# INARCH:
# International Network for Alpine Research Catchment Hydrology

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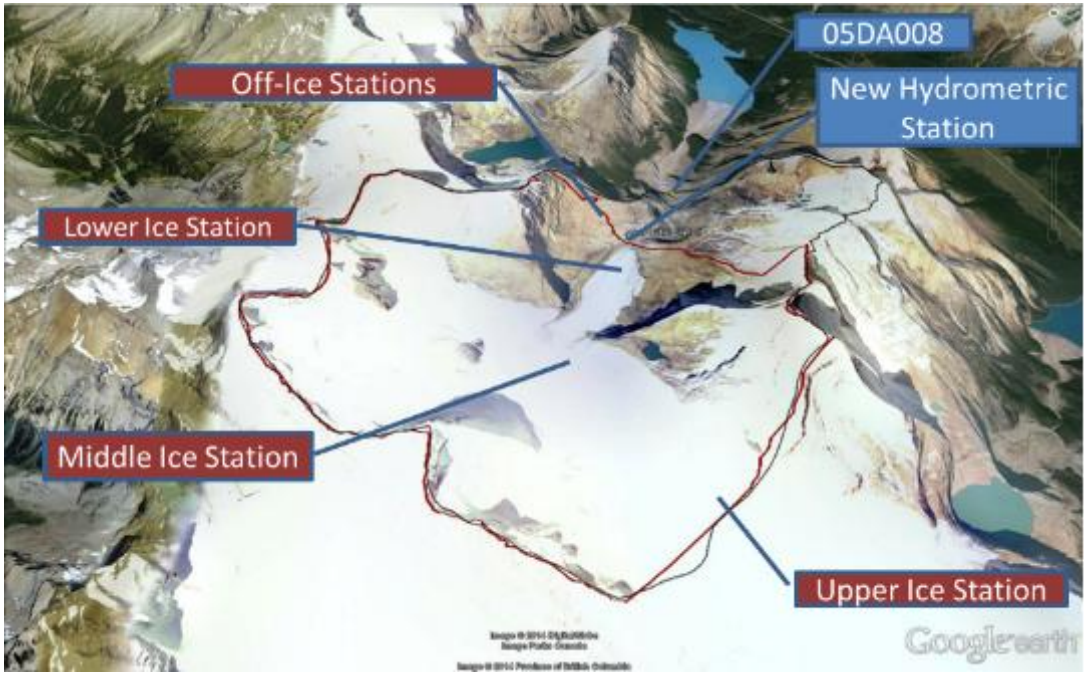
# INARCH Objectives

To better

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

and

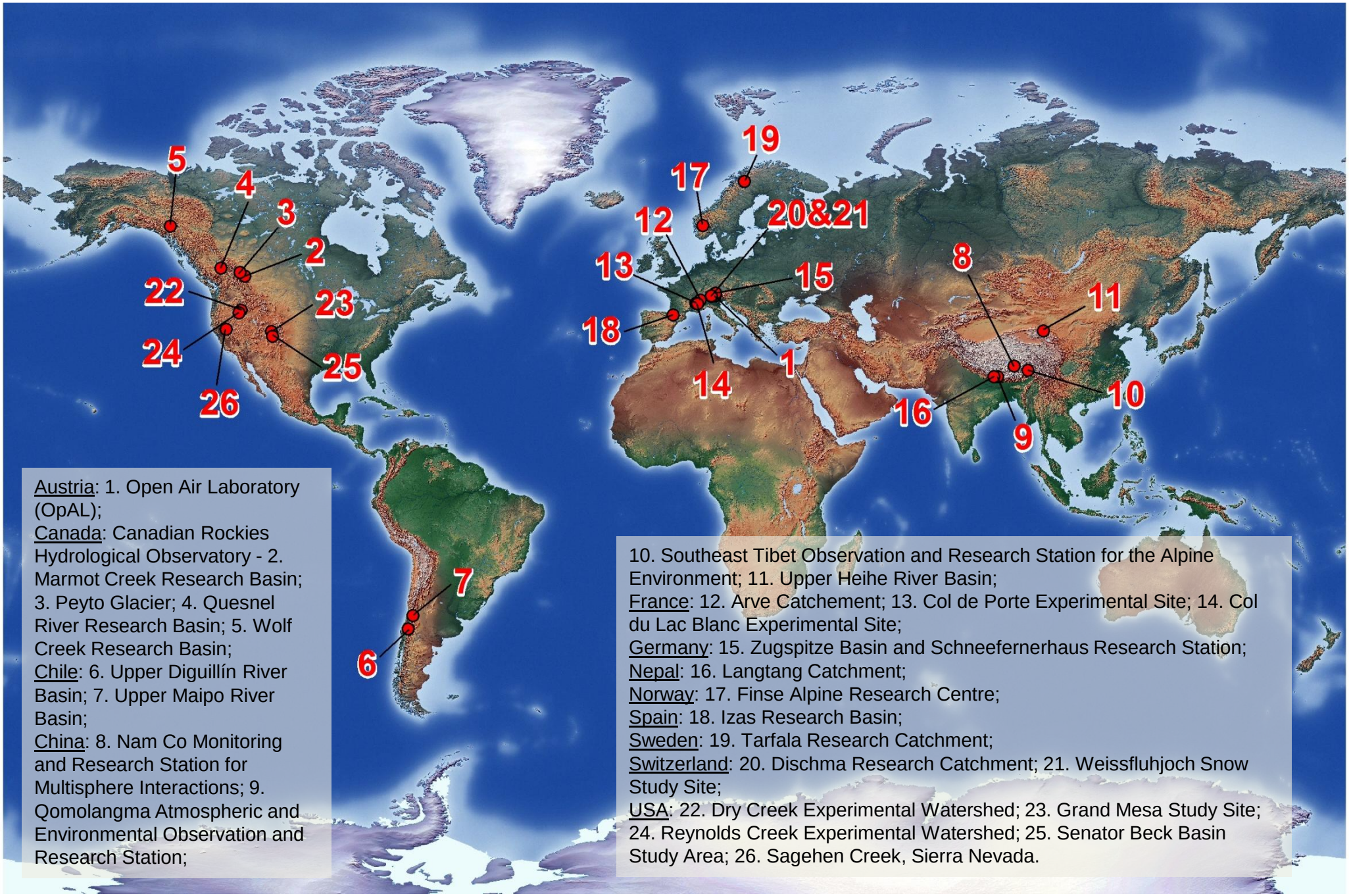
To find consistent measurement strategies.



# 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

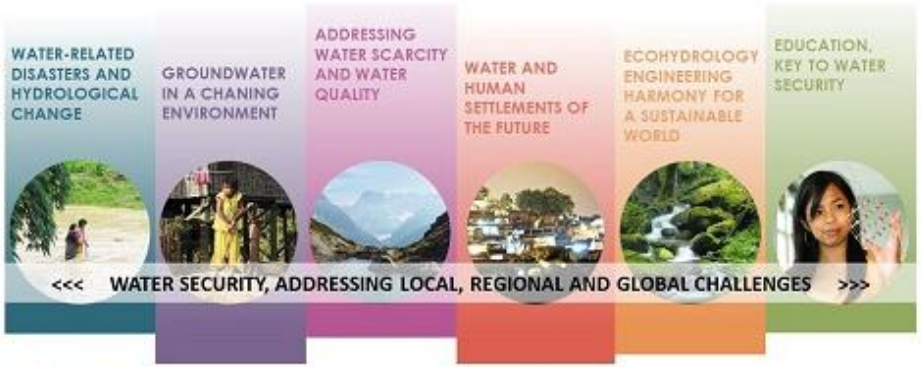



Austria: 1. Open Air Laboratory (OpAL);
Canada: Canadian Rockies Hydrological Observatory - 2. Marmot Creek Research Basin; 3. Peyto Glacier; 4. Quesnel River Research Basin; 5. Wolf Creek Research Basin;
Chile: 6. Upper Diguillín River Basin; 7. Upper Maipo River Basin;
China: 8. Nam Co Monitoring and 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;
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.

# Linkages

- GEWEX GHP Projects
  - Cold/Shoulder Season Precipitation Near 0ºC 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)*

# 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.

# 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*."

GEWEX INARCH

# INARCH and WMO

## High Mountain Summit

25–27 February, 2019, Geneva

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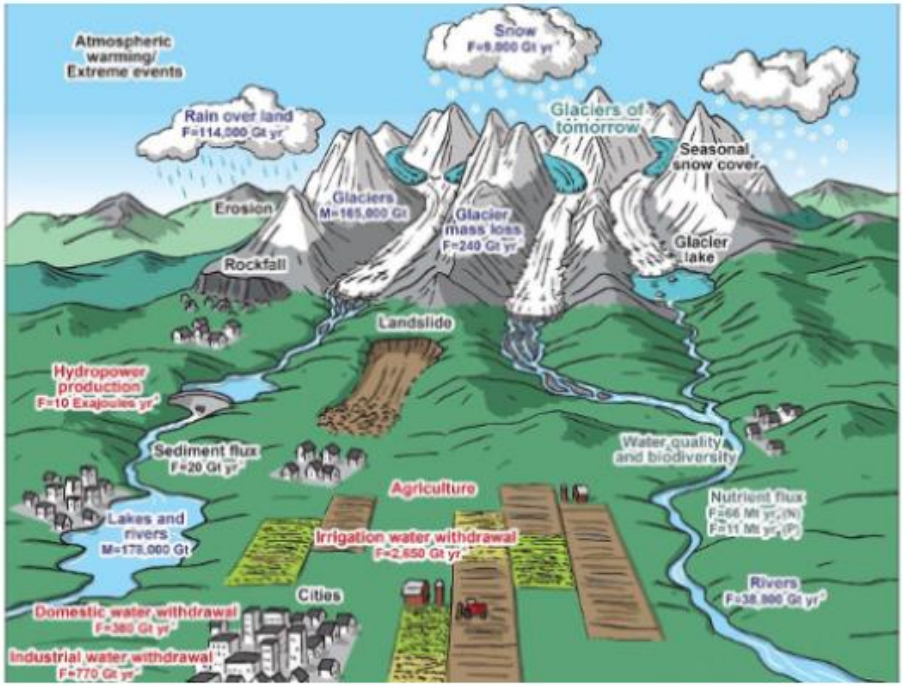


### High Mountain Summit

**Will take place on 25-27 February 2019 in Geneva, Switzerland**

The organizers are encouraging the participation of relevant stakeholders, practitioners, research communities, and decision-makers from national, regional, and international institutions, representing all regions of the world affected by changes in the high mountain climate and ecosystems, in recognition of the regional diversity of impacts, and the need for specific solutions.

To express your interest in attending this global event, please complete the **Expression of Interest (pre-registration) Form**.

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 Workshop Objectives

- High Mountain Water Cycle Research Needs **done**
- Catchment and process hydrology
  - Field observations and emerging techniques
  - Regional activities
- Glaciers and climate change
- Data and simulations
  - Big data techniques
  - Remote sensing
  - Data assimilation
  - Models
- Linkages to other programs and global contributions
  - What is our impact?

# Next Steps

- Mountain downscaling toolbox portal completion and posting to INARCH website
- LSS-H Model comparison and development – ongoing project linked to GEWEX-GLASS -Essery paper in review.
- 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

# THANK YOU
# to James and his students for exposing us to Portillo