

### 2<sup>nd</sup> INARCH Workshop

#### 17–19 October 2016 Grenoble, France

# John Pomeroy<sup>1</sup>, Vincent Vionnet<sup>2</sup> and INARCH Colleagues

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The International Network for Alpine Research Catchment Hydrology (INARCH) is a crosscutting project of the GEWEX Hydroclimatology Panel (GHP) and its objectives are to better understand alpine cold regions hydrological processes, improve their prediction, diagnose their sensitivities to global change and find consistent measurement strategies. INARCH is formulated around addressing five core 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 global validity? (5) How do transient changes in perennial snowpacks, glaciers, ground frost, soil stability and vegetation impact alpine water and energy models?

INARCH has a network of well-instrumented mountain research basins that INARCH members maintain—all of these research basins have hydrometeorological, cryospheric and hydrological observations at multiple scales over multiple years and have some snow, glacier, hydrological and atmospheric models run at various scales. Observations are embedded near the headwaters of larger river basins that supply water for vast downstream populations. The figure on the next page shows a map of INARCH mountain research basins. Mount Lebanon has been proposed as a new research basin.

INARCH has linkages to GHP crosscutting projects on precipitation phases and mountain precipitation, as well as to the Changing Cold Regions Network (CCRN), a Regional Hydroclimate Project. INARCH is seeking stronger connections with the Global Cryosphere Watch and the World Meteorological Organization Solid Precipitation Intercomparison Experiment (WMO-SPICE) and the Third Pole Environment (TPE) initiative. INARCH contributes to the UNESCO-International Hydrological Programme (IHP) efforts to gauge climate change impacts on snow, glaciers and water resources within the framework of the IHP-VIII (2014-2021), and has linkages with the International Commission for Snow and Ice Hydrology (IAHS-IUGG). INARCH also contributes to the Mountain Research Initiative led from Bern, Switzerland.

Over the last two years, INARCH has contributed to several conferences and workshops, such as the 2015 American

#### INARCH: International Network for Alpine Research Catchment Hydrology

<u>Canada</u> – Canadian Rockies, BC & Yukon; <u>USA</u> – Reynolds Creek, ID; Dry Creek, ID; Senator Beck, CO, Niwot Ridge, CO. <u>Chile</u> - Upper Maipo & Upper Diguillín River Basins, Andes, <u>Germany</u> – Schneefernerhaus & Zugspitze; <u>France</u> – 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



Current INARCH mountain research basins.

Geophysical Union Fall Meeting, where INARCH organizers chaired an oral and poster session on Improved Understanding and Prediction of Mountain Hydrology through Alpine Research Catchments. INARCH also participated in the WCRP International Conference on Regional Climate, CORDEX 2016, with a presentation by Richard Essery (UK) on observations and downscaling for alpine hydrological modeling and through several other INARCH participants, including Ethan Guttman (USA), Kabir Rasouli (Canada) and Deborah Verfaillie (France). John Pomeroy gave a general presentation on INARCH at the 6<sup>th</sup> Third Pole Environment Workshop and Joseph Shea, Maxime Litt (Nepal) and Walter Immerzeel (The Netherlands) gave talks or poster presentations.

An INARCH Special Issue in *Journal of Earth System Science Data* is now open for submissions until 30 September 2017 on the topic of "hydrometeorological data from mountain and alpine research catchments." Contributions from openly-available, detailed meteorological and hydrological observational archives from long-term research catchments at high temporal, well-instrumented mountain regions around the world are being prepared and at least 16 submissions are expected from the INARCH Project by the special issue co-editors, John Pomeroy (Canada) and Danny Marks (USA).

The 2<sup>nd</sup> INARCH Workshop was held at the Institut des Géosciences de l'Environnement (IGE) in Grenoble, France, and provided an opportunity for scientists to explore and discuss specific issues in mountain snow and ice hydrology highlighted in the first INARCH workshop held in October 2015. Sixty scientists from the USA, Canada, Chile, China, France, UK, Switzerland, Austria, Germany, Italy, Lebanon and Norway attended the workshop. The Local Organizing Committee of Vincent Vionnet [Météo France, Centre National de Recherches Météorologiques-Centre d'Etudes de la Neige (CNRM-CEN)], Isabella Zin (IGE), Jean-Emmanuel Sicart (IGE) and Delphine Six (IGE) arranged the workshop and a field tour to the nearby Mount Blanc area. The workshop focused on the following topics: (i) atmospheric downscaling for mountain snow and ice hydrology modeling; (ii) availability and suitability of observations from mountain observatories and discussion of the INARCH special issue; and (iii) sensitivity of the cryospheric and hydrological response of mountain catchments to various representations of a changing climate.

The workshop fieldtrip visited research sites in the Aiguille du Midi (3842m), near Chamonix. Christian Vincent (IGE) described the scientific activities of the CryObs-Clim Observing System, and Thomas Condom (IGE) outlined the experimental rain gauge network and related scientific activities and Florence Naaim Bouvet (IRSTEA) presented the Taconnaz avalanche path and associated protection. After enjoying the views of Mont Blanc and Aiguilles Rouges massifs, the group visited the Le Tour hydrometric station and learned about snow measurement techniques and hydrological issues in the Alps (Vincent Vionnet, Samuel Morin and Isabella Zin). At the confluence of the Arve and Arveyron d'Argentière, they were shown flood defenses (Isabella Zin), saw the sediment transport station at Pont des Favrands and heard about water quality issues (Thomas Condom).

The 2<sup>nd</sup> INARCH workshop had 42 oral and poster presentations covering high mountain environments from North and South America, Africa, Europe and Asia. The topics covered downscaling meteorological models for mountain snow and ice hydrology, modeling the cryospheric and hydrological response of mountain catchments under present and future climate and mountain observatories and links between INARCH and other research programs. Discussions on downscaling, observatories and future directions are summarized below.

### **Downscaling Discussion**

The discussion focused on developing a toolbox or set of guidelines for downscaling. It was agreed that the product should be end user specific (e.g., operational forecasts, 1-3 month water supply forecasts and climate predictions) and

the role of statistical versus dynamical methods for various end uses was discussed, including what tools are suitable for each use case. Reoccurring downscaling themes discused include the following:

- Statistical downscaling of larger-scale regional climate models (RCMs) may be unsuitable for driving physicallybased snow models where co-occurrence of wind, humidity, temperature and radiation fields with precipitation events control snow regimes, precipitation phase, blowing snow and melt.
- Atmospheric model failure. INARCH recognizes the need for carefully-applied bias corrections, but promotes the improved physical representation of atmospheric models in mountain environments. INARCH will interact with the atmospheric modeling community to make its members aware of performance issues in mountain environments. INARCH will promote the assimilation of mountain observations in atmospheric models and the use of mountain datasets in assessing model performance through multiobjective analysis.
- Physical models are never perfect. INARCH can quantify the impact of resolution increase on predicted surface variables (i.e., the diurnal temperature and precipitation cycle). The project will promote dynamical downscaling of atmospheric models but will assist in developing empirical, statistical or simpler dynamical downscaling at scales less than several kilometers.
- Ask questions that Global Climate Model (GCM) and RCM tools can answer. (Just because we want it doesn't mean we can have it.) What is the appropriate scale for evaluation of models given our catchment scales?
- Specify the questions we ask of GCM and RCM models based on results from our snow and ice models and sites. What is the likelihood of warming and precipitation change that will cause a certain result?



Participants at the INARCH Workshop 2016.

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• Ensure that RCMs better incorporate land surface feedbacks in mountain regions and test using observatories.

### **Observatories** Discussion

It was agreed that INARCH sites are valuable for climate change documentation and model verification. The discussion was centered around the following questions.

- How do measurement standards affect scientific findings? The transition from point to continuous spatial measurements opens up new dimensions.
- How do changing atmospheric dynamics affect mountain snow and ice hydrology?
- How well do improved model physics represent mountain snow and ice hydrology and what is the global validity of snow and ice hydrology models?
- Do uncertainties overwhelm models?
- What is the role of transient change in vegetation and the storage of water, snow and ice in enhancing or dampening climate impacts?
- Are INARCH sites valuable for GCM and RCM intercomparison studies? Data sets need to be published (DOI) and well documented on the INARCH website.

One outcome from the discussion was that the Project should compile data for model testing of the sensitivity of snow and ice to climate change in various alpine climates. Models driven by perturbed meteorological observations can be used to do this via virtual basins and mountains. Comparisons, such as the North American Cordillera and Mediterranean, are underway.

### Future Directions

The *ESSD* Special Issue on INARCH will continue to receive submissions until September 30<sup>th</sup>. Other journals will be approached for a special INARCH issue on mountain snow and ice hydrology that includes references to downscaling, processes and diagnosis of climate change impacts. Updates to the INARCH website (*http://www.usask.ca/inarch/*) will include a downscaling toolbox with a link to methods, as well as metadata for catchments and links to DOI data. A technical document is planned with UNESCO on "Best Practices in Instrumenting Mountain Research Catchments," as is a policy-relevant publication with UNESCO on "Risks to World Water Security from Changing Mountain Snow and Ice Hydrology."

The workshop concluded with a formal statement highlighting the upcoming special issue and the development of the downscaling toolbox for the INARCH website, as well as attempts by INARCH to calculate the impacts of climate change on mountain hydrology sensitivity, transient vegetation cover and hydrological and cryospheric storage.

## Third National OzEWEX Workshop

#### 14–15 December 2016 Canberra, Australia

#### Albert van Dijk

Fenner School of Environment and Society, Australian National University College, Canberra, Australia

The Third National Australian Water and Energy Exchange Research Initiative (OzEWEX) Workshop was held at the Australian National University in Canberra. Scientists and policy makers from Australia universities, government and private sectors attended the workshop. OzEWEX is an Initiatingphase GEWEX Regional Hydroclimate Project.

Prof. Albert van Dijk, OzEWEX Chair, opened the workshop and introduced the new OzEWEX Co-Chair, Assoc. Prof. Seth Westra from the University of Adelaide. Prof. van Dijk presented an overview of new OzEWEX initiatives, including a community data catalogue (*http://ozewex.org/data-set-catalogue/*) and the Australian Climate and Water Summer Institute (*http://ozewex.org/first-ozewex-summer-institute/*). The OzEWEX submission to the National Research Infrastructure Roadmap was discussed, including the need to maintain and strengthen national collaboration, data and model infrastructure.

Prof. Andy Pitman of the University of New South Wales, discussed the potential for broader collaboration in Australia across climate, hydrology and land surface sciences and how these research fields can do more to attract funding. Dr. Richard Thornton and Dr. Michael Rumsewicz from the Bushfire and Natural Hazards Cooperative Research Centre then gave a talk on the importance of connecting applied research with policy decision-making and converting it into action.

The first of two parallel sessions for day of the workshop one was entitled "Observation networks and enhancing data sharing" and included talks on topics, such as a network for observing surface fluxes of water and carbon across Australia and national computational infrastructure data collections. The second parallel session focused on "Community modeling and data assimilation systems," and included a project proposal by Dr. Martin DeKauwe (Macquarie University) on how continental-scale vegetation models could be improved through a better understanding of the behavior of Australian Eucalypts.

Mr. Nadeem Samnakay (Murray-Darling Basin Authority) talked about the importance of community collaboration in environmental decision-making. Dr. Pauline Grierson from the University of Western Australian presented the unique hydrology of the Pilbara region in Western Australia and how modern observations (under 100 years) often do not capture the full range of variability in the system (e.g., severe extremes that are seen in the geologic record).

On the second day of the workshop, Prof. Rob Vertessy (University of Melbourne/Australian National University) talked about the strengths of collaborative science research collectives,