INARCH:

International Network for Alpine Research Catchment Hydrology

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www.usask.ca/inarch

GHP Annual Meeting, Sydney, Australia, 11-12 October, 2019

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 Diguillín 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: Russia: 18. Djankuat Research Basin: Spain: 19. Izas Research Basin; 20. Guadalfeo Monitoring Network; Sweden: 21. Tarfala Research Catchment: Switzerland: 22. Dischma **Research Catchment: 23.** Weissfluhjoch Snow Study Site; **USA:** 24. Dry Creek Experimental Watershed; 25. Grand Mesa Study Site; 26. Reynolds Creek Experimental Watershed; 27. Senator Beck Basin Study Area; 28. Sagehen Creek, Sierra Nevada.

Data Requirements

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

- 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'.



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Workshops held

- The 4th INARCH Workshop was held at the Universidad de Santiago and the Hotel Portillo, Chile, 24–26, October, 2018
 - Local organizers: James McPhee, Thomas Shaw, and Yohann Videla (Universidad de Chile, Santiago, Chile)
 - Others in the organizing committee included John Pomeroy and Chris DeBeer (University of Saskatchewan, Saskatoon, Canada).



Participants at the 4th INARCH Workshop, 2018

4th Annual INARCH Workshop

Full details, outcome statements, summary • report, presentations, and photos are available on the meeting page at:

http://www.usask.ca/inarch/wkshp4 report.php



The International Network for

4th ANNUAL INARCH Workshop Santiago and Andes, Chile: 24-26 October 2018

24 scientists participated in the fourth INARCH workshop, organized under the leadership of Prof. James McPhee of Joint ANDEX - GHP - INARCH meeting in Santiago (24 October), and (from 25th - 26th October) the Hotel Portillo,

- Joint ANDEX GHP INARCH Meeting: agenda
- Workshop agenda
 ppr
- Workshop opening statement PD
- Workshop closing statement
- Full abstract list
 PDF
- Article in GEWEX News

Invited Presentations:

Runoff Processes in Alpine Catchments: Challenges and Opportunities Sean Carey (School of Geography and Earth Sciences, McMaster University, Ontario, Canada) Abstract

The 2010 Chile Mega-drought and its impacts on snow and glacier hydrology James McPhee (Universidad de Chile, Santiago, Chile)

 The hydrological role of glaciers in the Atacama Desert Shelley MacDonell (Centro de Estudios Avanzados en Zonas Áridas, Santiago, Chile) Abstract Slide





Gel/e Recent INARCH Activities and the 4th INARCH Worksho

antiago and Portillo, Chile 24-26 October 2018

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INARCH and Its Recent Activitie

Network for

sducts as outputs of the network rological Org. ion (WMO), the ate Change (IPCC ral Panel on Clim-

sing these questions and a am has grown with the incl

In just three years, INARCH has mad

ved as guest editors for an INARCH special issu tem Science Data (ESSD, https://www.earth-syst me by ESSD and will be handled by









INARCH and Future Earth

Sustainable Water Futures Programme



As a contribution to SWFP, INARCH has formed a 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/climateimpacts-on-global-mountain-water-security/



Session at Water Future Conference: "Towards a Sustainable Water Future" Bangalore, India, 24-27 September, 2019

- Climate Impacts on Global Mountain Water Security - Water Solutions for the 21st century in the Indian Himalayan Region (IHR) Joint session
- https://www.waterfutureconference.org/





mountain regions

Session at Water Future Conference: "Towards a Sustainable Water Future" Bangalore, India, 24-27 September, 2019

- Outcomes:
 - Collaboration with scientists from the Indian Institute of Science on modelling Indian river basins to help address the acute water crisis that is evolving in the Indian subcontinent
 - Support and guidance to the Integrated Mountain Initiative as they develop a "Himalayan Water Futures" in cooperation with Bhutan and Nepal
 - <u>https://www.waterfutureconference.</u> <u>org/water_solutions</u>



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
- 21 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 longterm 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



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29-31 October 2019, Geneva, Switzerland

The World Meteorological Organization (WMO) is convening a High Mountain Summit to foster highlevel dialogue and engage decision-makers and local actors to develop a roadmap to science-based, userdriven knowledge and information systems supporting sustainable development and risk reduction in mountain and downstream regions.



For additional information, please contact the Organizing Committee: highmountainsummit@wmo.int

https://highmountainsummit.wmo.int/en

Relevant Initiatives

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Summit Overview

Programme



5th INARCH Workshop

- Hosted by Dr. Ignacio López Moreno, Pyrenean Institute of Ecology, Spanish Research Council
- Focus on:
 - Integrated Mountain Observing and Prediction Systems, merging observations and prediction into coherent systems
 - forest and vegetation hydrological impacts, remote sensing advances and opportunities, next-generation snow and glacier modelling, and high resolution atmospheric modelling

Where: Zaragoza, Spain and the Hospital de Benasque in the Spanish Pyrenees When: March 31 – April 1, 2020





Next Steps



- WMO High Mountain Summit
- 5th INARCH Workshop
 - follow on from the WMO HMS with a major theme on Integrated Mountain Observing and Prediction Systems
- Build linkages with other GEWEX cross-cuts and RHPs
 - US Water for Foodbaskets, Canada GWF, ANDEX, TPE
- Plan next steps post-INARCH and produce synthesis papers on key INARCH science topics and questions



