REPORT OF THE INTERNATIONAL COMMISSION ON SNOW AND ICE HYDROLOGY (ICSIH) TO THE INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES.

For the IAHS Bureau Meeting, Paris, France, June, 2008

ICSIH Bureau Members Elected in Perugia, 2007

President: Professor John Pomeroy, University of Saskatchewan, Canada & Institute of Geography and Earth Sciences, University of Wales, Aberystwyth, UK
Vice-President: Dr. Alexander Gelfan, Russian Academy of Sciences, Moscow, Russia
Vice-President: Dr. Daniel Marks, Agricultural Research Service, Department of Agriculture, USA
Vice-President: Dr. Philip Marsh, National Water Research Institute, Environment Canada, Canada
Secretary: Dr. Regine Hock, Uppsala University, Sweden & University of Alaska, Fairbanks, USA

The International Commission on Snow and Ice Hydrology, IAHS was voted into existence by IAHS General Assembly at the IUGG in Perugia, Italy, July, 2007.

Progress on ICSIH Mission

Activities have included:

1.) Completion of one successful symposium and two successful workshops at the IUGG Perugia:
a) HS1003 Hydrology in Mountain Regions: Observations, Processes and Dynamics
*Sponsor **ICSIH** with co-sponsorship of UCCS, ICRS, ICSW, ICCLAS, ICGW,*

PUB
Convenor: **Daniel Marks (ICSIH)**
Co-Convenors: **Regine Hock, (ICSIH)** ; Michael Lehning, Switzerland; Robert Gurney, UK; Masaki Hayashi, Canada

b) JWH002 Climate-Permafrost-Hydrology Interactions: The Impact of Changing Climate on Cold Regions Hydrology
*Sponsors **ICSIH** with co-sponsorship of UCCS*
Convenor: **Philip Marsh (ICSIH)**; Co-convenors: **Lev Kuchment (ICSIH)**; Tingjun Zhang, USA/China; Oliver Frauenfeld, USA; Tetsuo Ohata, Japan.

c) JWH001 Interactions between snow, vegetation and the atmosphere
*Sponsors UCCS, **ICSIH**, IAMAS-ICPM, iLEAPS and IGS*
Convenor: Richard Essery, University of Wales,
Co-convenors: Robert Baxter, UK; **John Pomeroy (ICSIH)**; Matthew Sturm, USA; Takeshi Yamazaki, Japan.

Note that HS1003 is producing a Red Book.

2.) Completion of the successful workshop "Glaciers in watershed and Global Hydrology, held in Obergurgl, Austria, 27-31 August 2007. See report below. http://www.usask.ca/hydrology/icsih/obergurgl.htm

3.) Proposing two symposia for the IAHS Scientific Assembly for Hyderabad, India in 2009.

4.) Proposing one session for the joint IAMAS/IACS/IAPSO Scientific Assembly for Montreal, Canada in 2009.

5.) Preparation and completion of IAHS Red Book Publ. 318 (2007) "GLACIER MASS BALANCE CHANGES AND MELTWATER DISCHARGE", Edited by Patrick Ginot & Jean-Emmanuel Sicart

6.) Working as a liaison between IACS and IAHS.

7.) Making progress in hydrological components of the 2008-2009 International Polar Year.

Information Items

1. ICSIH Symposia for IAHS/IAH Hyderabad, 2009

HS.1 High mountain snow and ice hydrology

ICSIH, ICRS, PUB, IACS

Changes in storage of water as seasonal snowpack, frozen ground, and perennial snow and glacier ice, and release of meltwater are major components of hydrological systems in the high mountain regions of the world. In such areas, the annual cycle of meltwater production from snow and ice is critical, influencing streamflow regime, soil moisture, and both terrestrial and aquatic ecosystems. Meltwater availability is crucial in cold mountain environments, and in areas downstream, for agriculture and hydropower,

particularly where the areas surrounding mountains are otherwise arid and susceptible to drought. Snowpack, permafrost, glaciers and meltwater runoff will continue to be influenced strongly by climate change into the future. Detailed understanding of and the ability accurately to model inter-relationships between climate, snowpack, ground ice and glacier dynamics coupled with intra-basin hydrologic processes are necessary in order to test hypotheses concerning contemporary and future interactions between high mountain climate, snow, ice, runoff, biogeochemistry and water quality. This symposium addresses a broad range of topics important for better understanding of snow and ice hydrology in mountain regions and for reducing uncertainty and increasing physical realism in modelling and prediction. Contributions on the following topics are particularly welcome: measurement and monitoring techniques for snow and ice in cold mountainous regions; physical properties of snow, permafrost and ice - linking microscale properties to macroscale processes; using remote sensing for improvement of prediction of runoff from snow and ice in data-sparse mountain areas; forecasting meltwater runoff from ungauged high mountain basins; assessment of risk and prediction of glacier lake outburst floods in mountain areas, and impacts of mountain snow and ice hydrology on water resources in drier downstream areas in a changing climate.

Convener: David Collins (University of Salford, UK), d.n.collins@salford.ac.uk

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HS.2 New approaches to hydrological prediction in data sparse regions

ICCLAS, ICSIH, ICWRS, ICRS, PUB

In many regions of the world the reliability of hydrological predictions is limited because local data are often sparse or non-existent. New strategies to help reduce the negative consequences of data scarcity are crucial to improving water resources management and to better assessing the evolving impacts of natural and anthropogenic climate change. One important way around this problem is to draw on other sources of information, including, for example: 1) coupled hydro-meteorological predictions, 2) remote sensing technology, and 3) guided monitoring network design. Strategies for improving and exploiting hydro-meteorological predictions might include novel downscaling techniques, improved representation of critical land-surface-atmosphere continuum, assessment of the effects of climate variability/change on frequency/severity of floods and drought, and approaches to incorporate data assimilation and uncertainty assessment. Strategies for exploiting remote sensing technology might include methods that assimilate such information into water management, that improve water use effectiveness, or that monitor and understand land-use changes in relation to water availability and usage. Strategies focusing on alternatives to expensive ground-based monitoring networks might include guidance on the design of optimum network density and/or sampling strategy to address specific science problems (e.g., dominant process identification) and resource management challenges. Methods for using sparse networks to evaluate the approaches listed above are also important. This symposium seeks contributions that address how such approaches can help reduce the negative consequences of data scarcity and thereby improve hydrological predictions in data sparse regions.

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2. ICSIH Symposium for IAMAS/IACS/IAPSO Montreal, 2009

J15 High Latitude Terrestrial Processes, Hydrology, and Interactions with the Atmosphere

Sponsoring Associations: IACS/IAMAS

Convenors:
IAHS-ICSIH: John Pomeroy (john.pomeroy@usask.ca) – Lead Convenor
IAMAS: Richard Essery (richard.essery@ed.ac.uk)

In high latitudes, the state of the land surface snow, ice and water resources are strongly controlled by complex interactive processes that govern exchange between the climate, snow, lake ice, permafrost and hydrology. These processes are subject to intense investigation as part of the International Polar Year studies of freshwater supply and cold regions processes. Interactions such as those processes mediating climate, snow accumulation, snowmelt, sublimation, soil moisture, soil thermodynamics, evaporation, and vegetation are of particular interest. In order to consider future changes in hydrology and water resources due to anthropogenic climate change it is necessary to understand these processes. However, the nature of these interactions, and our ability to model the relevant processes, are currently very limited. It is expected that both natural climate variability and anthropogenic climate change will result in significant changes to the state of high latitude cryosphere and hydrology, however, due to the complex processes and their cumulative effects it is difficult to predict with confidence what direction and with what celerity these changes will occur.

This symposium will address these issues by bringing together experts in the fields of cold regions hydrology, snow and ice and land surface atmosphere interactions in order to discuss important issues and advances in our understanding of high latitude terrestrial processes, hydrology and the interactions between these processes and the atmosphere.

Contributions are be solicited on, but not limited to, the following:
- the interactions between surface, snow and atmospheric processes in high latitudes,
- snow processes and hydrology,
- the effects of changing Arctic vegetation on land surface processes, snow, hydrology and the atmosphere,
- the effects of climate change on high latitude hydrometeorological processes,
- the ability of existing hydrological and land-surface models to consider the complex interactions between land, snow, ice, hydrology and atmospheres, and the ability of these models to consider the impact of climate change on high latitude hydrological systems.

3. Report on the ICSIH Workshop on Glaciers in Watershed and Global Hydrology

More than 60 researchers from 20 countries gathered in the beautiful Austrian village of Obergurgl to attend the workshop “Glaciers in watershed and global hydrology” from 27-31 August 2007. The aim of the workshop was to bridge the intellectual gap at the glacier terminus—where glaciology traditionally ends and hydrology traditionally begins. Fittingly, those in attendance were from both disciplines and all shared an interest in the downstream effects of glaciers.

The workshop comprised three days of presentations (33 oral and 14 poster) focused on

(1) Incorporation of glaciers in runoff-models: How can glaciers be represented in runoff models? Which glacier melt and routing routines are necessary to capture the specific characteristics of glacial discharge? How can glaciers be included in global hydrological models? How is it best to deal with changing glacier geometries in runoff predictions?
(2) Effects of climate change on glacier runoff and the hydrology of glacierized catchments: How will annual, seasonal and diurnal runoff characteristics change as glaciers continue to retreat? How does the response vary in different climate regions?
(3) Glaciers as information repositories for hydrological modelling: What kind of information can be extracted from glaciers that can aid hydrological modelling? How can glacier measurements help to constrain model parameters or provide model input?

The pleasant conference location at the Universitätszentrum in Obergurgl, where most participants were accommodated, provided an excellent platform for the interactive and relaxed nature of the workshop (in sessions and at the bar) with ample opportunity for informal discussions and networking. A half-day hiking excursion in the local mountains provided an intermission during the workshop.

The rapid decline of glaciers and associated runoff changes came to life for more than 25 participants who attended the two-day excursion to the glacier Vernagtferner in the nearby Vent valley and toured the impressive gauging and meteorological station. Those who stayed overnight at the Vernagt mountain hut were rewarded with blue sky and sunshine, proving the miserable weather forecast wrong. The full-day hike across the glacier, through a spectacular 250 m ice cave and to nearby Schwarzkögele (>3000 m a.s.l.) was clearly a highlight of the workshop.

Sixteen participants have submitted papers to a special issue of *Hydrological Processes,* edited by the conveners of the meeting, which will be published later in 2008. The event was sponsored by the *International Commission on Snow and Ice Hydrology* (ICSIH) of IAHS and the *Union Commission for the Cryospheric Sciences* (UCCS). We are grateful for financial support from UNESCO-IHP, the University of Innsbruck and the IUGG, which enabled us to support five early-career scientists from Brazil, India, Nepal and Pakistan with travel grants, and to cover the organisational costs.

Conveners
Regine Hock, University of Alaska, Fairbanks*;* Tómas Jóhannesson, Icelandic Meteorological Office, Reykjavík; Gwenn Flowers, Simon Fraser University, Burnaby, Canada; Georg Kaser, University of Innsbruck, Austria

4. Report on Snow and Ice Hydrology in the International Polar Year

John Pomeroy, Centre for Hydrology, University of Saskatchewan, Saskatoon, Canada
Alexander Gelfan, Russian Academy of Sciences, Moscow, Russia
Árni Snorrason, Hydrological Service, National Energy Authority, Reykjavík, Iceland
Julie Friddell, IP3 Network, University of Saskatchewan, Saskatoon, Canada

There are substantial hydrology activities in the International Polar Year (2007-2008), driven by the need for a better understanding of hydrology in the Polar Regions. This need is made urgent by the ungauged or poorly-gauged nature of much of the Arctic and Antarctic drainage basins and by the importance of melt in governing the balance between terrestrial snow and ice and streamflow. Freshwater inputs can modify ocean currents, particularly those in the North Atlantic which currently warm Europe. The impacts of a warming Arctic are already raising serious

concerns about the stability of the sensitive balance between climate conditions, freshwater input, oceanic circulation and the state of cryospheric components.

In the International Polar Year cold regions hydrology activities are mainly organised around the Arctic-Hydra Project lead by Árni Snorrason of Iceland, http://arcticportal.org/arctichydra. The Arctic-HYDRA project consists of a network for the observation of the Arctic Hydrological Cycle (AHC) coupled with a suite of intensive, focussed process studies that are based on in-depth measurements and modelling of the individual components of the AHC. Furthermore, hydrological models and data assimilation techniques will be developed to generate a comprehensive, integrated description of the AHC including the feedbacks between the atmosphere, cryosphere and the oceans. The main scientific goals of the Arctic HYDRA project are to i) characterize variability in the AHC, ii) examine linkages between atmospheric forcing and continental discharge to the oceans, iii) assess the historical response of the Arctic Ocean to variations in freshwater input from rivers and net precipitation over the ocean, iv) attribute to specific elements of the AHC or to external forcing the sources of observed spatial temporal variability in the land-ocean- ice-atmosphere system, v) detect emerging changes in the contemporary state of the AHC in near real time and to place such changes into a broader historical context.

Two major activities relating to the IPY and linked to Arctic-Hydra are the Russian national programme for hydrology in IPY and the Canadian IP3 Network (Improved Processes and Parameterisations for Prediction in Cold Regions) both of which recently have had important meetings. The format and results of these meetings are briefly described below.

Russian hydrology activities related to IPY

The scientific program for Russian participation in IPY was adopted in 2006 by the Russian National Committee for IPY 2007-2008 (http://www.ipyrus.aari.ru/orgcom_comp.html; in Russian language only) under the support of the Government of the Russian Federation. Russian IPY 2007–2008 activities assemble researchers from the Federal Service for Hydrometeorology and Environmental Monitoring, Russian Academy of Sciences, Moscow State University, institutes of the government ministries and some non-government organizations. A total of 164 projects have been endorsed by the Russian National Committee for IPY 2007-2008. These projects have an interdisciplinary emphasis and address seven branches of research. The first branch is particularly devoted to the hydrological processes in the Arctic region. The main objectives of the hydrological section are the estimation of the current and the future changes in hydrological and ice regime of the rivers and lakes, and snow processes in the Russian arctic regions under the climate changes. Within the framework of these objectives, the projects are directed to

(1) collecting a broad-ranging set of hydrometeorological data which will be made available worldwide,

(2) developing a strategy to account for climate change impacts on arctic rivers,

(3) assessing the probable changes in the large river runoff under the changing climate and adapting existing water resources systems to these changes, and

(4) estimating the spatial-temporal variability of snow processes and their sensitivity to climate change.

On 3-9 October 2007 in Sochi, the Russian National Committee for IPY 2007-2008 organized a conference where the first results of these studies were discussed. The conference was hosted by the Scientific Centre of the Russian Academy of Science (RAS) and opened with a plenary talk from academician of RAS Vladimir M. Kotlyakov, Chairman of the Scientific Council of Arctic and Antarctic Research. Over 100 people attended the conference and presented 92 oral and poster reports from which thirteen were focused on the hydrological topics listed above. These hydrological reports were presented by researchers from the Water Problems Institute of RAS, the Institute of Geography of RAS, the Institute of Atmospheric Physics of

RAS, and Moscow State University. Different approaches to modelling river runoff generation in the permafrost regions, river ice-cover dynamics and ice jam flooding, and seasonal snowcover processes as well as to estimating the current changes in water and chemical flow of the large Siberian rivers into the Arctic Ocean, and the physical properties of snow cover were developed and reported by these researchers. The conference closed with a discussion on integration, in the framework of IPY, of the Russian IPY hydrological activity with the international community of cold region hydrology.

The IP3 Research Network: Enhancing Understanding of Water Resources in Canada's Cold Regions as part of IPY

IP3, *Improved Processes and Parameterisation for Prediction in Cold Regions*, is a research network funded by the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS) for 2006-2010. The Network, which is comprised of about 80 Investigators, Collaborators, postgraduate students, and postdoctoral fellows from across Canada, the US, and Europe, is devoted to an improved understanding of surface water and weather systems in cold regions, particularly Canada's Rocky Mountains and western Arctic. IP3 makes a contribution to better weather and climate prediction, to estimation of streamflow from ungauged basins, to predicting changes in Rocky Mountain snow and water supplies, to calculating freshwater inputs to the Arctic Ocean, and to sustainable management of mountain and northern water resources.

IP3 has three goals: understanding the key climate system **Processes** relating to the hydrometeorology of cold regions; **Parameterising** land surface hydrology processes that control the coupled atmospheric-hydrological system in cold regions; and validating and improving models for weather, water, and climate systems leading to better **Prediction** and simulation of related atmospheric impacts on water resources and surface climates in cold regions. The first of these goals is being addressed through intense field campaigns along a transect of eight highly instrumented, small (10-200 km2) research basins that characterize the range of Canada’s cold regions. Field investigations are focused on snowpacks (based on land, glaciers, and lake ice), open water (primarily small lakes), and runoff generation over frozen ground, glacierized areas, and permafrost. To address the other two goals, the Network members are pursuing a new generation of process hydrology and coupled atmospheric-hydrological models. Recent advances in understanding are being parameterised and integrated into numerical models to improve the predictive capabilities for complex land-atmosphere systems in cold regions.

IP3 held its Second Annual Network Workshop at the Cold Regions Research Centre of Wilfrid Laurier University in Waterloo, Ontario, Canada, 8-10 November 2007. Approximately 90 people attended the Workshop, including 27 students from across Canada and the UK. The event was also the launch of the Canadian component of the International Polar Year (IPY) aspect of IP3 and related studies of Arctic-Hydra. The Workshop provided the first link between the IPY and the PUB (IAHS Predictions in Ungauged Basins) Decade.

Dr. Gordon Young, President-elect of IAHS, provided a plenary talk on "Cold Regions Hydrology and its Relevance to Canada and the World". Dr. John Pomeroy, IP3 Principal Investigator, gave an overview of the Network and its goals. This was followed by 27 scientific reports from Investigators and Collaborators highlighting cold regions hydrological processes, parameterization of these processes into models, and prediction using a range of modelling strategies which encompassed small-scale process hydrology models through larger scale coupled atmosphere-land surface hydrology models. The third day of the Workshop focussed on IP3's international and national collaborations. The Network contributes to PUB as Working Group 16 and has established linkages with the Western Canadian Cryospheric Network, a related CFCAS-funded glaciological research network. Dr. Fred Wrona, Acting Director General of the Water Science and Technology Directorate of Environment Canada, spoke on behalf of the Canadian

government and highlighted its links to IP3 in *Freshwater Systems: Hydrology and Ecology*, a Canadian Arctic IPY initiative.

The IP3 Users' Advisory Committee, chaired by Bob Reid, held its first in-person meeting as part of the IP3 workshop with plenary presentations from Ian Church, Science Advisor to the Government of the Yukon, on "The User's Perspective from the North" and from Bob Sandford, Executive Director of the Western Watersheds Climate Research Collaborative and prolific Alberta-based author, on "A Tower of North American Babel: Making Climate Science Intelligible To Leaders, Policy Makers, and the Public." These presentations were followed by a round table discussion on water resource and ecohydrology users' needs from IP3.

In the closing session, Dr. Hok Woo, Chair of the IP3 Board of Directors, summarized the good progress IP3 has made in its 16 months of existence. Since the workshop, IP3 has been accepted as a project of CliC (the Climate and Cryosphere Project) of the World Climate Research Programme.

Next Meetings

The Nordic Hydrological Conference will be held in Reykjavík on 11-13 August 2008 where Arctic-Hydra and ICSIH will sponsor sessions relating to climate modelling in the Arctic, hydrological measurements and modelling in the Arctic, glaciological measurements and modelling in the Arctic, and climate impacts on Arctic water resources and hydroeco-systems. **http://www.nhc2008.com.** There will also be further Russian and Canadian meetings dealing with their IPY studies, including the next IP3 workshop in Whitehorse, Yukon Territory in November, 2008.