

UNIVERSITY OF SASKATCHEWAN

Global Institute for Water Security

www.usask.ca/water



 Marmot Creek and the Saskatchewan River
 Basin project – a large-scale observatory for new water science

Howard Wheater, Canada Excellence Research Chair



Global Institute for Water Security

Global water challenges



Aral Sea





Pakistan 2010





Texas 2012



New York 2012

www.usask.ca/water

Lake Winnipeg/Red River 2007



Global Institute for Water Security

The future for water?



Increased demand

Environmental change



- Estimated 6 billion in water scarce areas by 2050
- Increasing severity of floods and droughts

www.usask.ca/water



The science challenges

To understand, diagnose and predict Earth system change at multiple scales:

- climate, including its hydro-meteorological extremes
- key land surface systems, including their response to climate variability and climate change
- effects of anthropogenic land use change on water quantity and quality and aquatic ecosystems
- societal controls on water management, including policy options and economic instruments

We need a new paradigm in interdisciplinary research, and new approaches to scientific infrastructure



Saskatchewan River Basin



www.usask.ca/water



Water Security

Saskatchewan River Basin

- One of the most extreme and variable climates in the world
- Home to 80% of Canada's agricultural production and strategically-important natural resources
- With a growing population and rapidly developing economy
- Embodies key science challenges of global significance
- Embodies key management challenges of global relevance





A critical trans-boundary resource for the prairie provinces of Canada:

- 80% of Saskatchewan River water comes from the Rocky Mountains
- 40-50% of basin does not normally contribute to river flows
- < 1% of flow originates in Saskatchewan, but
 70% of population uses river water
- 86% of consumption of South Saskatchewan River goes to irrigation



Flobal Institute for

Water Security

Management issues include:

- the South Saskatchewan river has reached limits for use in southern Alberta
- Climate change and land management are changing the land and its water in complex ways, affecting river flows and prairie hydrology
- Pollution is changing water quality
- Water governance in the prairie provinces is complex and fragmented



Prairie Drought of 1999-2004 Most Expensive Natural Disaster in Canadian

Canada



Prepared by PFRA (Prairie Farm Rehabilitation Administration) using data from the Timely Climate Monitoring Network and the many federal and provincial agencies and volunteers that support it.

- \$5.8 billion decline in GDP 2001-2002
- \$3.6 billion drop in agricultural production, 2001-2002
- 41,000 jobs lost
- BC, Alberta forest fires
- Saskatchewan dust storms

www.usask.ca/water



Floods









Glaciers are Changing



2001 Landsat 7 false color image (Columbia Mts., British Columbia)

- Glacier retreat and volume loss has been widespread in Western Canada
- Some glaciers have retreated up to one to two km since early 1950s
- Total glacier covered area has declined by 5 – 15% over the period 1951 – 2001
- The relative loss of ice volume is likely greater than this amount



Temperature Trends at Elevation Marmot Creek, 1962-Present



Winters are warmer by 3 to 4 °C since the 1960s Harder & Pomeroy



Global Institute for Water Security

Water resources South Saskatchewan River - natural and actual flow leaving Alberta



Natural flow: 12% decline over 90 years; Actual flow: 15% decline over 30 years

www.usask.ca/water



Water Quality – the South SK River Basin



Total Phosphorous Concentration (1973-2009)

S. Saskatchewan River near Clarkboro Ferry



The SaskRB as a GEWEX RHP



- Lack of current N American RHP
- Successful legacy of MAGS
- Ending of Canadian federal programs DRI, IP3
- New needs and opportunities
- Potential linkage to NAWP



SaskRB Project - science objectives

To improve monitoring, understanding and modelling of:

- the region's variable climate, including its hydrometeorological extremes
- key land surface systems, including Rocky Mountains, Boreal Forest and Prairies, and their response to climate variability and climate change
- effects, on water quantity and quality and aquatic ecosystems, of anthropogenic land use change
- societal controls on water management, integrating humans and their activities into water science



Water Security

This will deliver:

- new hydrological models and land surface schemes, including human impacts on land and water management
- assessment of ecosystem vulnerability to climate variability and change and the associated feedbacks to land-atmosphere exchanges of energy and water
- new water resource system models for the SRB for analysis of vulnerabilities and exploring scenarios of environmental change and economic development



www.usask.ca/water



Rocky Mountain Research Basins - Marmot Creek





Boreal Forest Research Sites BERMS/BOREAS







Prairie Research SitesSt DenisKenaston

Smith Creek









Lake Diefenbaker/Swift Current Creek







Algal bloom Sept 24 2011



Socio-hydrology

 understanding and managing complex human-natural systems

Group mind-mapping exercise. Stakeholder workshop, Canmore , Alberta, March 2012





Hydrological/LSS Modelling





Observed freeze-thaw





GCM/Data comparison

- The Boreal Ecosystem Research and Monitoring Sites (BERMS) in Saskatchewan
- Three operating towers sites dominated by Old Aspen (OA), Old Black Spruce (OBS) and Old Jack Pine (OJP)
- CGCM3 gridded simulated variables





Comparable Data Structures – Pressure/Radiation/Temperature





Different Data Structures – Wind/Relative Humidity/Temperature





Remote sensing/data assimilation

GRACE validation





Water resource systems modelling - the SSRB in Alberta







Vulnerability assessment



www.usask.ca/water



Downscaling precipitation futures

Probability of Daily Rainfall Saskatoon, 1962-2004



Probability of Daily Rainfall, Saskatoon, 2071-2100 (CGCM3 A1B)





Water resource vulnerability to climate change Probability of system infeasibility, South Saskatchewan,

southern Alberta, due to changing Rocky Mountain flows





Interactive modelling of water futures





Systems dynamic modelling





Exploration of future scenarios





In conclusion:

The problems society now faces with respect to water security are complex and multi-faceted.

New science, technologies and modelling tools are needed to enable society to understand and manage change.

This requires a new approach to research infrastructure and interdisciplinary collaboration

The SaskRB RHP builds on the 50 year legacy of Marmot Creek to provide this focus and enable national and international collaboration to address these critical challenges

Water means the WORLD to Us...



UNIVERSITY OF SASKATCHEWAN

Global Institute for Water Security

www.usask.ca/water