INARCH: International Network for Alpine Research Catchment Hydrology

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www.usask.ca/inarch

GHP Annual Meeting, Kathmandu, Nepal, 18 October, 2017
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

Canada – Canadian Rockies, BC & Yukon;
USA – Reynolds Creek, ID; Dry Creek, ID; Senator Beck, CO, Niwot Ridge, CO.
Chile – Upper Maipo & Upper Diguillín River Basins, Andes,
Germany – Schneefernerhaus & Zugspitze;
France – Arve Catchement, Col de Porte & Col du Lac Blanc;

Switzerland – Dischma & Weissfluhjoch;
Austria – OpAL Open Air Laboratory, Rofental
Spain – Izas, Pyrenees;
China – Upper Heihe River, Tibetan Plateau,
Nepal – Langtang Catchment, Himalayas
Sweden – Tarfala Research Catchment
Norway – Finse Alpine Research Centre
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
  - Precipitation phase
  - Mountain precipitation
  - Changing Cold Regions Network
  - Possible North American Network??

- Global Cryosphere Watch

- WMO-SPICE

- TPE (Third Pole Environment)


- International Commission for Snow and Ice Hydrology (IUGG)
Workshops held

- The 2\textsuperscript{nd} INARCH Workshop was held at the Institut des Géosciences de l’Environnement (IGE) in Grenoble, France, 17–19 October, 2016
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• Issues:
  • Atmospheric downscaling for mountain snow and ice hydrology modeling;
  • Availability and suitability of observations from mountain observatories and discussion of the INARCH special issue; and
  • Sensitivity of the cryospheric and hydrological response of mountain catchments to various representations of a changing climate
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• Further information and links to presentations: http://www.usask.ca/inarch/wkshp2_report.php
GSQ1: Observations and Predictions of Precipitation

Automatic weather stations and drifting snow measurement inter-comparison at Col du Lac Blanc, French Alps.

(Credit: Florence Naaim Bouvet.)
GSQ1: Observations and Predictions of Precipitation

Credit: Ethan Gutmann
GSQ3: Changes in Extremes

Late lying snowpatch – energy & mass fluxes

Upper Marmot Creek – energy and mass fluxes

Alberta floods of June 2013 – mountain energy and water budgets – rain-on-snow
Pomeroy et al., 2016 *Hydrol. Proc.*
GSQ4: Water and energy cycles

- Mediterranean mountain water and energy fluxes to snow

Lopez Moreno et al., Environ. Res. Letters, 2017
WCRP Grand Challenges: Melting Ice and Global Consequences

Lopez Moreno et al., Environ. Res. Letters, 2017
WCRP Grand Challenges: 
Melting Ice and Global Consequences

Visualisation of the glacier evolution model: Ice thickness 2000-2050 (Ötztal Alps/Austria), initialized with ice thickness 1997 (Austrian glacier cataster), temperature change (for Austria) 0.048 °C/year. (Credit: Florian Hanzer, Kristian Förster, Thomas Marke, and Ulrich Strasser.)
WCRP Grand Challenges:
Climate extremes and water availability

Credit: Isabelle Gouttevin
INARCH and Outreach
INARCH Special Issue

- Special Issue open in Earth System Science Data (ESSD)
- Editors: Dr. John Pomeroy, and Dr. Danny Marks (USA)

**Topic:** Hydrometeorological data from mountain and alpine research catchments

- Contributions of openly available detailed meteorological and hydrological observational archives from long-term research catchments at high temporal in well-instrumented mountain regions around the world
- Submission possible until 6 April, 2018. Six submissions and more in prep.
INARCH and UNESCO

Knowledge Forum on Water Security and Climate Change: Innovative solutions for sustainable water resources management

18 – 20 October 2017
Room IX
UNESCO HQ, Paris, France

Session on “Water Security and Climate Change Impacts in Mountains”
3rd INARCH Workshop

Environmental Research Station
Schneefernerhaus on Zugspitze, Germany,
8–9 February, 2018

Topics:

- Snow Hydrology
- Glacier Hydrology
- Alpine Measurements including Remote Sensing
- Climate Models and Downscaling for Mountains

- Each theme will be addressed by a keynote speaker and followed by a moderated discussion, and supplemented with topical poster sessions.

- **Audience:** 50 scientists from USA, Canada, Chile, China, France, UK, Switzerland, Austria, Germany, Italy, Norway
INARCH session at 2018 GEWEX Open Science Conference

Canmore, AB, Canada
7–10 May, 2018

Title: The Mountain Water Cycle (Session 14)

Topic: Advances in remote sensing, big data techniques and process understanding that are often developed in instrumented alpine research catchments inform mountain water cycling predictions. This session welcomes papers that
- advance mountain water and energy cycle modelling techniques,
- process understanding,
- observations,
- downscaling methods, and
- predicting the impacts of a changing mountain cryosphere on water cycling.

Convenors: R. Rasmussen, J. Pomeroy, C. DeBeer, M. Bernhardt, D. Marks
Next Steps

• Special Issue of *Earth System Science Data*.
• Mountain downscaling toolbox further development
• LSS-H Model comparison and development – link to GLASS
• Comparative analysis of alpine snow and ice hydrological sensitivity to warming – “Mediterranean Climate” and “Continental Climate” snow sensitivity comparison in progress
• Trans-Iberian Snow Hydrology Transect – extend to Morocco
• Multiscale climate change vulnerability analysis of alpine snow, ice and hydrological systems
• Link with Canadian-funded GWF (Global Water Future) Program