The Changing Cold Regions Network: Observation, Diagnosis, and Prediction of Environmental Change in the Saskatchewan and Mackenzie River Basins

Saman Razavi
Global Institute for Water Security,
University of Saskatchewan,
Saskatoon, SK, Canada

2016 GHP Meeting, Gif-sur-Yvette, France
October 3, 2016
Changing Cold Regions Network (CCRN)

“The Network aims to **understand, diagnose and predict interactions** amongst the cryospheric, ecological, hydrological, and climatic components of the **changing Earth system** at multiple scales, with a geographic focus on Western Canada’s rapidly changing cold interior.”

CCRN builds on a strong legacy of past Canadian and international research initiatives.
Changing Cold Regions Network (CCRN)

- Funded for 5 years (2013–2018) under the NSERC Climate Change and Atmospheric Research (CCAR) Initiative
- Leveraging $24 million in-kind support
- Strongly linked to GEWEX, CliC, GEO, NCAR, NASA, and more
  - In December 2014, the World Climate Research Programme endorsed CCRN as a GEWEX Regional Hydroclimate Project
- CCRN has developed a large, multi-disciplinary team of researchers
  - 42 investigators and 136 students, post-doctoral fellows, and other HQP from 8 Canadian universities and 4 federal government agencies
  - International collaboration includes 18 scientists from Germany, France, the U.S., U.K., and China
CCRN Research: Thematic Approach

Theme A: Observed Earth System Change in Cold Regions - Inventory and Statistical evaluation

Theme B: Improved Understanding and Diagnosis of Local Scale Change

Theme C: Upscaling for improved Atmospheric Modelling and River Basin Scale Prediction

Theme D: Analysis and Prediction of Regional and Large Scale Variability and Change

Theme E: User Community Outreach and Engagement
Geographic Focus:
The vast interior of western Canada, including the Saskatchewan River Basin (336,000 km²) and Mackenzie River Basin (1.8 million km²)
CCRN Research:
Geographic Focus / Water, Ecosystem, Cryosphere and Climate (WECC) Observatories

• A network of WECC Observatories combine meteorological, hydrological, ecosystem, and cryospheric observations with multi-scale coupled models from the surface to the atmosphere.

• Observatories contain long-term legacy data sets, including hydro-meteorological variables, remote sensing observations, LiDAR topography, and soils, geology, and vegetation characterization.
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Kenaston / Brightwater Creek

BERMS—Black Spruce

Prairie and Arctic
Activities and Progress
Theme A – Inventory of Observed Change

- Work in the network has produced local to regional scale assessments of change, with many publications and forthcoming papers.

- A major review paper has pulled together and synthesized recent changes in the CCRN domain.

- This points to systematic change in climate and cryospheric regime, but complex and mixed hydrological response signals.
Activities and Progress
Theme B – Local-Scale Understanding/Diagnosis

• A Special Observation and Analysis Period (SOAP) was carried out over the 2014–15 hydrological year, involving coordinated and intensive field campaigns at most WECC observatories
  • SOAP year was highly anomalous (warm, dry in much of the region)
  • Workshop (Oct 3-4) to address observations, key science questions, and data legacy

• Diagnosis of Change
  • Coordinated model runs using the Cold Regions Hydrological Model (CRHM) platform
  • Workshop to plan and coordinate the diagnosis of change at WECC observatories


The SOAP initiative involved coordinated, consistent, high-quality observations—CCRN is positioned to provide a world-class legacy dataset for process insights and model application over interior western Canada
Activities and Progress
Theme C – Improved Large-Scale Modelling

• Work in this theme has been done largely in close collaboration with our partner, Environment and Climate Change Canada
  • Improvements to Canadian LAnd Surface Scheme (CLASS), Modélisation Environmentale Communautaire (MEC) – Surface and Hydrology (MESH), Canadian Terrestrial Ecosystem Model (CTEM)
• Focus is on developing improved large-scale models of the Saskatchewan and Mackenzie River Systems
• CCRN is linked to a GEWEX cross-cut project on including water management in large scale models
Activities and Progress
Theme C – Improved Large-Scale Modelling

Using GRACE for improved model parameterization
Yassin et al. (under review, WRR)

Multi-criteria Sensitivity Analysis

Multi-criteria Parameter Identification

Sensitivity of Water Storage

NSE-TWS IVARS$\text{S}_0$

Sensitivity of Streamflow

- Vegetation parameters
- Forestland soil parameters
- Grassland soil parameters
- Cropland soil parameters
- Routing and PDMROF parameters
Activities and Progress
Theme C – Improved Large-Scale Modelling

Streamflow Results

(a) Approach 1
(b) Approach 2

Without GRACE
With GRACE

Water Storage Results

(a) Approach 1
(b) Approach 2

Without GRACE
With GRACE

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Activities and Progress
Theme C – Improved Large-Scale Modelling

Including Water Management in a Land surface-Hydrology Model
Annis et al. (in prep.)

MODSIM-DSS

Integrated Modelling

Basin-wide Priority-based Water Management

MODSIM-DSS

Meteorological Data

Land Surface Scheme (CLASS)

Topography and Drainage

Routing Model

Surface Water

Reservoir Release For Domestic Industrial Livestock

Power Generation

Evaporation

Reservoir Storage

Groundwater Loss

Reservoir + Hydro Power

Hydro power plant only

Reservoir storage only
Activities and Progress
Theme C – Improved Large-Scale Modelling

Sensitivity Analysis and Insights into Large Models
By VARS Framework
(VARS: Variogram Analysis of Response Surfaces)
Razavi and Gupta (2015, 2016, WRR)
Activities and Progress
Theme D – Analysis/Prediction of Large-Scale Change

• Important analyses on large-scale variability and change have been undertaken and were reviewed at a recent workshop
  http://www.ccrnetwork.ca/science/workshops/theme-d-workshop-2016

• A major focus is on examination of recent extremes in the domain
  • 2013 flooding in Alberta
  • Sequence of 3 record-setting wildfire seasons
  • Extreme dry conditions during 2015 (SOAP year)
Activities and Progress
Theme E – Outreach and Engagement

• Collaboration with our partners and outreach to communities and user groups across our domain has continued

• A recent focus on developing clear-language information products on aspects of the research program and on recent extreme events

See http://www.ccrnetwork.ca/outputs/information-products

2013 Alberta flood

2014 Assiniboine River flood
Activities and Progress
Data Management

• “We are committed to produce, document, and archive our results in an integrated, long-term repository.”

• Data archiving for all WECC observatories and other special projects has been progressing and CCRN will deliver a world-class legacy dataset.

See: [http://www.ccrnetwork.ca/outputs/data](http://www.ccrnetwork.ca/outputs/data)

CCRN uses the WISKI tool to manage, process, and edit time series information
Upcoming Activities
Meetings and Workshops

• We have several key workshops coming up this fall
  http://www.ccrnetwork.ca/science/workshops

  • Special Observation and Analysis period (SOAP) Workshop (Oct 3-4)
    • Review observations from across the domain during this anomalous year
    • Synthesize network activities and address common science questions
    • Plan data archiving and publication, and special issue papers on SOAP

  • CCRN 4th Annual General Meeting (Nov 2-4)
    • Review network progress and plan future activities
    • Plan for our final deliverables around scenarios of change

  • CCRN Fall Modelling Workshop (Nov 28-29)
    • Synthesize activities to date
    • Plan the final round of model runs, focused on projections of change at our sites and over the region
New Funding: Global Water Futures

- The University of Saskatchewan, in partnership with University of Waterloo, McMaster University and Wilfrid Laurier University, has been awarded $77.8 million over 7 years from the Canada First Research Excellence Fund to lead the **Global Water Futures: Solutions to Water Threats in an Era of Global Change**.

- **Aims:**
  - deliver new capabilities for providing disaster warnings
  - diagnose and predict water futures
  - develop new models, tools and approaches to manage water-related risks

- For more information, visit the GWF website at [http://gwf.usask.ca/](http://gwf.usask.ca/)
The final 18 months of CCRN

• Over the remainder of the CCRN programme, we will continue to:
  • Improve our understanding of recent Earth system change in the cold interior of western and northern Canada (CCAR Theme 3);
  • Advance water, weather, climate and environmental prediction (CCAR Theme 2); and
  • Improve our understanding of Earth system processes and their representation in hydrological, atmospheric and ecological models (CCAR Theme 1).

• In doing so, we will:
  • Enhance our capability for water management;
  • Train the next generation of Earth System Scientists; and
  • Provide high quality datasets for change assessment and model verification.
List of CCRN Participants

Network Co-Investigators and Collaborators

- Vivek Arora (Env. Can.)
- Jenifer Baltzer (Wilfrid Laurier U.)
- Alan Barr (Env. Can.)
- Paul Bartlett (Env. Can.)
- Aaron Berg (U. Guelph)
- Andy Black (U. British Columbia)
- Barrie Bonsal (Env. Can.)
- Sean Carey (McMaster U.)
- Garry Clarke (U. British Columbia)
- Mike Demuth (Nat. Resources Can.)
- John Diiwu (AB Env. and Sus. Res. Dev.)
- Vincent Fortin (Env. Can.)
- John Hanesiak (U. Manitoba)
- Masaki Hayashi (U. Calgary)
- Warren Helgason (U. Sask.)
- Al Howard (Ag. and Agri-Food Can.)
- Dave Hudak (Env. Can.)
- Andrew Ireson (U. Sask.)
- Richard Janowicz (Yukon Environment)
- Ed Johnson (U. Calgary)
- Jill Johnstone (U. Sask.)
- Bob Kochtubajda (Env. Can.)
- Yanping Li (U. Sask.)
- Murray MacKay (Env. Can.)
- Phil Marsh (Wilfrid Laurier U.)
- Sean Marshall (U. Calgary)
- Jeff McDonnell (U. Sask.)
- Al Pietroniro (Env. Can.)
- John Pomeroy (U. Sask.)
- William Quinton (Wilfrid Laurier U.)
- Garry Scrimgeour (Parks Can.)
- Chris Spence (Env. Can.)
- Craig Smith (Env. Can.)
- Saman Razavi (U. Sask.)
- Ron Stewart (U. Manitoba)
- Kit Szeto (Env. Can.)
- Julie Thériault (U. Québec à Montréal)
- Merritt Turetsky (U. Guelph)
- Garth van der Kamp (Env. Can.)
- Howard Wheater (U. Sask.; CCRN PI)
- Daqing Yang (Env. Can.)
- Xuebin Zhang (Env. Can.)

International Advisory Panel

- Don Cline (National Oceanic and Atmospheric Administration)
- Richard Harding (UK Centre Ecology and Hydrology)
- Larry Hinzman (U. Alaska)
- Eric Kasischke (U. Maryland; NASA ABoVE)

Secretariat (@ GIWS, U. Sask.)

- Chris DeBeer (CCRN Project Manager)
- Stacey Dumanski (Outreach Coordinator)
- Michelle Martel-Andre (Executive Assistant)
- Chris Morin (Communications Specialist)
- Sherry Olauson (Clerical Assistant)
- Graham Strickert (Theme E lead)
- Tim Zagozewski (Finance Officer)
- Branko Zdravkovic (Database Manager)

*Indicates member of Science Committee

www.ccrnetwork.ca
For further information visit the webpage at www.ccrnetwork.ca

Or contact the network manager, Chris DeBeer (chris.debeer@usask.ca) or Principal Investigator, Howard Wheater (howard.wheater@usask.ca)
Upcoming Activities
Science Focus and Directions

• Theme A
  • Development of conceptual models of change, to be diagnosed quantitatively in Theme B

• Theme B
  • Historical diagnostic modelling of change and examination of local-scale future variability and change (driven by WRF pseudo-global warming runs)

• Theme C
  • Working models of the major river basins in place by late fall and transfer of improved large-scale models for analyses in Theme D

• Theme D
  • Application of models to predict and understand regional changes in hydrology under scenarios of landscape and ecological change for 21st Century
  • Focus on occurrence of wildfires, aspects of change in 0°C, and chain-of-events surrounding several recent disasters in the CCRN domain