Terrestrial Hydrology in Cold Regions: ICARPII to WCRP-CliC

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IP3 Workshop #3, 12-15 November 2008, Whitehorse, Yukon
RECOGNIZED IN ICARPII

~ 20 international groups and agencies sponsored ICARPII.

Major goal: prepare Arctic research plans to guide international cooperation over the next 10-15 years.

Working Group 7:
Terrestrial Cryosphere & Hydrology
Working Group 7 Membership:
Terrestrial Cryosphere & Hydrology

Terry D. Prowse, Environment Canada & University of Victoria, Canada (Chair)
Carl E. Bøggild, Geological Survey of Denmark and Greenland, Denmark
Andrey F. Glazovsky, Russian Academy of Sciences, Russia
Jon Ove M. Hagen, University of Oslo, Norway
Larry D. Hinzman, University of Alaska Fairbanks, U.S.A.
Ånund Killingtveit, Norwegian University of Science and Technology, Norway
Dennis P. Lettenmaier, University of Washington, U.S.A.
Frederick E. Nelson, University of Delaware, U.S.A.
Wayne R. Rouse, McMaster University, Canada
Konrad Steffen, University of Colorado, USA
Igor A. Shiklomanov, State Hydrological Institute, Russia
Kathy L. Young, York University, Canada
Vladimir M. Kotlyakov, Russian Academy of Sciences, (Liaison to ICARP II SG)
KEY SCIENTIFIC QUESTIONS:

Changes in Hydrologic system important to:

1. global and regional feedbacks to the climate system
2. terrestrial and freshwater aquatic system production and biodiversity
3. impacts on humans
B. ST. Inflow km³/yr

River Inflow km³/yr

P-E Inflow km³/yr

Outflow km³/yr

\[ O_{\text{Fram}} = (P-E) + I_{\text{Bering}} + I_{\text{Rivers}} \]

"Why do you hydrologists keep giving us different numbers for the total river flow to the Arctic Ocean?"

Howard Cattle, Tallin Estonia, May 1998
Arctic precipitation +8% over last 100 yr

Eurasian discharge increased at ~2 km³/yr 1936-99

rapid retreat of glaciers: Alaska ~1/2 of global loss

INTEGRATING THEME: Changes In The Terrestrial Components Of The Freshwater Budget Of The Arctic Ocean

Increasing melt of Greenland Ice Sheet 1979-2007
MAJOR INCREASES IN ARCTIC EURASIAN FLOW WITH VARYING CONTROLS

INCREASES IN EURASIAN RIVER FLOW from Peterson et al., 2002

Slope = 2.0 +/- 0.7 km³/yr

Seasonal effect

assessment for changes by, e.g., McClelland et al. 2004

4m thaw depth?
LSMs: HYDROLOGIC DIFFICULTIES IN MODELLING BASIN FLOWS

- Freshet & Snow Duration
- Permafrost/ Groundwater
- Low Flows in Winter
- Storage

“No single model is the best or worst performing when compared to a range of observations.”

Slater et al. 2007
ICARPII Proposed “Supersite” Approach

- designed to meet multi-disciplinary water science needs for northern regions

Elements of Supersite Science

1. Observations
2. Process Studies & Modelling
3. Upscale Modelling/Synthesis
4. Future Climate Scenarios

Figure 4: Major components of ICARPII study approach.
More than 100 countries identified with cryospheric components. Cryosphere truly is global.

• Implementation Workshop (Potsdam, 2006) ICARP-II
WG7 Research Plan adopted by WCRP-CliC and becomes central to Theme 1: TCHM
**CliC Goal and Themes**

**Principal Goal:**

To assess and quantify the impacts that climatic variability and change have on components of the cryosphere and the consequences of these impacts for the climate system.

In addressing this aim, CliC also seeks to determine the stability of the global cryosphere.

CliC focuses its activities through the following themes:

1. **Terrestrial cryosphere and hydro-climatology of cold regions**
2. **Ice Masses and Sea Level**
3. **Marine Cryosphere and Climate**
4. **Global Prediction of the Cryosphere**
1. The Terrestrial Cryosphere and Hydroclimatology of Cold Regions (TCHM)

• What are the magnitudes, patterns and rates of change in terrestrial cryosphere regimes on seasonal to century timescales? What are the associated changes in the water cycle?

• What is the role of terrestrial cryospheric processes in the spatial and temporal variability of the water, energy and carbon cycles of cold climate regions, and how can they be parameterized in models?

• What are the interactions and feedbacks between the terrestrial cryosphere and atmosphere/ocean systems and current climate? How variable are these interactions and how will they change in the future?
CliC- *TCHM* developments, e.g.

- IP3 joins TCHM
- FreshNor joins TCHM
- Norway proposes TCHM supersite
- Asia-CliC workshop progress


3. Casassa et al. Detection of changes in glacial runoff in alpine basins: examples from North America, the Alps, central Asia and the Andes.


7. Bavay et al. Simulations of future snow cover and discharge in alpine headwater catchments.

8. Yang et al. Yukon River streamflow responses to seasonal snowcover changes.


11. McNamara and Kane. The impact of a shrinking cryosphere on the form of arctic alluvial channels.

Joint effort with **WCRP-CliC-TCHM & GEWEX** on “High Latitude & High Elevation Hydrology”

2009 Joint CliC-GEWEX “think tank” planned to evaluate and develop best procedures for linking GCM/RCMs with cold-regions hydrologic models (e.g., snow to glaciers to freshwater ice); lead to: a) special journal publication; b) supersite testing
Climate Change and the Cryosphere: Snow, Water, Ice, and Permafrost in the Arctic (SWIPA, 2011)

An Arctic Council ‘Cryosphere Project’ in Cooperation with IASC, CliC and IPY

1. Component 1: Arctic Sea Ice in a Changing Climate
2. Component 2: Climate Change and the Greenland Ice Sheet (2009)
3. Component 3: Climate Change and the Terrestrial Cryosphere
   • 3A. Module 1: Changing snow cover and its impacts
   • 3B. Module 2: Changing permafrost characteristics, distribution and extent and their impacts
   • 3C. Module 3: Glaciers and ice caps
   • 3D. Module 4: Hydrology: Rivers and lakes
4. Modeling Activities in Support of the Climate Change and Cryosphere Project
Global Cryosphere Watch—A WMO Initiative

- 15th WMO Congress (May 2007) Canadian proposal for GCW as part of IPY legacy
- WMO Inter-commission Task Group on IPY to establish an ad-hoc expert group to develop GCW

**Proposed mission would:**
- Implement the IGOS Cryosphere Theme (CryOS)
- Provide means to predict the future state of the cryosphere;
- Facilitate assessment of changes in the cryosphere and its impact, and to use this information to aid the detection of climate change