Terrestrial Hydrology in Cold Regions: ICARPII to WCRP-CliC

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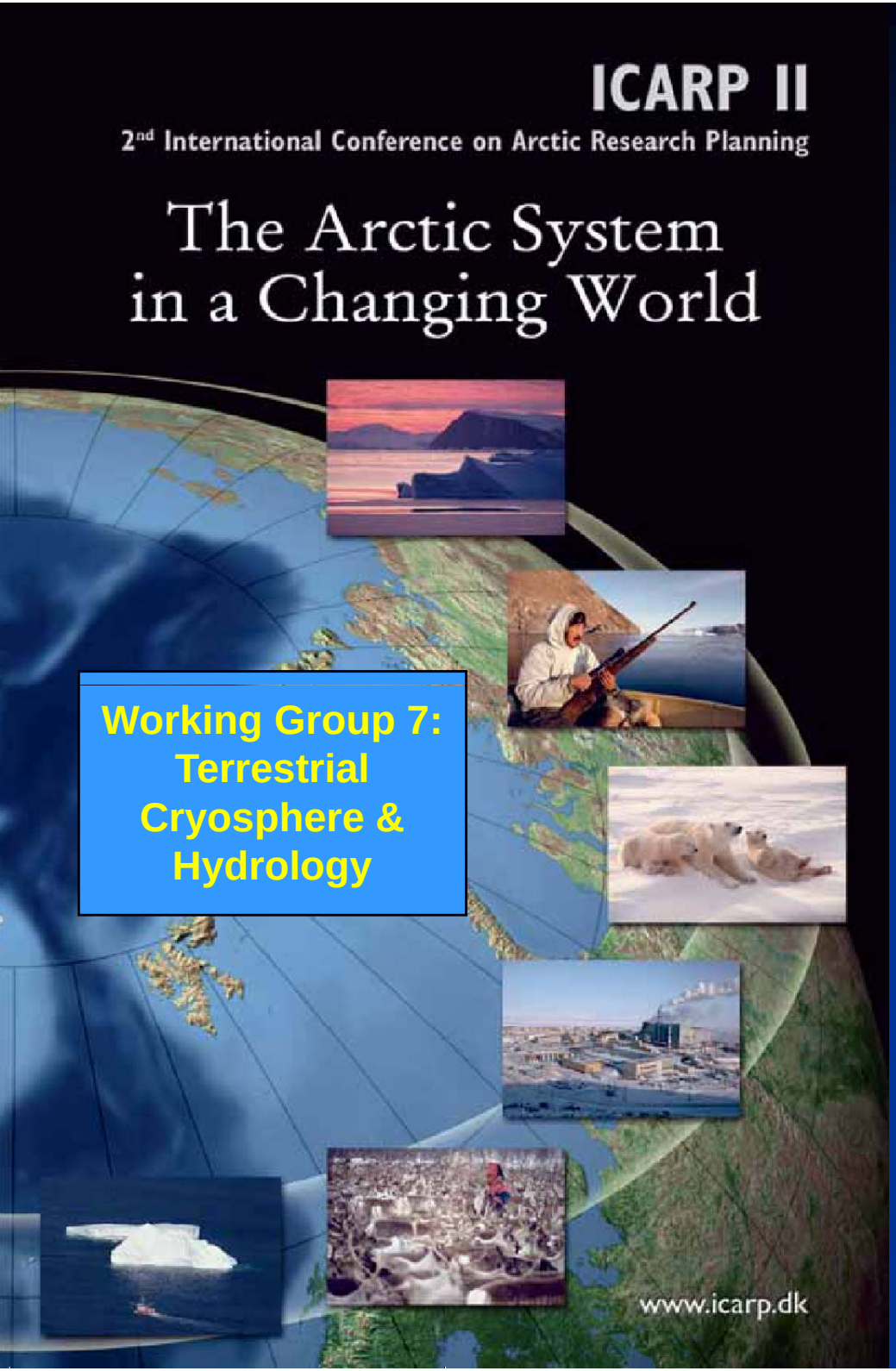
Environment Canada & University of Victoria

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

Environment Canada Environnement Canada

W-CIRC WATER AND CLIMATE IMPACTS RESEARCH CENTRE

University of Victoria



IMPORTANCE OF CHANGE & HOW TO ADDRESS IT 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

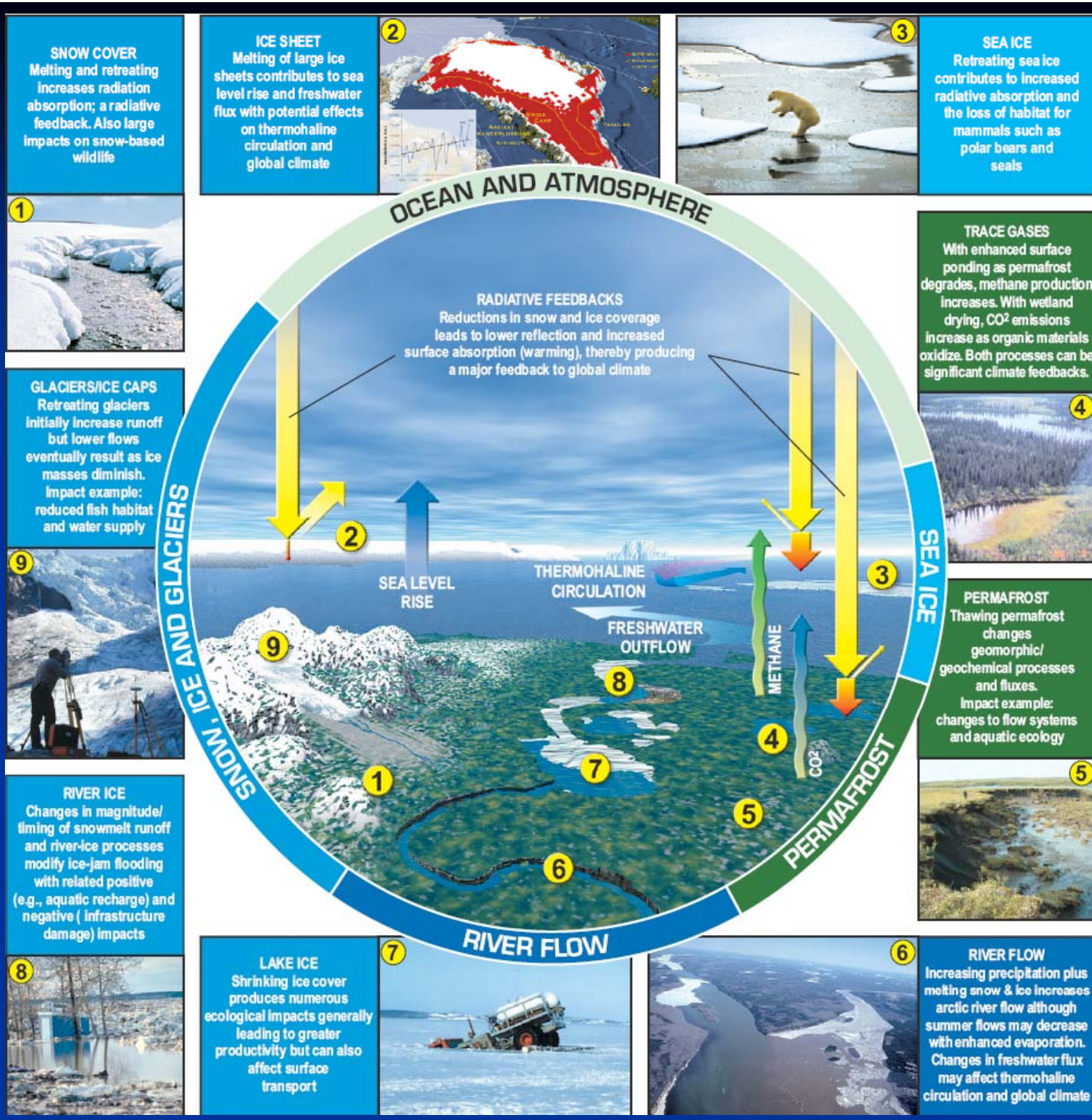
Vladimir M. Kotlyakov, Russian Academy of Sciences, (Liaison to ICARP II SG)

WG7: Terrestrial Cryosphere & Hydrology

KEY SCIENTIFIC QUESTIONS:

Changes in Hydrologic system important to:

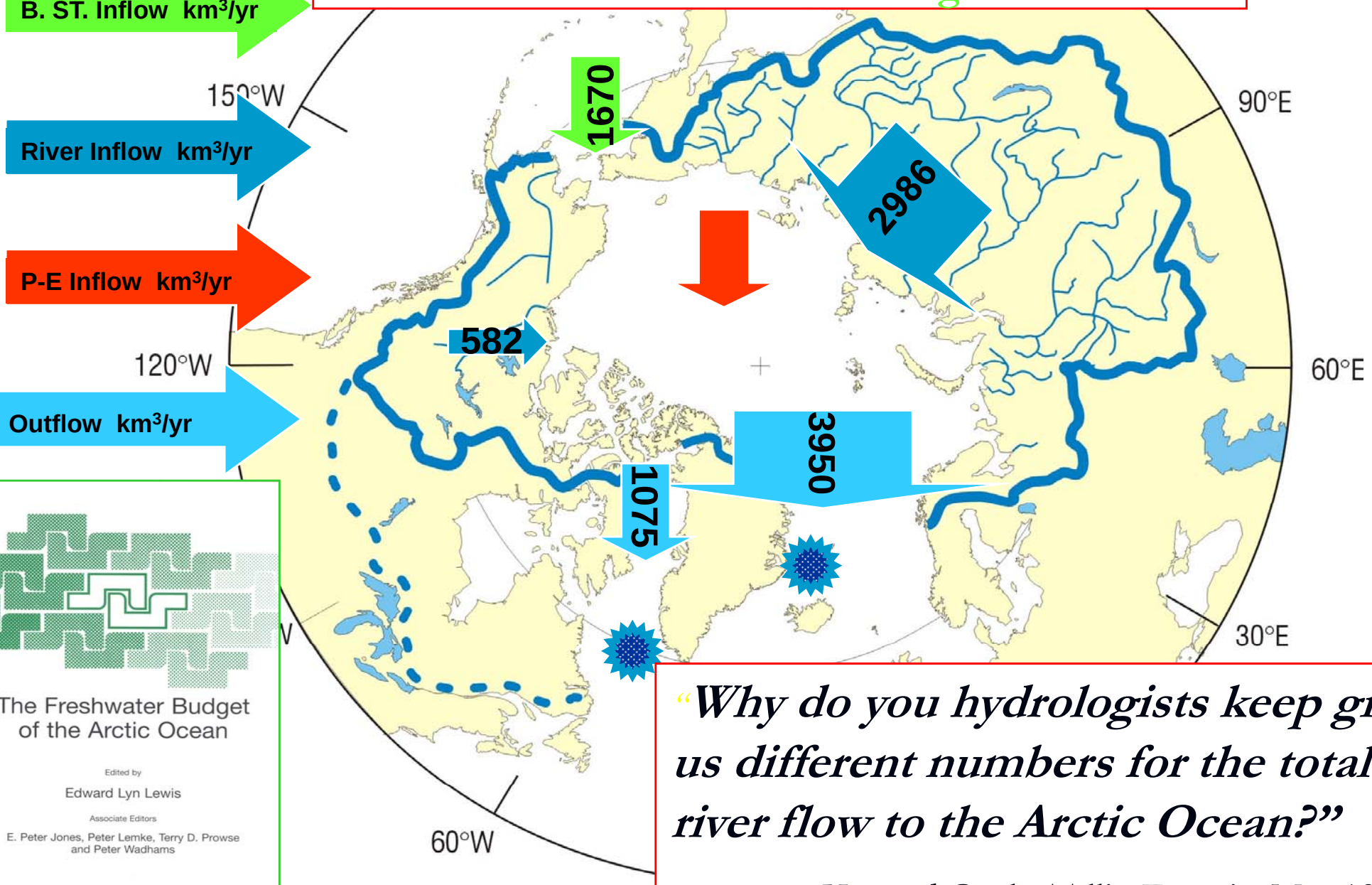
1. global and regional feedbacks to the climate system
2. terrestrial and freshwater aquatic system production and biodiversity
3. impacts on humans



BINDING ICARPII FOCUS:

AN "early" BASIC FW BUDGET OF THE ARCTIC OCEAN

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



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

Howard Cattle, Tallin Estonia, May 1998

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

Arctic precipitation +8% over last 100 yr

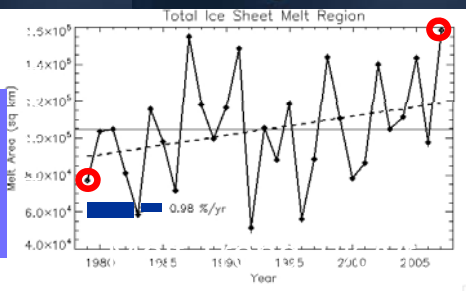
Eurasian discharge increased at ~2 km3/yr 1936-99

150°E
120°E
120°W
60°E
90°W

1670
2986
582
3950
1075
713

Inflow km³/yr

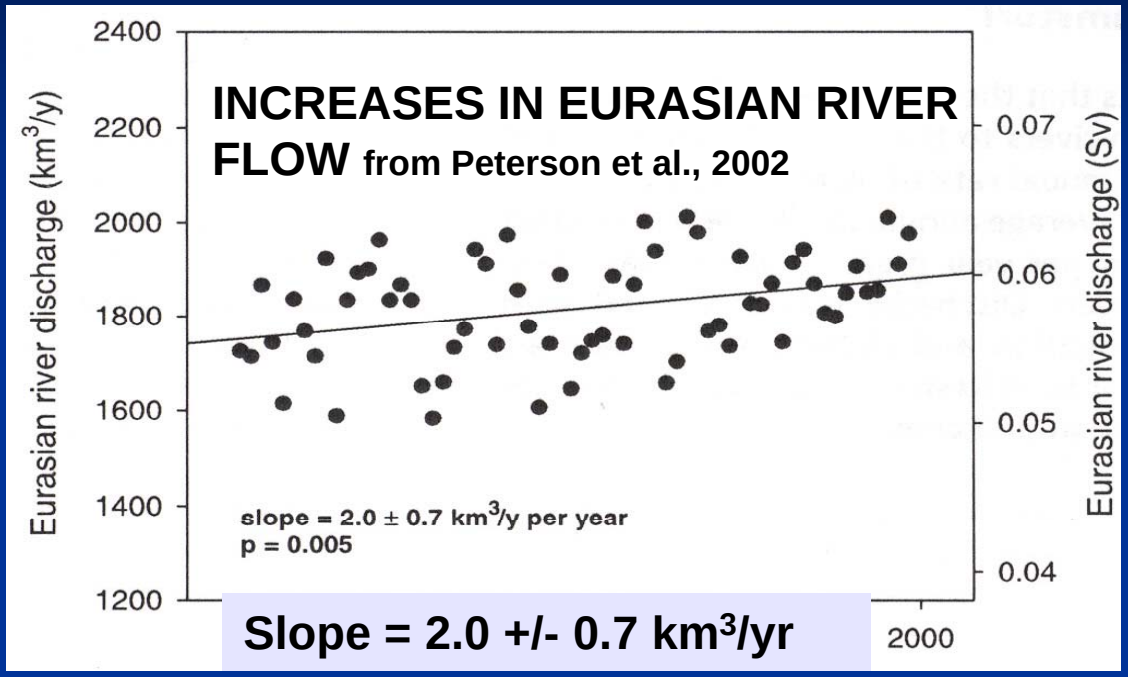
Outflow km³/yr



Increasing melt of Greenland Ice Sheet 1979-2007

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

MAJOR INCREASES IN ARCTIC EURASIAN FLOW WITH VARYING CONTROLS

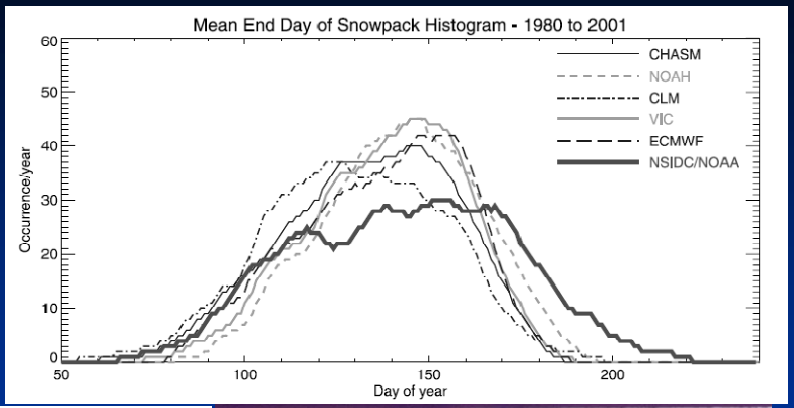


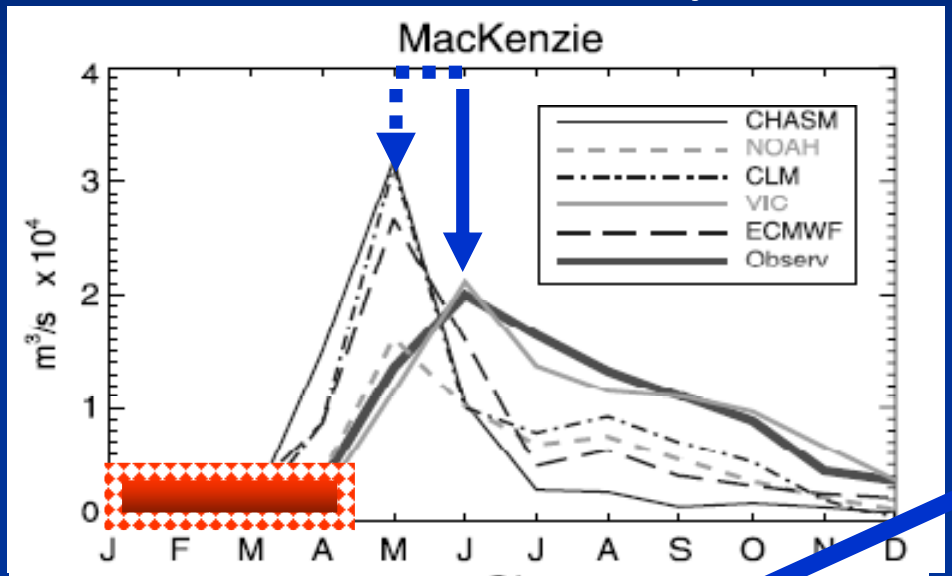
assessment for changes by, e.g., McClelland et al. 2004

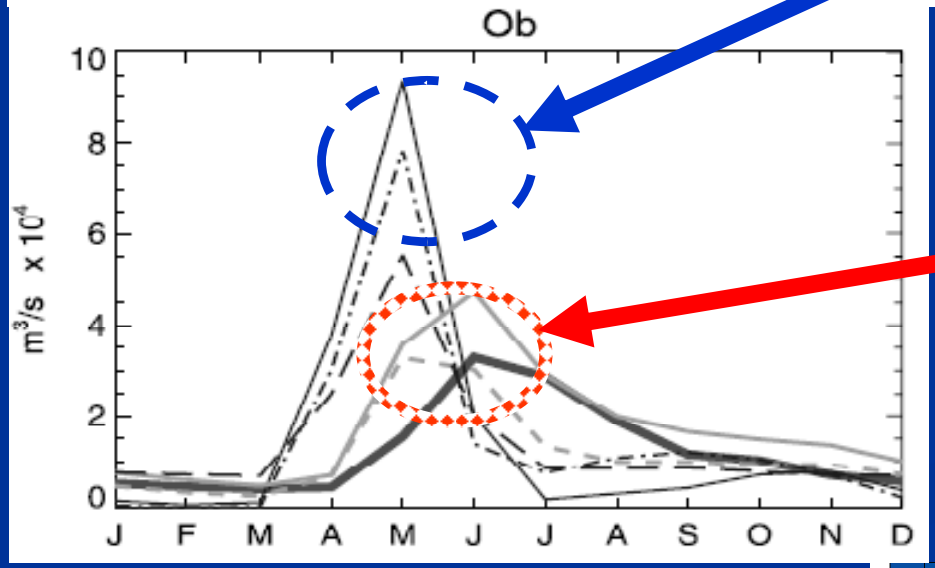
LSMs: HYDROLOGIC DIFFICULTIES IN MODELLING BASIN FLOWS

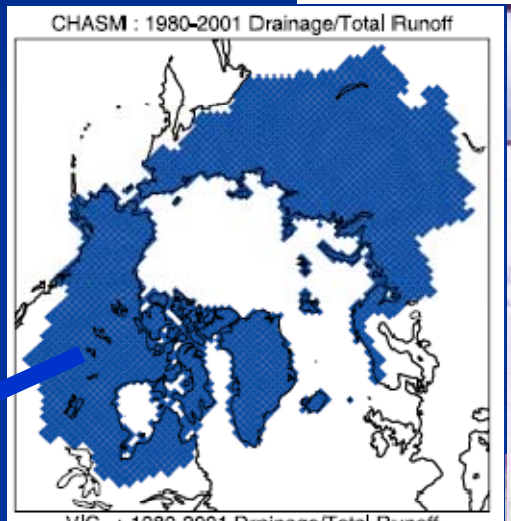
- Freshet & Snow Duration
- Low Flows in Winter
- Permafrost/ Groundwater
- Storage

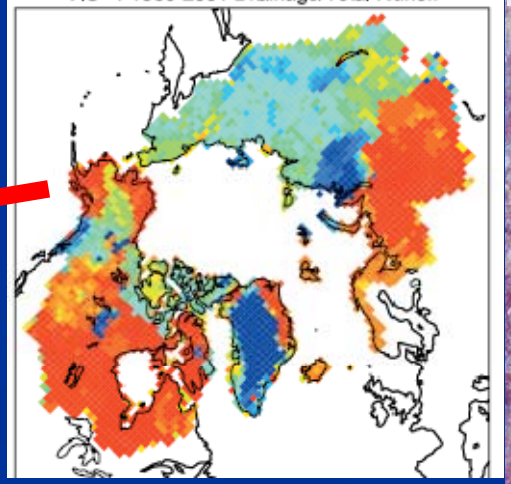
"No single model is the best or worst performing when compared to a range of observations."

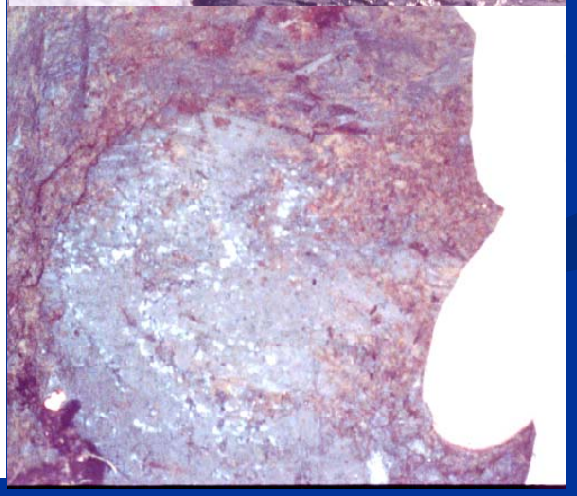


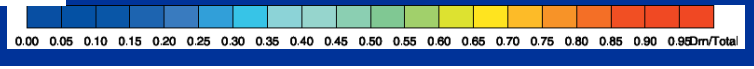












Slater et al. 2007

ICARPII Proposed "Supersite" Approach

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

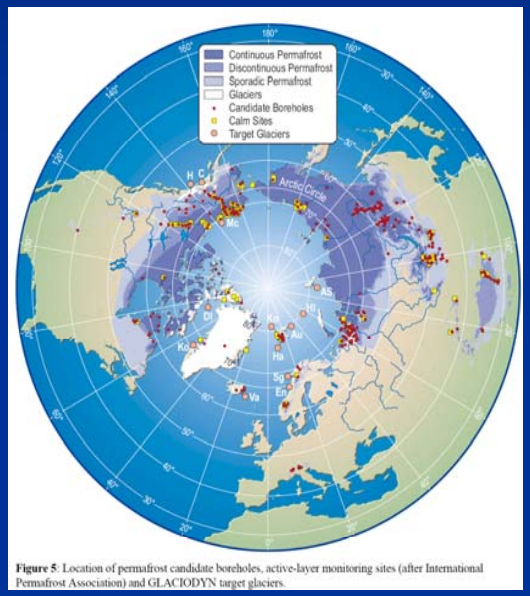


Figure 5: Location of permafrost candidate boreholes, active-layer monitoring sites (after International Permafrost Association) and GLACIODYN target glaciers.

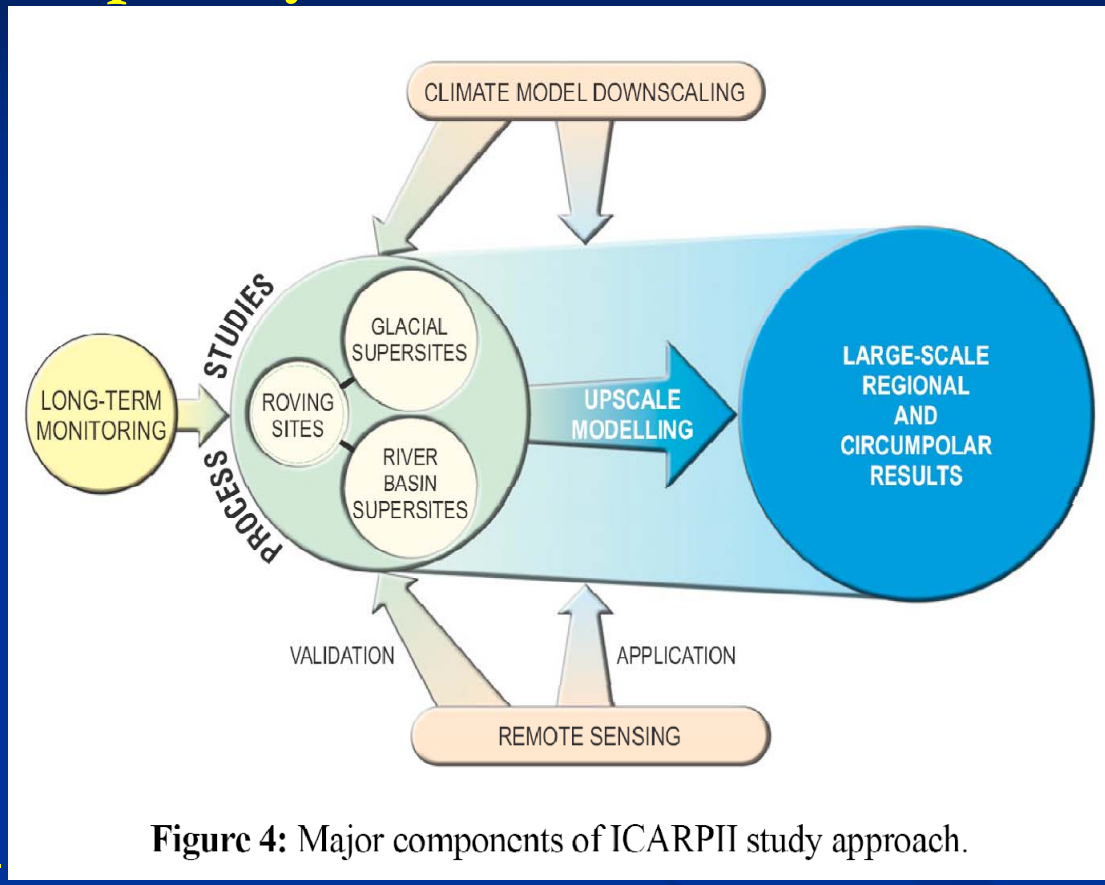
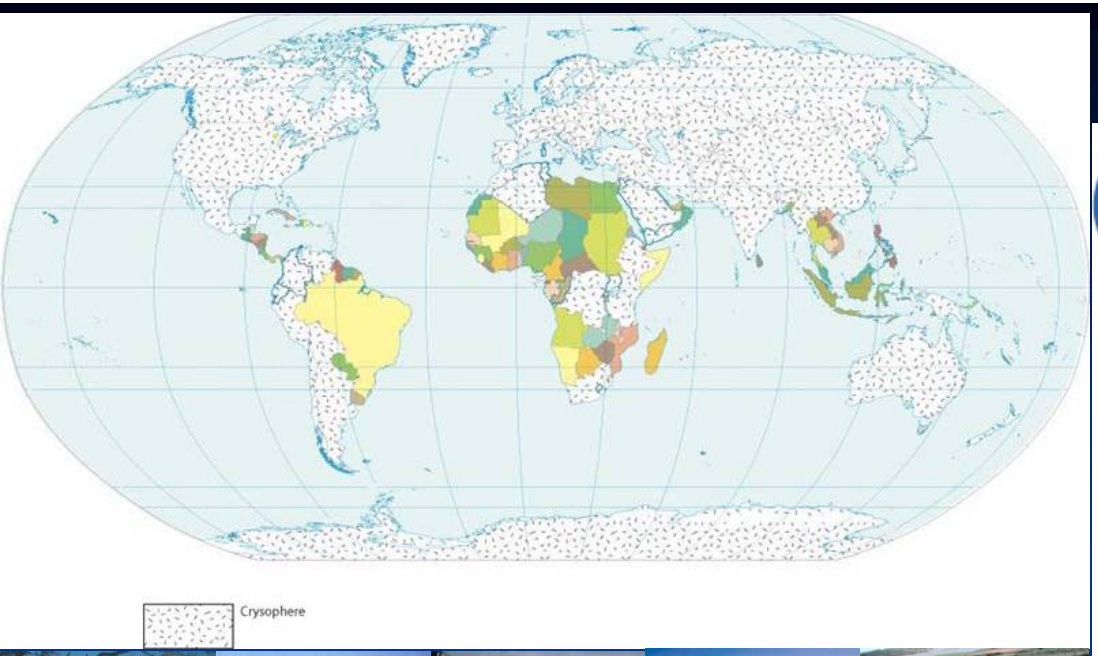


Figure 4: Major components of ICARPII study approach.

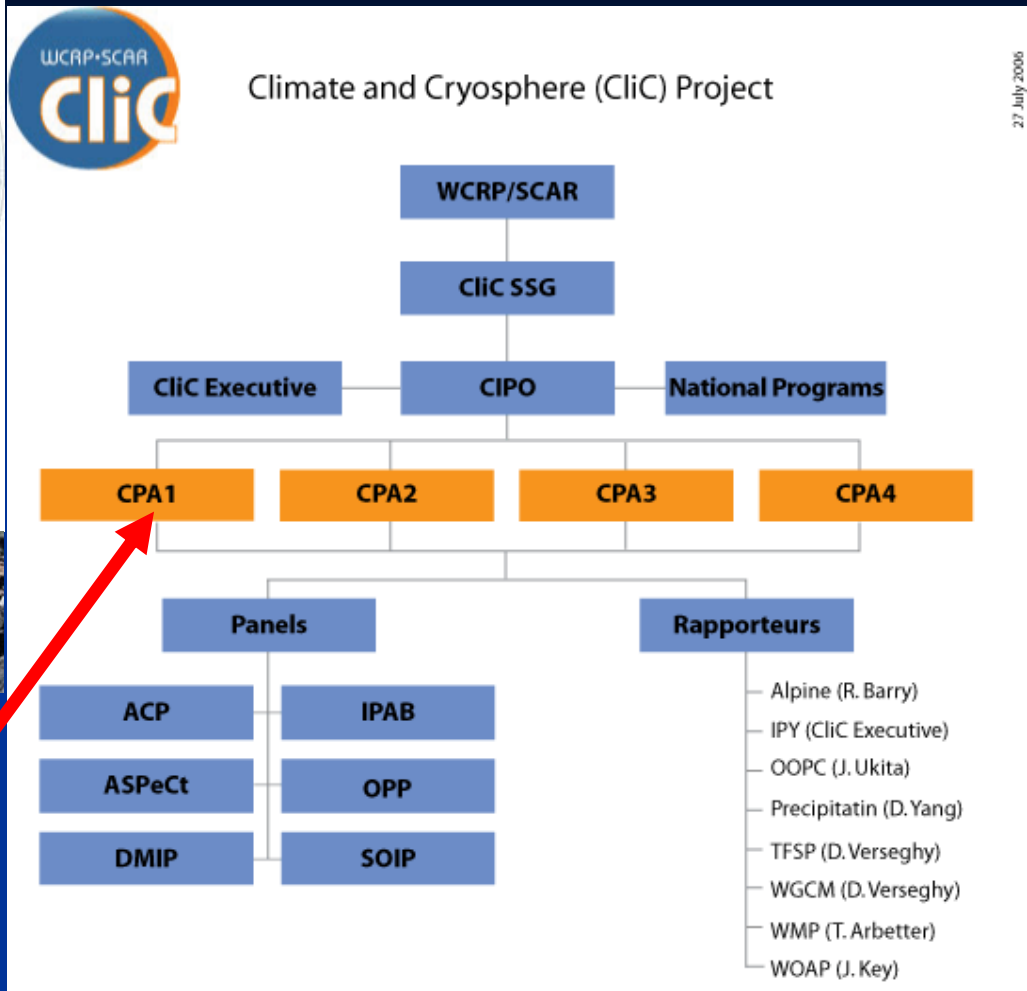
Elements of Supersite Science

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



~ 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**



ACP - Arctic Climate Panel
ASPeCt - Antarctic Sea Ice Processes and Climate
CIPO - CliC International Project Office
CPA - CliC Project Area
DMIP - Data Management and Information Panel
IPAB - International Project for Antarctic Buoys
IPY - International Polar Year
OOPC - Ocean Observation Panel for Climate (GCOS/GOOS/WCRP)
OPP - Observation Products Panel
SCAR - Scientific Committee on Antarctic Research
SOIP - Southern Ocean Implementation Panel
SSG - Scientific Steering Group
TFSP - Task Force on Seasonal Predictions
WCRP - World Climate Research Programme
WGCM - Working Group on Coupled Modelling
WMP - WCRP Modelling Panel
WOAP - WCRP Observations & Assimilations Panel

CliC Project Areas (CPAs)

CPA1: The terrestrial cryosphere and hydrometeorology of cold regions.

CPA2: Glaciers, ice caps and ice sheets, and their relation to sea level.

CPA3: The marine cryosphere and its interactions with high latitude oceans and atmosphere.

CPA4: Links between the cryosphere and global climate.

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?

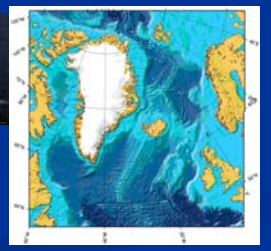
CliC-*TCHM developments, e.g.*

- **IP3 joins TCHM**

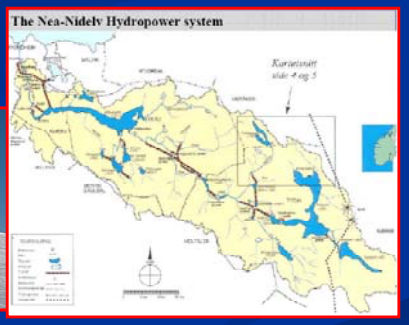
- **FreshNor joins TCHM**

FreshNor
The freshwater budget of the Nordic Seas

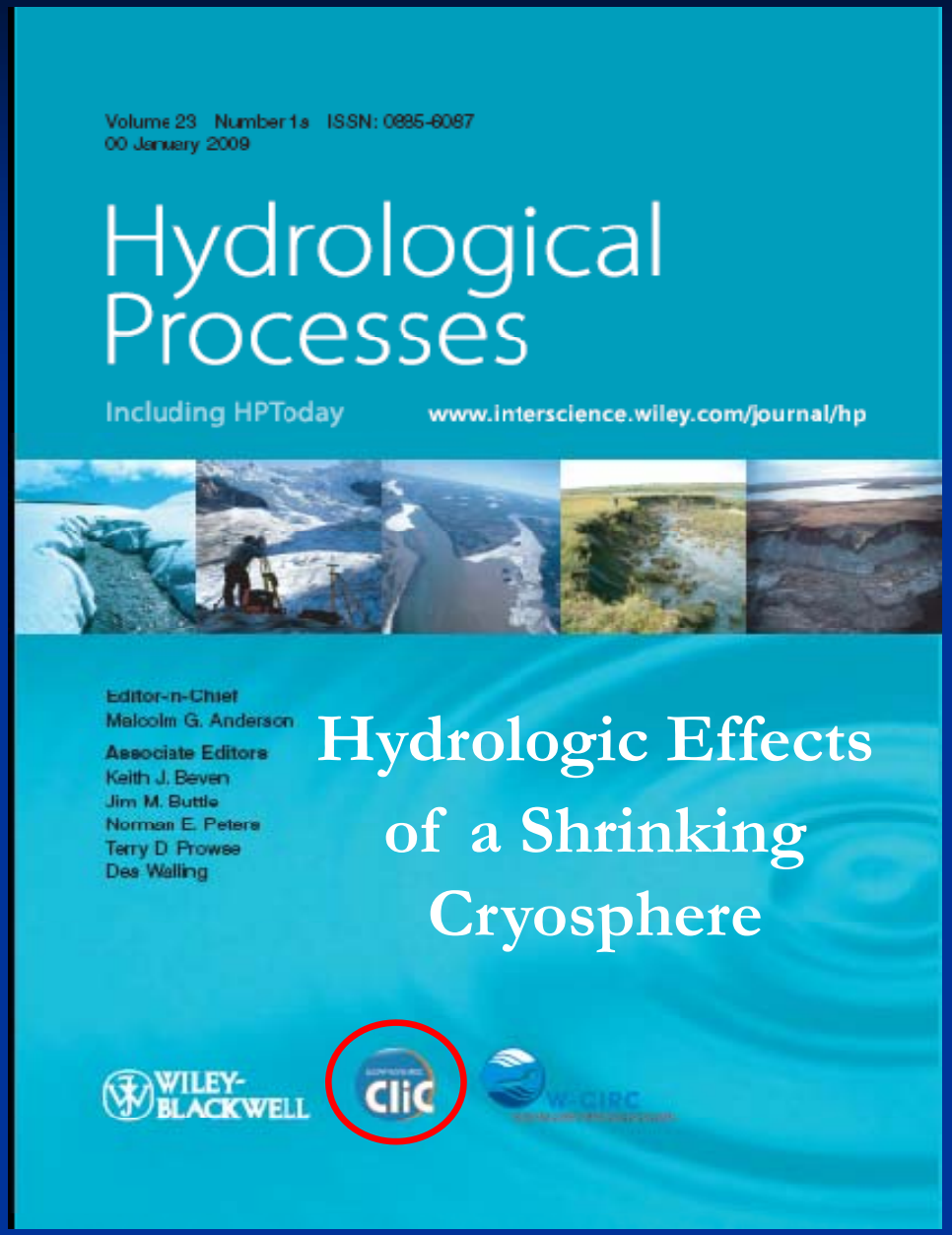
Consortium of: Danish Climate Centre, DMI; Rossby Centre, SMHI; Iceland Meteorological Institute; Nansen Centre, Norway; Greenland Nature Institute



- **Norway proposes TCHM supersite**

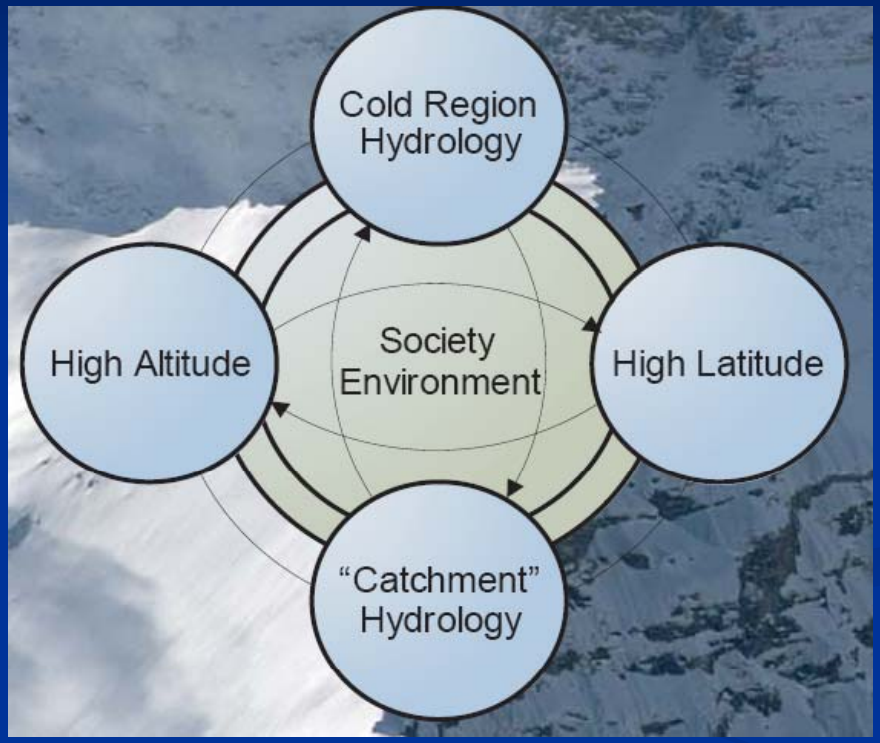


- **Asia-CliC workshop progress**



1. Prowse. Introduction: Hydrologic effects of a shrinking cryosphere.
2. Hanna et al. Response of the Greenland Ice Sheet: the role of oceanographic warming
3. Casassa et al. Detection of changes in glacial runoff in alpine basins: examples from North America, the Alps, central Asia and the Andes.
4. **Moore** et al. Glacier change in western North America: Influences on hydrology, geomorphic hazards and water quality.
5. Milner et al. Hydroecological response of river ecosystems to shrinking glaciers.
6. Stewart. Changes in snowpack and snowmelt runoff for key mountain regions.
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.
9. Beltaos & Prowse. River ice hydrology in a shrinking cryosphere.
10. **Marsh** et al. Changes in thaw lake drainage in the Western Canadian Arctic from 1950 to 2000.
11. McNamara and Kane. The impact of a shrinking cryosphere on the form of arctic alluvial channels.
12. Frey and McClelland. Impacts of permafrost degradation on arctic river biogeochemistry.

- 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

AMAP
Arctic Monitoring and Assessment Programme

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