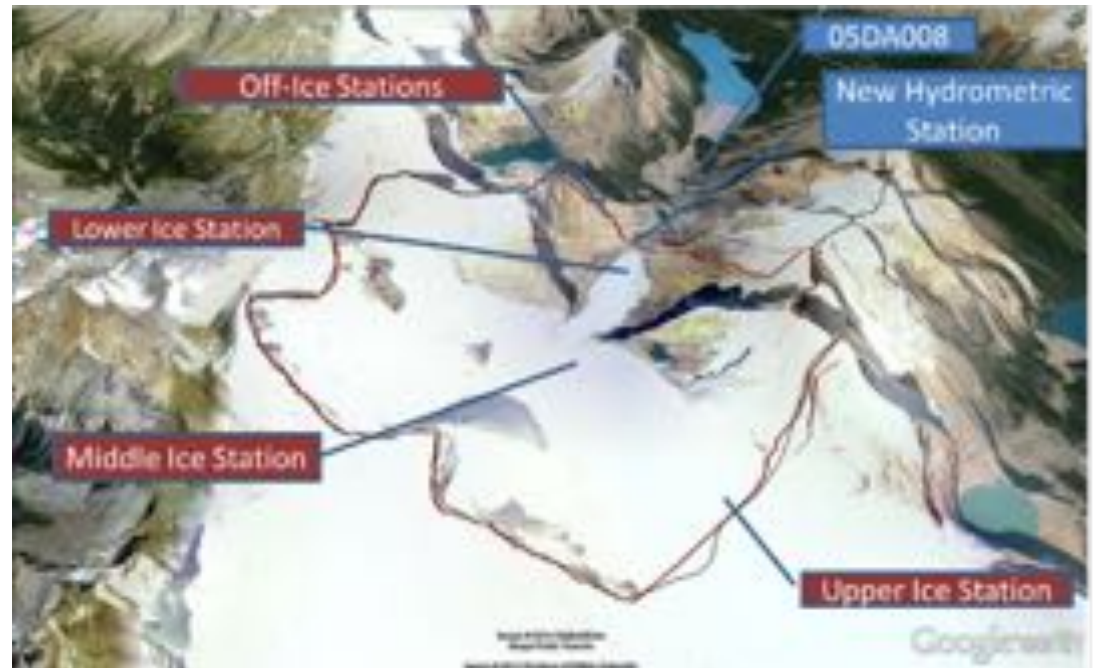
INARCH Objectives

To better

- understand alpine cold regions hydrological processes,
- improve their prediction,
- diagnose their sensitivities to global change

and

To find consistent measurement strategies.



INARCH Questions

1. How do varying **mountain measurement standards** affect scientific findings around the world?
2. What control does **changing atmospheric dynamics** have on the predictability, uncertainty and sensitivity of alpine catchment energy and water exchanges?
3. What improvements to alpine energy and water exchange predictability are possible through **improved physics, downscaling, data collection and assimilation in models**?
4. Do existing mountain model routines have a **global validity**?
5. How do **transient changes** in perennial snowpacks, glaciers, ground frost, soil stability, and vegetation **impact alpine water and energy models**?

INARCH Research Basins



Austria: 1. Open Air Laboratory (OpAL);

Canada: Canadian Rockies Hydrological Observatory - 2. Marmot Creek Research Basin; 3. Peyto Glacier; 4. Quesnel River Research Basin; 5. Wolf Creek Research Basin;

Chile: 6. Upper Diguillfn River Basin; 7. Upper Maipo River Basin;

China: 8. Nam Co Monitoring and Research Station for Multisphere Interactions; 9. Qomolangma Atmospheric and Environmental Observation and Research Station;

10. Southeast Tibet Observation and Research Station for the Alpine Environment; 11. Upper Heihe River Basin;

France: 12. Arve Catchement; 13. Col de Porte Experimental Site; 14. Col du Lac Blanc Experimental Site;

Germany: 15. Zugspitze Basin and Schneefernerhaus Research Station;

Nepal: 16. Langtang Catchment;

Norway: 17. Finse Alpine Research Centre;

Spain: 18. Izas Research Basin;

Sweden: 19. Tarfala Research Catchment;

Switzerland: 20. Dischma Research Catchment; 21. Weissfluhjoch Snow Study Site;

USA: 22. Dry Creek Experimental Watershed; 23. Grand Mesa Study Site; 24. Reynolds Creek Experimental Watershed; 25. Senator Beck Basin Study Area; 26. Sagehen Creek, Sierra Nevada.

Data Requirements

Surface based data requirements for this project will primarily be met by:

1. 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 selected heavily instrumented alpine regions
2. atmospheric model reanalyses
3. downscaled climate model as well as regional climate model outputs

Data Requirements

The ideal is for sites to be Integrated Alpine Observing and Predicting Systems (IAOPS). A provisional classification scheme for IAOPS is:

CLASS A: sites receiving technology transfer and developing towards CLASS B to E

CLASS B: Single measurement points with highly accurate driving data and snow or glacier data

CLASS C: gauged catchments that contain Class B sites and detailed vegetation coverage, soils, topography, snowcovered area, glacier mass balance or permafrost information

CLASS D: domains for which high resolution gridded meteorological data is available that includes CLASS C sites

CLASS E: the same as CLASS D but gridded meteorological data is also available as climate change scenarios.

Linkages

- GEWEX GHP Projects
 - Cold/Shoulder Season Precipitation Near 0°C project
 - Changing Cold Regions Network and Global Water Futures
 - Western US RHP & Water for Foodbaskets
- Global Cryosphere Watch
- WMO-SPICE and WMO High Mountain Summit
- TPE (Third Pole Environment)
- Future Earth, Sustainable Water Futures Programme (SWFP)
- International Commission for Snow and Ice Hydrology (IUGG)
- UNESCO-International Hydrological Programme efforts on climate change impacts on snow, glacier and water resources within the framework of IHP-VIII (2014-2021) ***‘Water Security: Responses to Local Regional and Global Challenges’***.



Workshops held

- **The 3rd INARCH Workshop** was held at the Schneefernerhaus Environmental Research Station, Zugspitze, Germany, 8–9, February, 2018
- Local organizers: Matthias Bernhardt and Karsten Schulz (University of Natural Resources and Life Sciences, Vienna, Austria)
- Others in the organizing committee included Georg Kaser (University of Innsbruck, Austria), John Pomeroy and Chris DeBeer (University of Saskatchewan, Saskatoon, Canada).



Participants at the 3rd INARCH Workshop, 2018 (photo: Markus Weber)

3rd INARCH Workshop

- Issues:

- Snow and Glacier Hydrology;

- >More climate sensitivity and vulnerability studies are needed in INARCH – we need to focus on a concerted effort using a selection of models driven by perturbed or downscaled climate on this using INARCH basins and data.

- >INARCH will continue to encourage scientifically appropriate, physically realistic approaches to snow and ice hydrology.

- Observations Including Remote Sensing;

- >INARCH research basin observational datasets will be proposed to GCW for inclusion in their global data portal. INARCH will provide input to GCW to inform their development of observational guidelines using current science.

- >INARCH will continue to publish datasets and metadata in the ESSD special issue.

- >INARCH basins will contribute to future coupled surface and remote sensing observational studies including multispectral missions.

- Climate Models and Downscaling

- >Dynamical downscaling is needed to create INARCH mountain policy runs for future climate at scales appropriate for snow and glacier hydrology models



INARCH Workshop Statement 2018

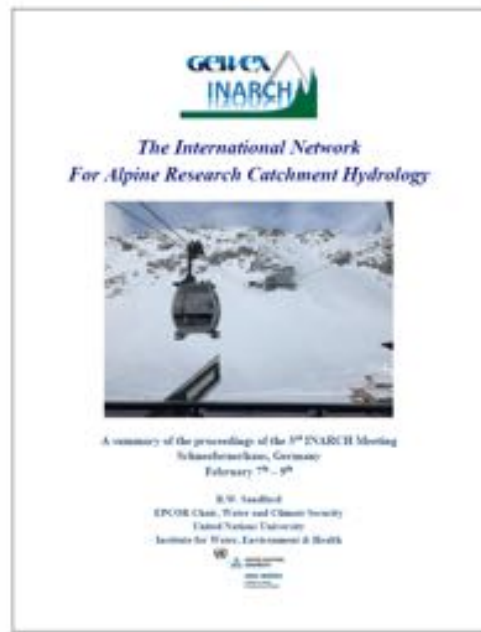


- INARCH's global mountain observatories are providing a unique set of published, archived, high quality, surface, model and remote sensing datasets that will be made available to WMO-GCW and other global initiatives including remote sensing.
- INARCH encourages process validation and description to inform large scale and operational model advances, acknowledging the need to demonstrate improved predictions of the water security impacts of global change in mountain regions.
- INARCH is implementing hybrid downscaling with moderate (km) scale dynamical downscaling from atmospheric models followed by fine (<100s m) scale downscaling (dynamical, empirical) to *snowdrift resolving* scales for improved snow and ice hydrology prediction in support of mountain climate change policy runs.
- INARCH will use these model runs to predict the response of mountain snow, ice and hydrology to climate change, taking into account transient vegetation cover, basin geometry and hydrological and cryospheric storage.

3rd INARCH Workshop



Feb–May 2018 issue of *GEWEX News* on pages 16–18:
<https://www.gewex.org/gewex-content/uploads/2018/08/Feb-May2018.pdf>



Detailed summary written by Bob Sandford available at:
http://www.usask.ca/inarch/wkshp3_report.php

The Schneefernerhaus Research Station, Zugspitze, and surrounding views from the meeting space (photos: Chris DeBeer).



Earth System Science Data Special Issue

- **Hydrometeorological data from mountain and alpine research catchments**
- https://www.earth-syst-sci-data.net/special_issue871.html
- Guest Editors: J. Pomeroy, D. Marks
- 18 data papers contributed / issue closed 30 Sept, 2018

“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. ...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.”



INARCH and WMO



High Mountain Summit

25–27 February, 2019, Geneva

HOME

ABOUT

PARTNERS

PRE-REGISTRATION

PROGRAMME

OUTCOMES



- The High Mountain Summit seeks to foster international and regional inter-agency collaboration,... addressing the need for reliable information on water and hazard management, precipitated by accelerated changes in high mountain cryosphere and ecosystems, with the objective to inform, and therefore, promote Sustainable Mountain Development.
- The central theme of the Summit will be “Addressing the information needs for adequate adaptation strategies of the coupled human and environmental systems, experiencing changes in high mountain regions”.

<https://highmountainsummit.wmo.int/en>

INARCH and Future Earth

Sustainable Water Futures Programme



Working Group on *Climate Impacts on Global Mountain Water Security*

Activities and Outputs:

- Assembling climate change scenarios and hydrological model forcing data;
- Setup, testing, calibration/validation, and scenario generation for atmospheric and hydrological models over various high mountain regions globally, including climate model downscaling and bias correction;
- Running climate scenarios/sensitivity analyses, and linking these to hydrological models to examine impacts on water availability (e.g. timing, magnitude, and duration of flows) and better understand and predict water management concerns.
- Relating these results to water security of mountain communities, impact on mountain cultures and ecosystem services and to downstream water use for communities, energy and food.

http://water-future.org/working_groups/climate-impacts-on-global-mountain-water-security/



4th INARCH Workshop



Where: Hotel Portillo, Chile.
32.8°S, 70.1°W
2,880 m a.s.l.

When: Oct 24-26, 2018



Next Steps



- Mountain downscaling toolbox portal completion and posting to INARCH website
- LSS-H Model comparison and development – ongoing project linked to GEWEX-GLASS
- Pre-assessment synthesis article from INARCH for IPCC AR6 WG1 (Physical Science Basis) and AR6 WG2 (Impacts, Vulnerability and Adaptation, including Cross Chapter Paper on Mountains).
- WMO High Mountain Summit
- GEWEX RHPs – US Water for Foodbaskets, Canada - GWF, ANDEX

