INARCH:
International Network for Alpine Research Catchment Hydrology
2018 Meeting Closing

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3rd Annual INARCH Workshop, Zugspitze, Germany, 8 Feb 2018

INARCH Workshop Statement 2015

INARCH has identified a global set of mountain hydrometeorological observatories that address an urgent need for enhanced observations, and will promote the development of, and data publication for these observatories.

INARCH notes the need to identify and reduce uncertainty in application of mountain atmospheric, cryospheric and hydrological models. This can be accomplished by

1) improving the capability and range of downscaling methods to drive models,
2) improving exchange processes with frozen surfaces, and
3) integrating atmospheric, cryospheric and hydrological models to consider impacts of

- *-dynamic climate*
- *-transient vegetation and*
- *-hydrological and cryospheric storage at multiple scales.*

INARCH will conduct diagnostic modelling experiments using our instrumented catchments from around the world, paying particular attention to the impact of loss of snow and ice on hydrological cycling in order to predict the water security impacts of global change in mountain regions.

INARCH Workshop Statement 2016

- INARCH has identified a series of observatories around the world that provide enhanced mountain hydrometeorological and cryospheric observations with open availability of data, and will promote publication of these observations.
- INARCH will help quantify and improve the diagnostic and prognostic potential of models for predicting the water security impacts of global change in mountain regions.
- INARCH will promote hybrid downscaling with moderate (km) scale dynamical downscaling followed by fine (10s m) scale empirical and other downscaling to snowdrift resolving scales.
- INARCH will calculate the sensitivity of mountain snow, ice and hydrology to climate change and resulting impacts, taking into account transient vegetation cover, and hydrological and cryospheric storage.

Snow and Glacier Hydrology 2018

- There is a need for procedures to generate model input data at appropriate scales for the model application – links between atmospheric and surface models
- There is continued need for detailed validation of individual processes at the process scale.
- There is a need for mechanisms to inform large scale and operational models from small scale and process advances - advection, vegetation interactions, snow redistribution, human impacts, albedo dynamics, variable model resolution.
- Scaling of process representations and model structure is needed in models. The same processes and process representations are not applicable to all scales.
- Variations in basin configuration, hypsometry, glacier coverage, ice exposure, and vegetation need to be considered in climate sensitivity studies
- support for physical realism, not necessarily complexity, in models.
-TI methods – not considered an scientifically appropriate, physically realistic approach to snow and ice hydrology – there may be niche/legacy applications

-More climate sensitivity and vulnerability studies are needed in INARCH – we need to focus on a concerted effort using a selection of models driven by perturbed or downscaled climate on this using INARCH basins and data.

-INARCH will continue to encourage scientifically appropriate, physically realistic approachs to snow and ice hydrology.

Climate Models and Downscaling 2018

- R. Rasmussen: “you cannot statistically correct nothing”
- Dynamical downscaling using nested, multi-scale atmospheric models is strongly preferred over statistical downscaling for mountain snow, ice and hydrology model applications because of its ability to predict precipitation and wind in mountain environments
- Possibility of “mountain policy runs” – long term high resolution climate models – there is an opportunity to use ICAR nested in climate models for this – this needs exploration and testing.
-Downscaling wind flow over complex terrain can and should employ physically based approaches.

Dynamical downscaling is needed to create INARCH mountain policy runs for future climate at scales appropriate for snow and glacier hydrology models

Observations including Remote Sensing 2018

-There is value in observations from well-instrumented observatories and from remote sensing, model reanalysis and other coupled products.
-Remote sensing advances are providing improved albedo/radiative transfer information for snowpacks and accurate, large area estimates of snow and ice surface elevations – DSM from airplanes, drones and satellites.
-SWE still cannot be remotely sensed in mountains at scales relevant to INARCH
-There is value in extending LiDAR or SfM estimates of DEM with and without peak snowpacks for INARCH and other basins
-There is need to co-locate remote sensing initiatives and INARCH basins for joint verification, upscaling, parameter identification, modelling and assimilation advances.
-Data quality needs to be identified and documented before it can be used in atmospheric or surface models. Metadata is of high value in interpreting observations

INARCH research basin observational datasets will be proposed to GCW for inclusion in their global data portal. INARCH will provide input to GCW to inform their development of observational guidelines using current science. INARCH will continue to publish datasets and metadata in the ESSD special issue.

INARCH basins will contribute to future coupled surface and remote sensing observational studies including multispectral missions.

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.

Next Steps

- Complete Special Issue of *Earth System Science Data.*
- Mountain downscaling toolbox portal completion and posting to INARCH website
- LSS-H Model comparison and development – ongoing project linked to GEWEX-GLASS
- Multiscale climate change vulnerability analysis of alpine snow, ice and hydrological systems GWF PDFs to use CRHM at INARCH basins and provide data to GLASS comparison
- Pre-assessment synthesis article from INARCH for IPCC mountain report May 2019
- Link with Global Water Futures Program – international strategy
- GEWEX RHPs – US Water for Foodbaskets, Canada - GWF, ANDEX
- Next Meetings
    - Oct 20 Chile,
    - GEWEX convection permitting Sept 4-6 USA

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