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

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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

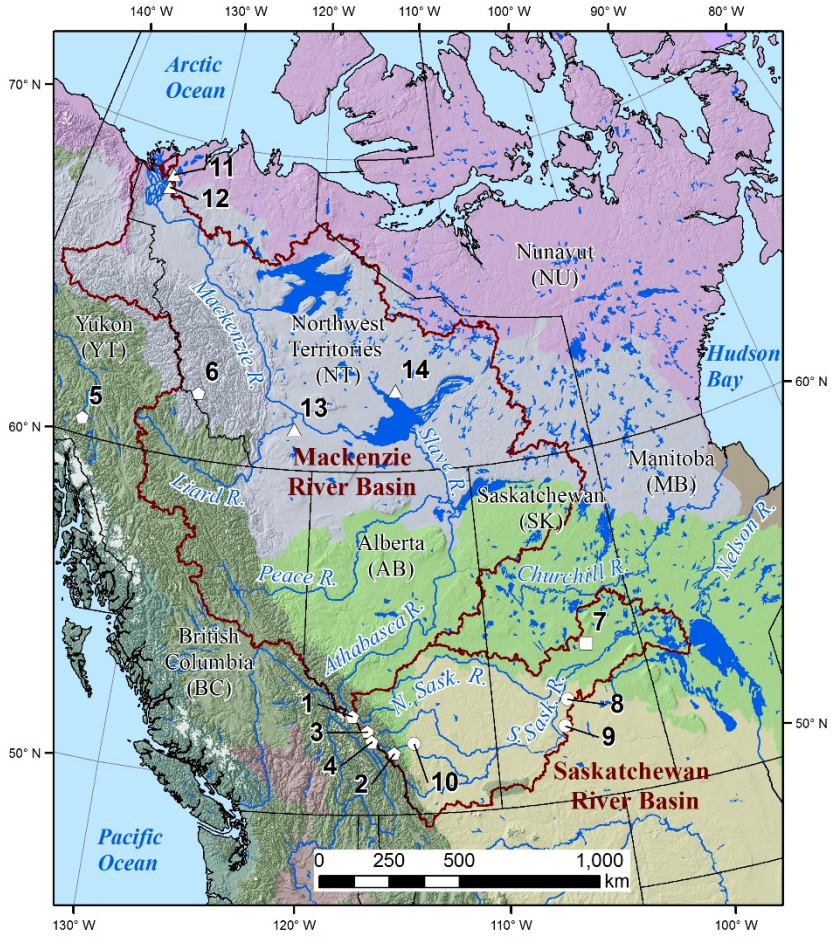
Geographic Focus:

The vast interior of western Canada, including the Saskatchewan River Basin (336,000 km^2) and Mackenzie River Basin (1.8 million km^2)

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



Water, Ecosystem, Cryosphere and Climate Observatories

Western Cordillera

1: Columbia Icefield, AB
2: Marmot Creek, AB
3: Peyto Glacier, AB
4: Lake O'Hara, BC
5: Wolf Creek, YT
6: Brintnell-Bologna Icefield, NT

Boreal Forest

7: Boreal Ecosystem Research and Monitoring Sites (BERMS), White Gull Creek, SK

Prairie

8: St. Denis National Wildlife Area, SK
9: Brightwater Creek/ Kenaston Mesonet Site, SK
10: West Nose Creek, AB

Taiga and Southern Arctic

11: Trail Valley Creek, NT
12: Havikpak Creek, NT
13: Scotty Creek, NT
14: Baker Creek, NT

Ecoregions and Landcover

- Glaciers
- Tundra
- Taiga
- Hudson Plains
- Boreal Forest
- Northwestern Forested Mountains
- Marine West Coast Forest
- Great Plains
- N. American Deserts

CCRN Research:

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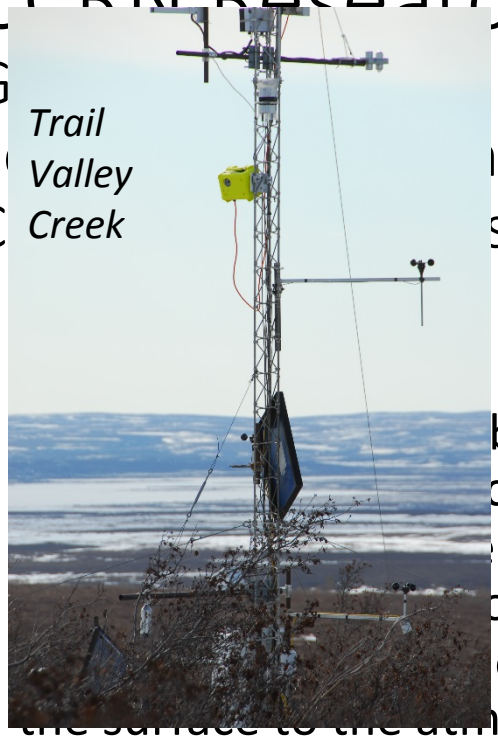
C… servatories



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- Observatories contain long-term
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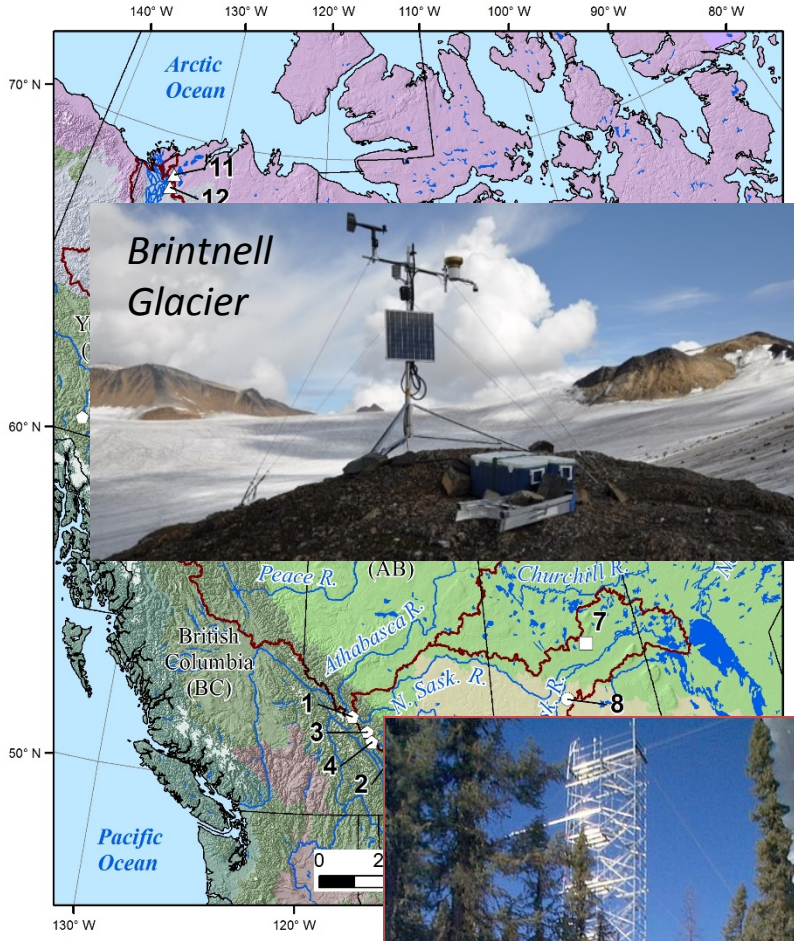

Water, Ecosystem, Cryosphere and … Observatories

Western Cordillera
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Prairie
8: St. Denis … Wildlife Are…
9: Brightwa…
Kenaston …
SK
10: West N…

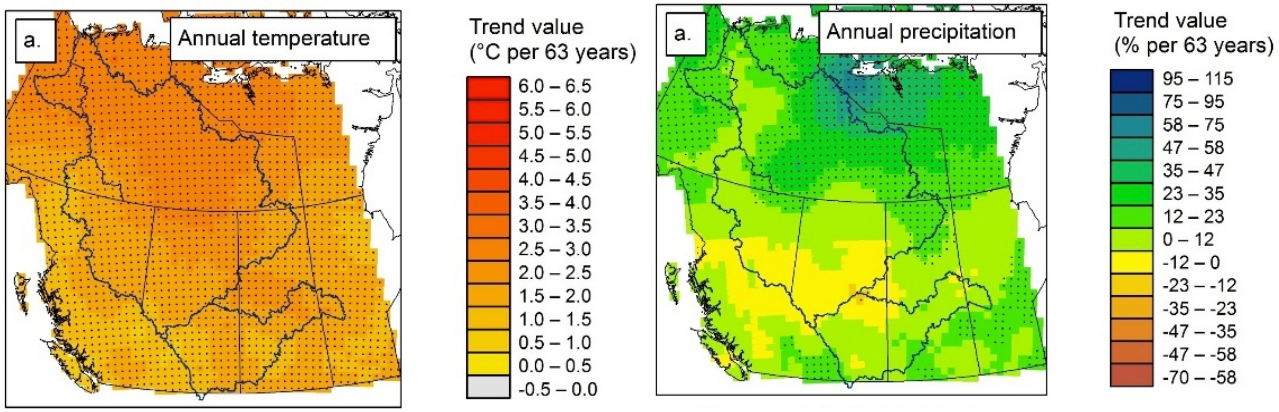
Taiga a… Arctic
11: Trail Va…
12: Havikpa…
13: Scotty …
14: Baker Creek, NT

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
  - DeBeer, C. M., Wheater, H. S., Carey, S. K., and Chun, K. P.: **Recent climatic, cryospheric, and hydrological changes over the interior of western Canada: a review and synthesis**, *Hydrol. Earth Syst. Sci.*, 20, 1573-1598, doi:10.5194/hess-20-1573-2016, 2016.
- This points to systematic change in climate and cryospheric regime, but complex and mixed hydrological response signals

Climate trends (1950–2012)



CCRN
Changing Cold Regions Network

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

  http://www.ccrnetwork.ca/science/workshops/crhm-workshop-2016

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),

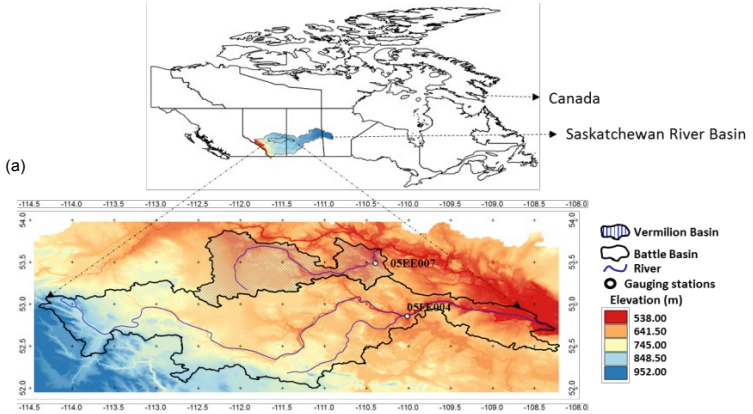
    Canadian Terrestrial Ecosystem Model (CTEM)
- Focus is on developing improved large-scale models of the Saskatchewan and Mackenzie River Systems
- CCRN is linked to a GEWEX cross-cut project on including water management in large scale models

Activities and Progress

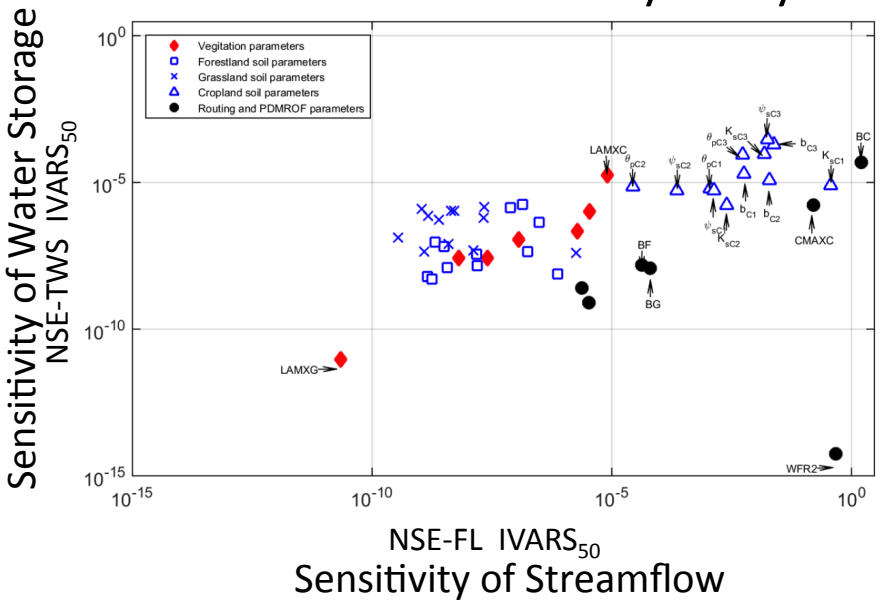
Theme C – Improved Large-Scale Modelling

Using GRACE for improved model parameterization

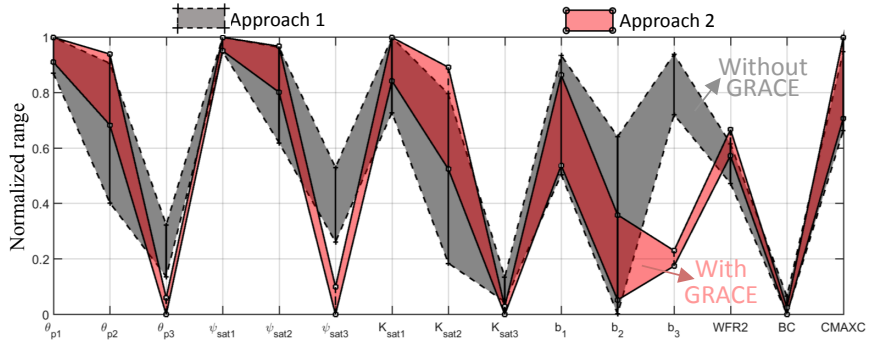
Yassin et al. (under review, WRR)



Multi-criteria Sensitivity Analysis



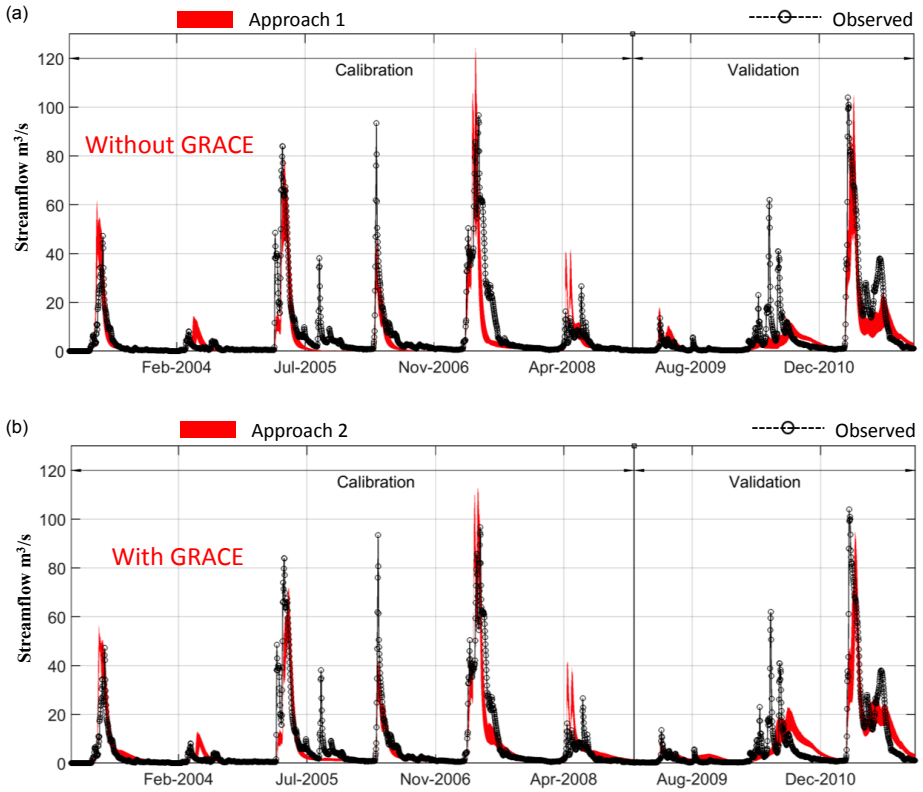
Multi-criteria Parameter Identification



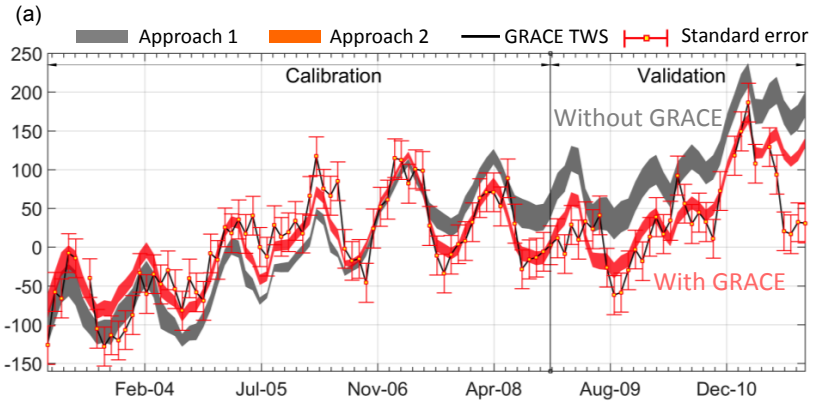
Activities and Progress

Theme C – Improved Large-Scale Modelling

Streamflow Results



Water Storage Results



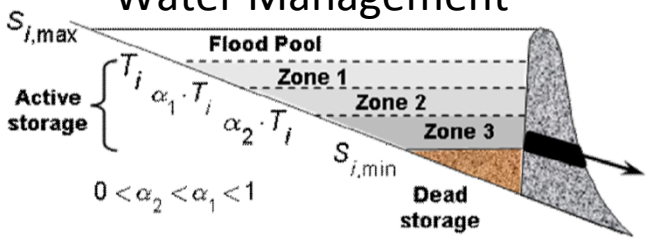
Activities and Progress

Theme C – Improved Large-Scale Modelling

Including Water Management in a Land surface-Hydrology Model

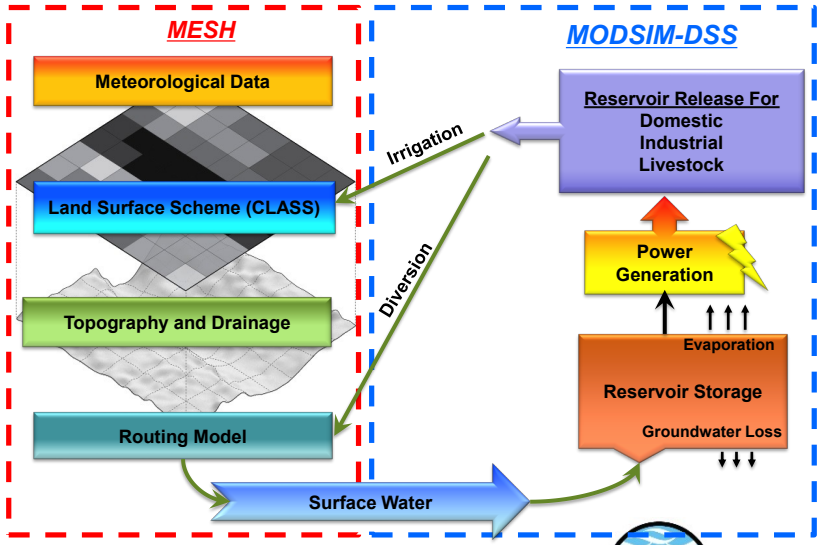
Annis et al. (in prep.)

Basin-wide Priority-based Water Management



MODSIM-DSS

Integrated Modelling

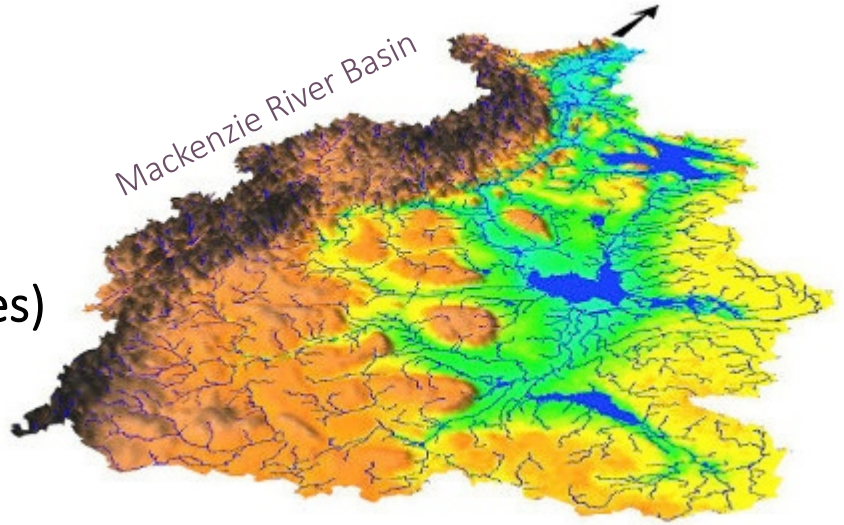


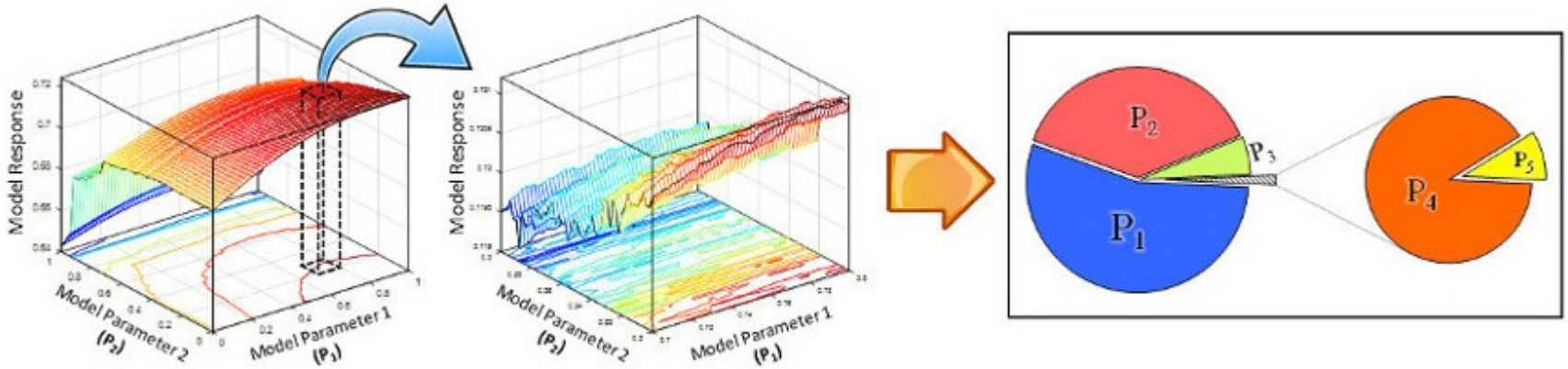
Activities and Progress

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)





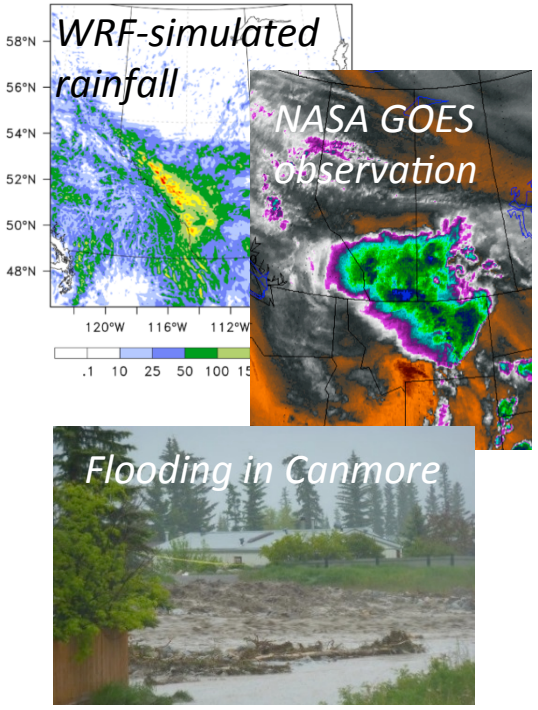
Activities and Progress

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 http://www.ccrnetwork.ca/science/2013-Alberta-flood
  - Sequence of 3 record-setting wildfire seasons
  - Extreme dry conditions during 2015 (SOAP year)



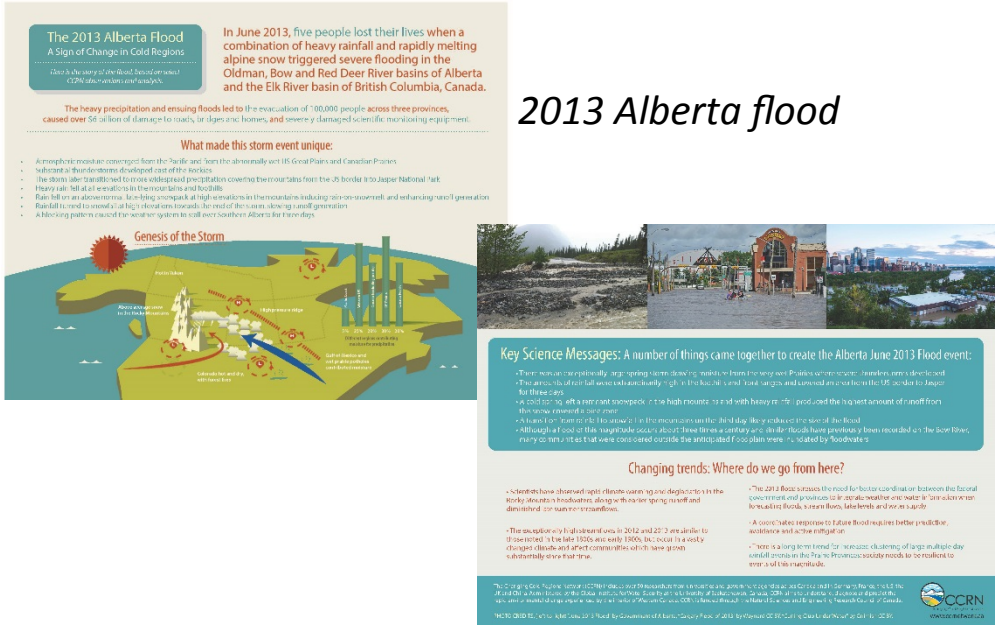
The extreme weather & flooding events of June 2013 are a focus of CCRN research activities

Activities and Progress

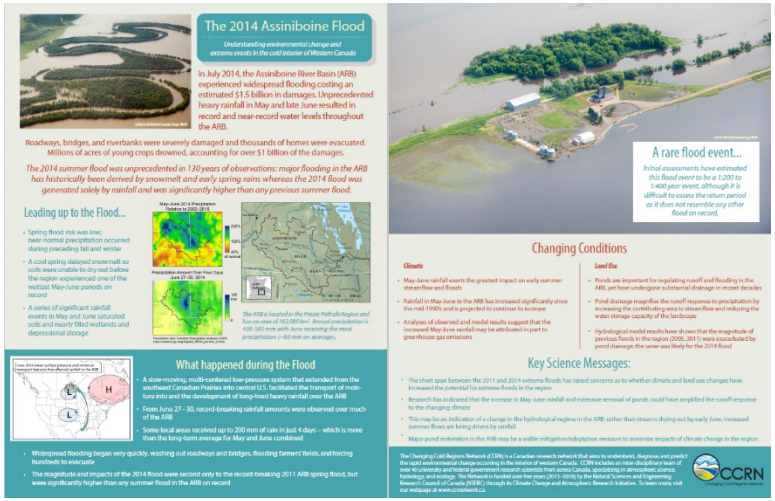
Theme E – Outreach and Engagement

- 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



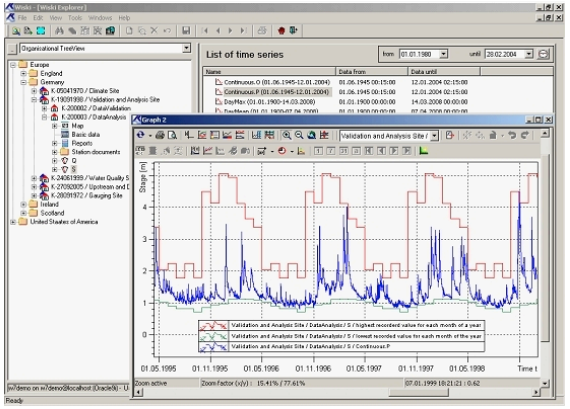
2014 Assiniboine River flood

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



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/

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.)
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- **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.)

Board of Directors

- Jim Bruce (Env. Can., ret.)
- Wayne Dybvig (SK WSA)
- Ken Greenway (AB Env. & Sus. Res. Dev.)
- Michel Jean (Env. Can.)
- Donna Kirkwood (Nat. Resources Can.)
- David Livingstone (Gov. NWT, ret.)
- Denis Petitclerc (Ag. and Agri-Food 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)

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

***Indicates member of Science Committee**

CCRN
Changing Cold Regions Network

NSERC
CRSNG

Environment Canada
Environnement Canada

Northwest Territories

University of Guelph

University of Calgary

University of Manitoba

Natural Resources Canada
Ressources naturelles Canada
Canada

Parks Canada
Parcs Canada

Yukon
Environment

The University of British Columbia

University of Saskatchewan

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Alberta Environment and Sustainable Resource Development

McMaster University

UQÀM Université du Québec à Montréal

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

Water Security Agency

Wilfrid Laurier University

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