INARCH:
International Network for Alpine Research Catchment Hydrology

John Pomeroy [1], Vincent Vionnet [2] and colleagues

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

[2] Snow Research Center, CNRM, Météo France/CNRS Saint Martin d'Hères, France

www.usask.ca/inarch

GHP Annual Meeting, Gif sur Yvette (France), 3-5 October 2016

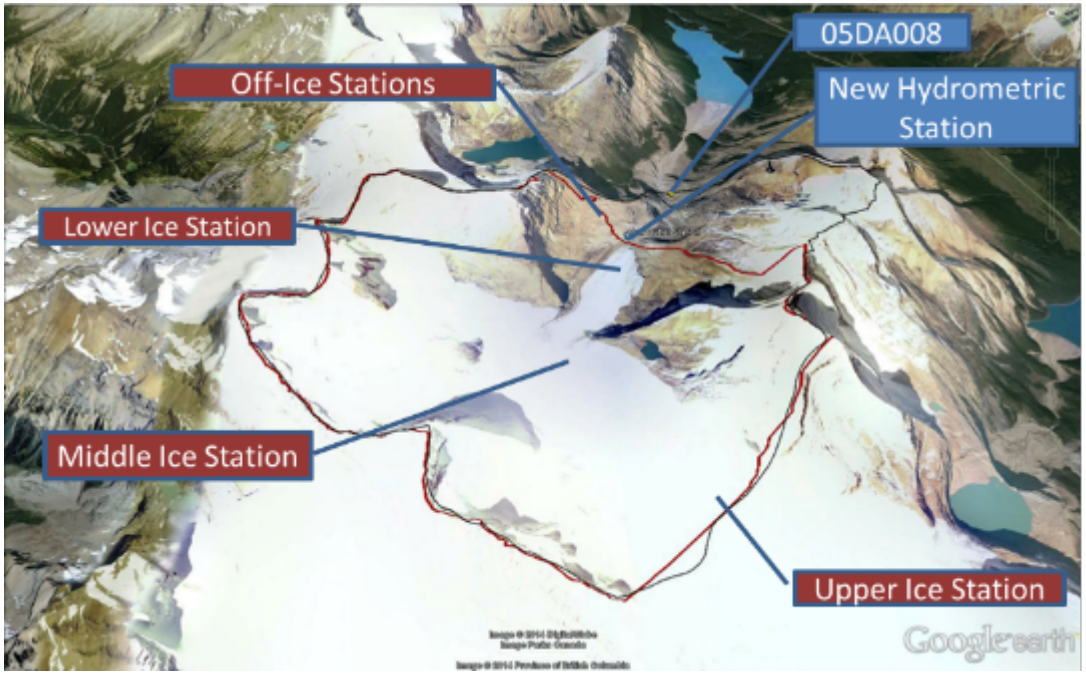
INARCH Objectives

To better

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

and

To find consistent measurement strategies.

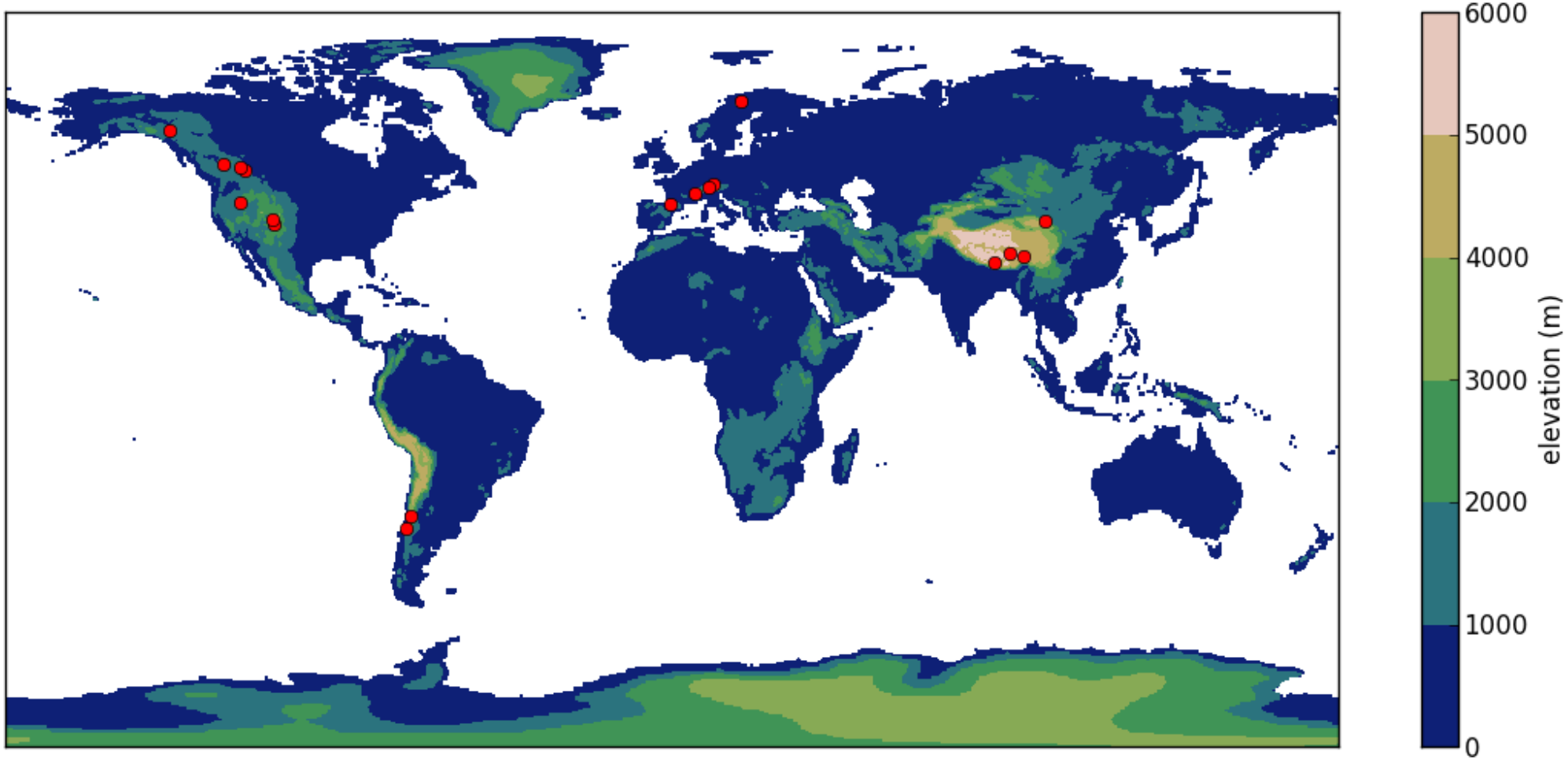


INARCH Questions

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: International Network for Alpine Research Catchment Hydrology

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



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)

- 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'.***
- International Commission for Snow and Ice Hydrology (IUGG)

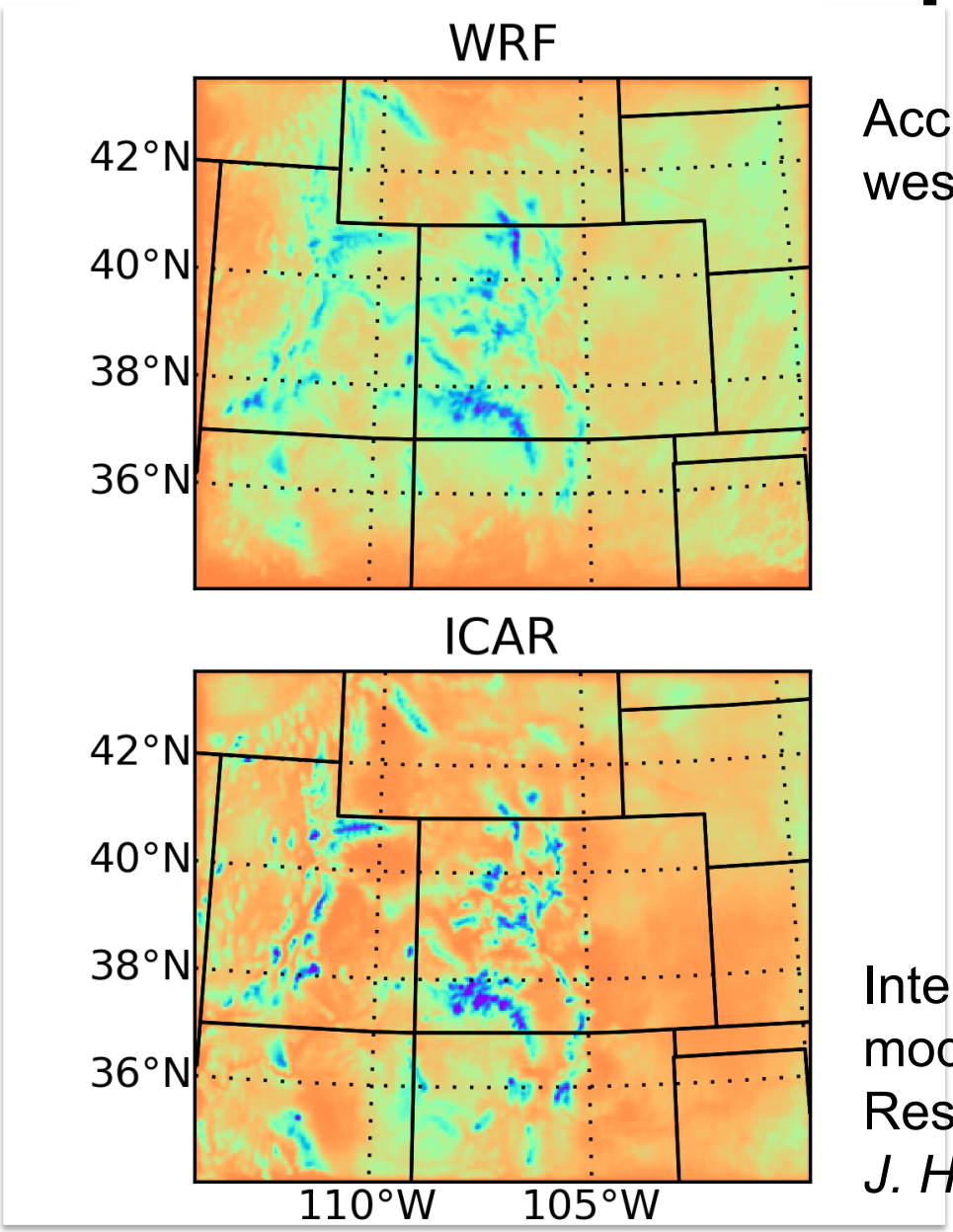
Contribution to international conferences

- **AGU 2015**: Organisation and chairing of an oral and a poster session on Improved Understanding and Prediction of Mountain Hydrology through Alpine Research Catchments

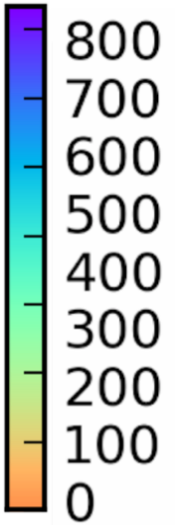
- WCRP's International Conference on Regional Climate – **CORDEX 2016:**
  - overall INARCH presentation by R. Essery (UK) on current thinking on observations and downscaling for alpine hydrological modelling
  - contributions of several INARCH participants; E. Guttman (USA), K. Rasouli (Canada), D. Verfaillie (France)

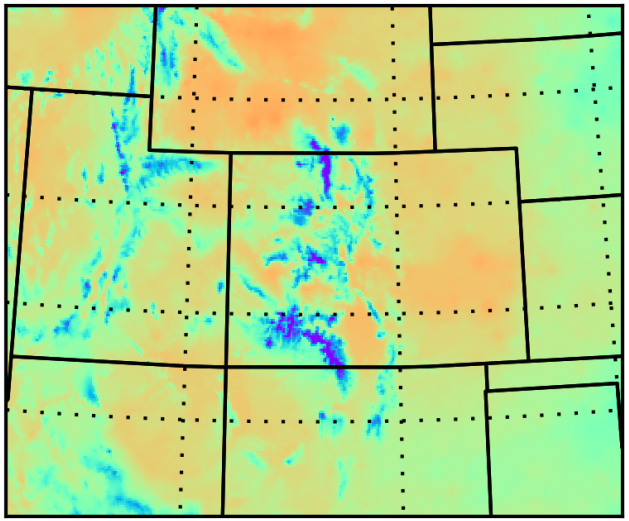
- 6th **Third Pole Environment** Workshop:
  - contributions of several INARCH participants; J. Shea and M. Litt (Nepal), W. Immerzeel (Netherlands)
  - General presentation of INARCH by J. Pomeroy

GSQ1: Observations and Predictions of Precipitation



Accumulated October – May precipitation for western US



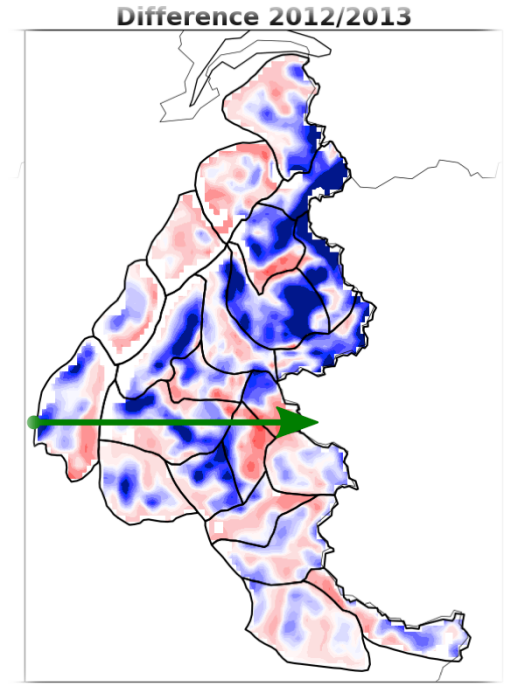


Intermediate Complexity Atmospheric Research model
Results from Ethan Gutmann
J. Hydrometeorol., **17**, 957 – 973 (2016)

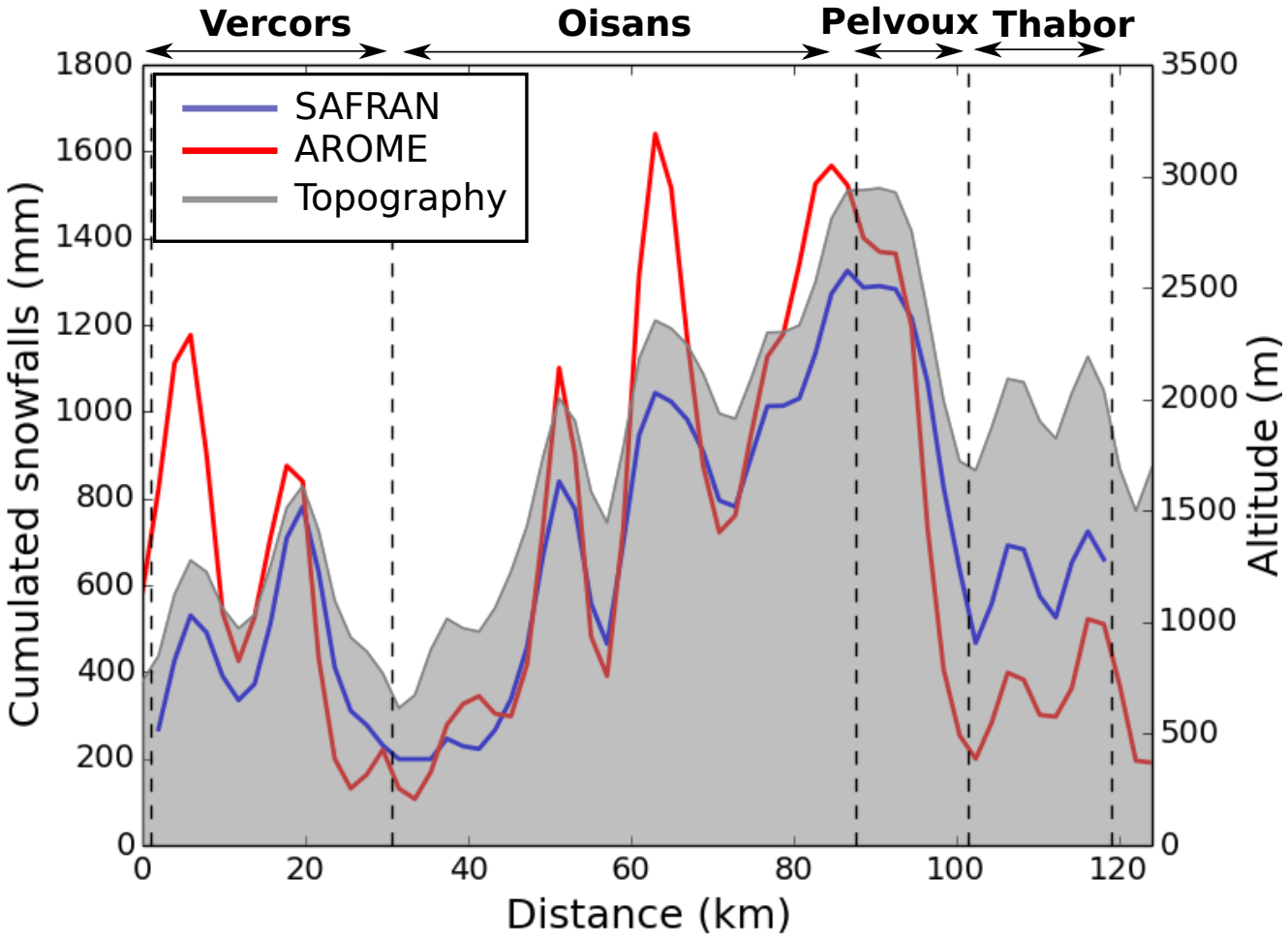
- Evaluation being extended to the Canadian Rockies and Yukon

GSQ1: Observations and Predictions of Precipitation

- Operational NWP system AROME: evaluation of winter precipitation



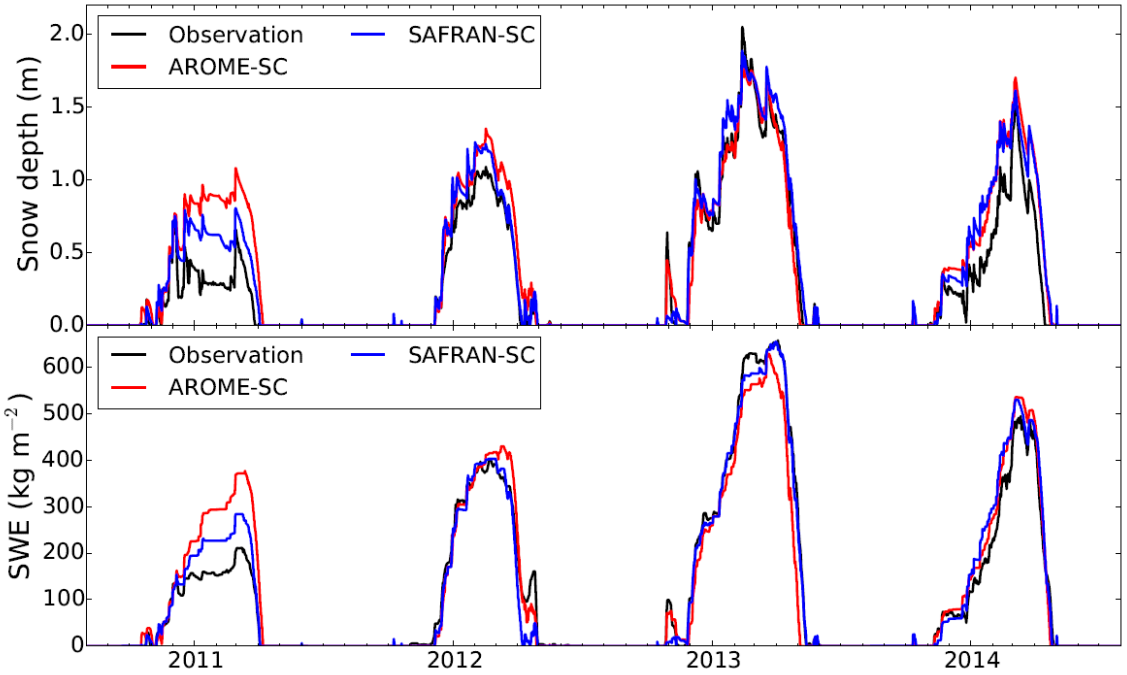
Vionnet et al (JHM, 2016)



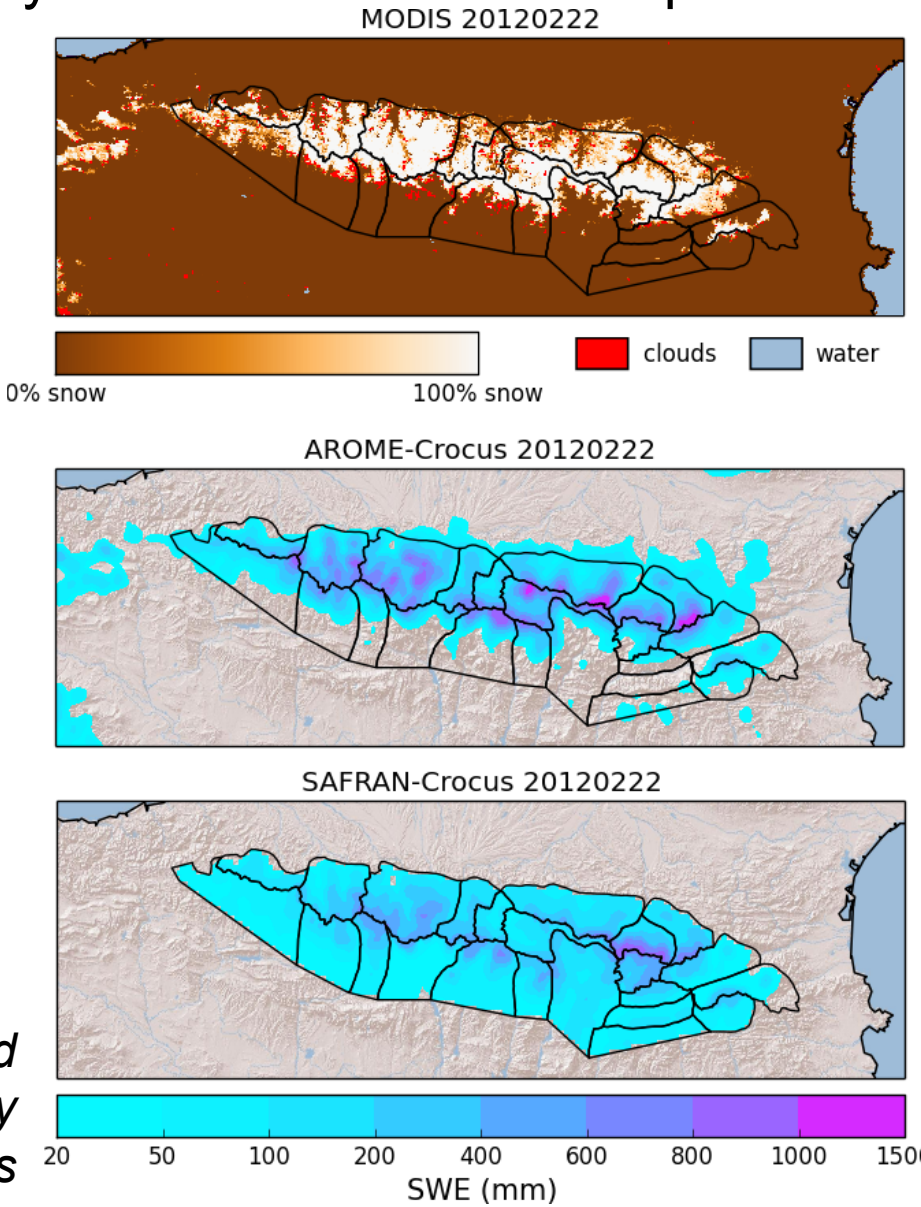
- Comparison of seasonal snowfall forecasted by AROME and analysed by SAFRAN

GSQ1: Observations and Predictions of Precipitation

- Operational NWP system AROME: ability to drive seasonal snowpack simulations



Simulations at Col de Porte (1320 m French Alps)



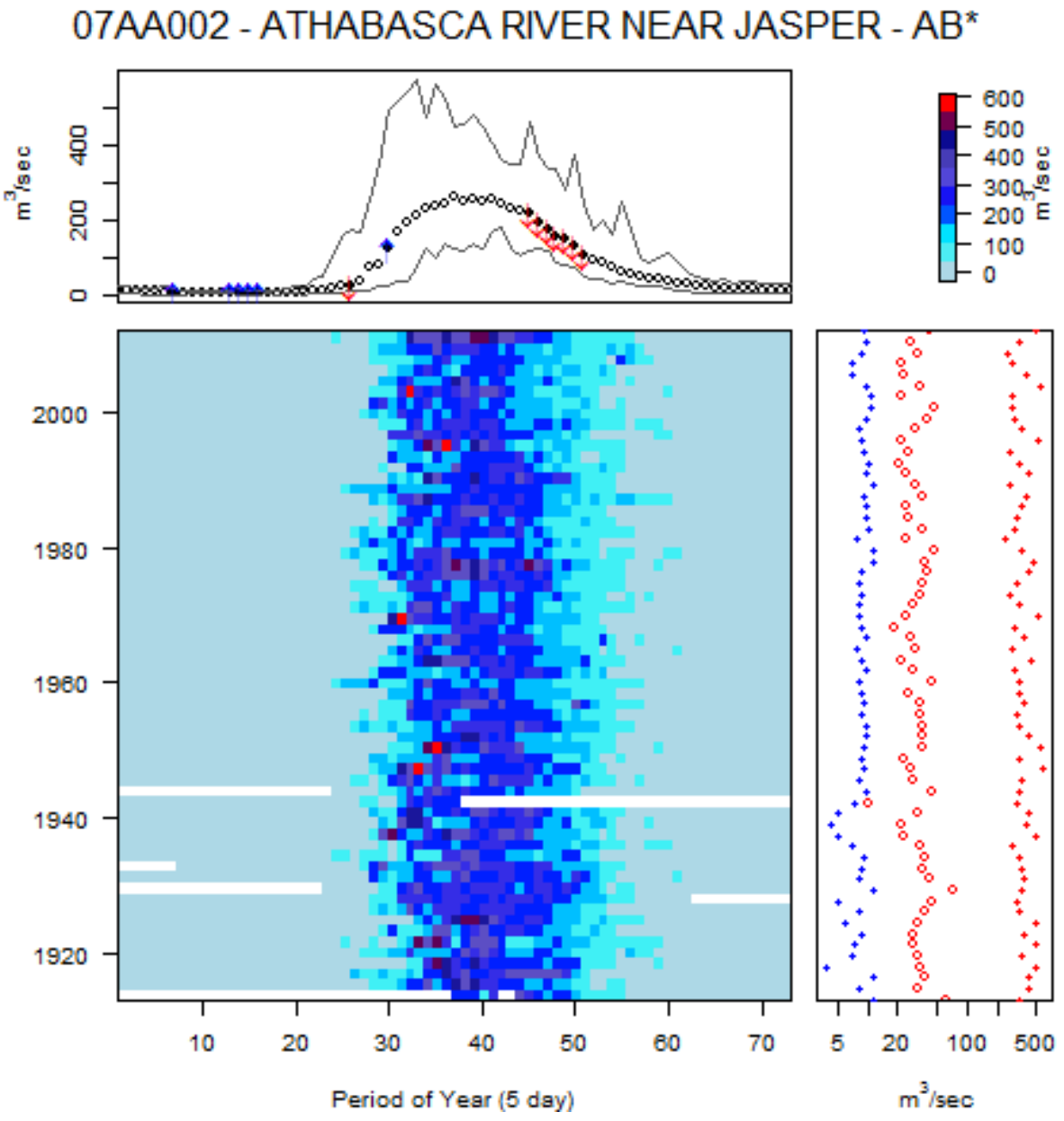
Observed and simulated snowpack spatial variability in the Pyrenees

Vionnet et al (JHM, 2016)
Quéno et al. (TC, 2016)

GSQ3: Changes in Extremes

- Study of the snowmelt, rainfall-runoff and glacier melt dominated Athabasca River in NW Canada

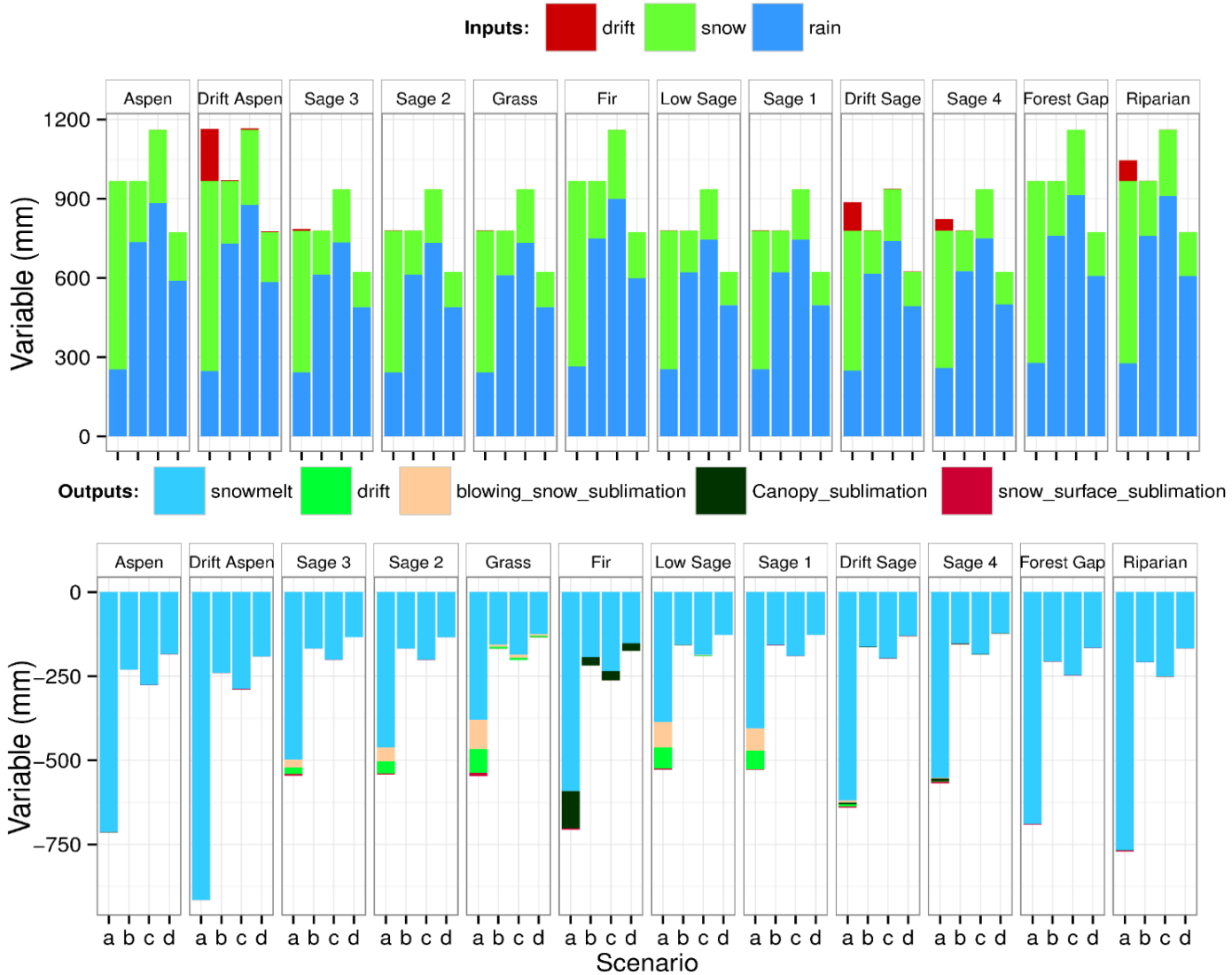
- Analysis of changes in extremes from this hydrograph over time and also changes to the timing of streamflow.
- Greater late winter streamflow and reduced late summer streamflow reflecting earlier snowmelt and reduced glacier contribution to runoff
- No trends in extremes of high and low flows over time.



Whitfield and Pomeroy (2016)

GSQ4: Water and energy cycles

- Annual contribution of snow mass and energy exchange processes by ecozone in the Reynolds Creek Research Watershed (USA)
- Sensitivity to perturbed climate: a) control period of current climate, b) P=100%, T= +5 C, c) P=120%, T=+5C. d) P=80%, T=+5C



CHRM model

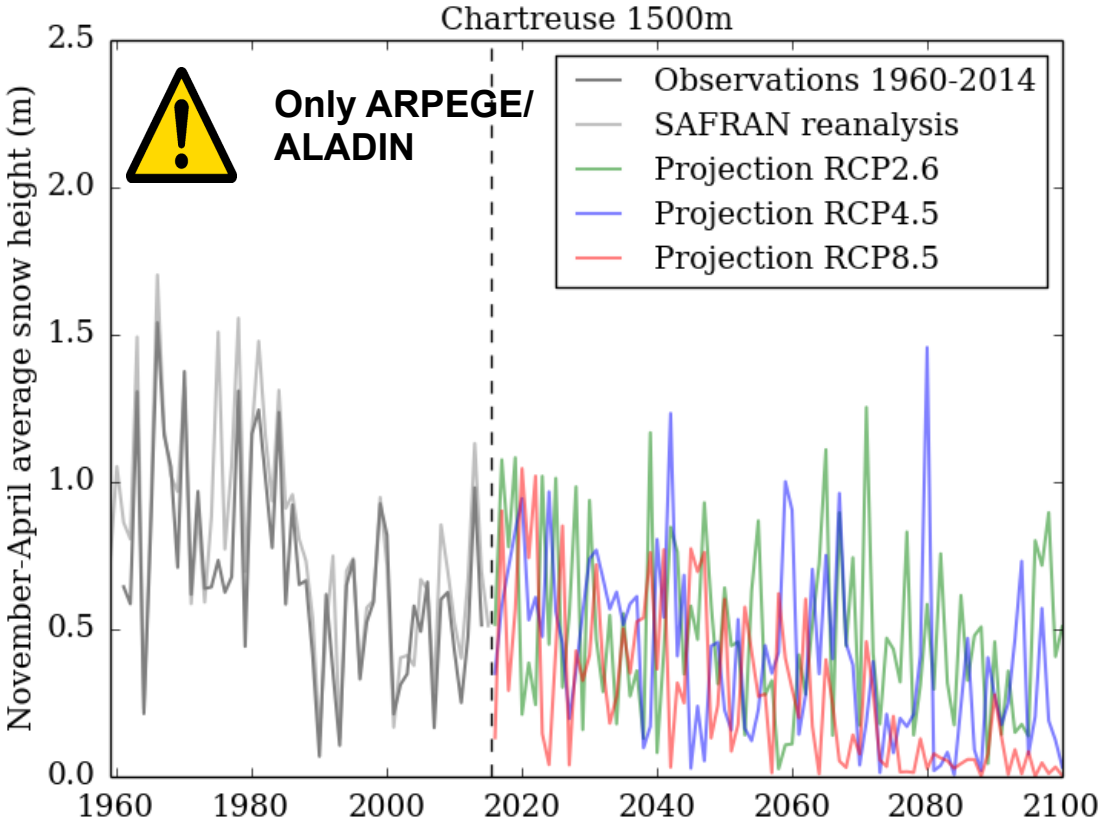
Rasouli (2016)

GSQ4: Water and energy cycles

ADAMONT: ADAptation of RCM outputs to MOuNTain regions:

- Downscaling of projections from a RCM against a regional reanalysis of hourly meteorological conditions using quantile mapping.
- Application to multi-scenario, multi-RCM simulation of snowpack evolution in the French mountains

Verfaillie et al (GMDD, 2016)



Snow height from ALADIN – Crocus at Col de Porte

INARCH Special Issue

- Special Issue open **in Earth Sytem Science Data** (ESSD)

- Editors: Dr. John Pomeroy, Dr. Danny Marks (USA) and Dr. Tobias Jonas (Switzerland)

Earth Syst. Sci. Data, 4, 13–21, 2012
www.earth-syst-sci-data.net/4/13/2012/
doi:10.5194/essd-4-13-2012

Open Access Earth System Science Data

An 18-yr long (1993–2011) snow and meteorological dataset from a mid-altitude mountain site (Col de Porte, France, 1325 m alt.) for driving and evaluating snowpack models

S. Morin[1], Y. Lejeune[1], B. Lesaffre[1], J.-M. Panel[1], D. Poncet[1], P. David[1,†], and M. Sudul[1,†]
[1]Météo-France – CNRS, CNRM-GAME, URA1357, CEN, Grenoble, France
[†]deceased
Correspondence to: S. Morin (samuel.morin@meteo.fr, col_de_porte@meteo.fr)

Received: 16 January 2012 – Published in Earth Syst. Sci. Data Discuss.: 6 February 2012
Revised: 31 May 2012 – Accepted: 9 June 2012 – Published: 6 July 2012

- **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 30 September 2017. 16 papers in prep.!

2nd INARCH Workshop

Grenoble (France) 17-19 October 2016

Topics:

- Atmospheric downscaling for mountain snow and ice hydrology modelling
- Availability and suitability of observations from mountain observatories and discussion of the INARCH special issue
- Sensitivity of the cryospheric and hydrological response of mountain catchments to various representations of a changing climate

- Two days of workshop and a 1-day field trip to Chamonix and the Mont Blanc area
- **Audience:** 60 scientists from USA, Canada, Chile, China, France, UK, Switzerland, Austria, Germany, Italy, Norway

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 – “Mediterrenean 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