

# Climatic, Cryospheric, Ecological, and Hydrological Change in the Interior of Western Canada: The Changing Cold Regions Network and its activities as a GEWEX RHP

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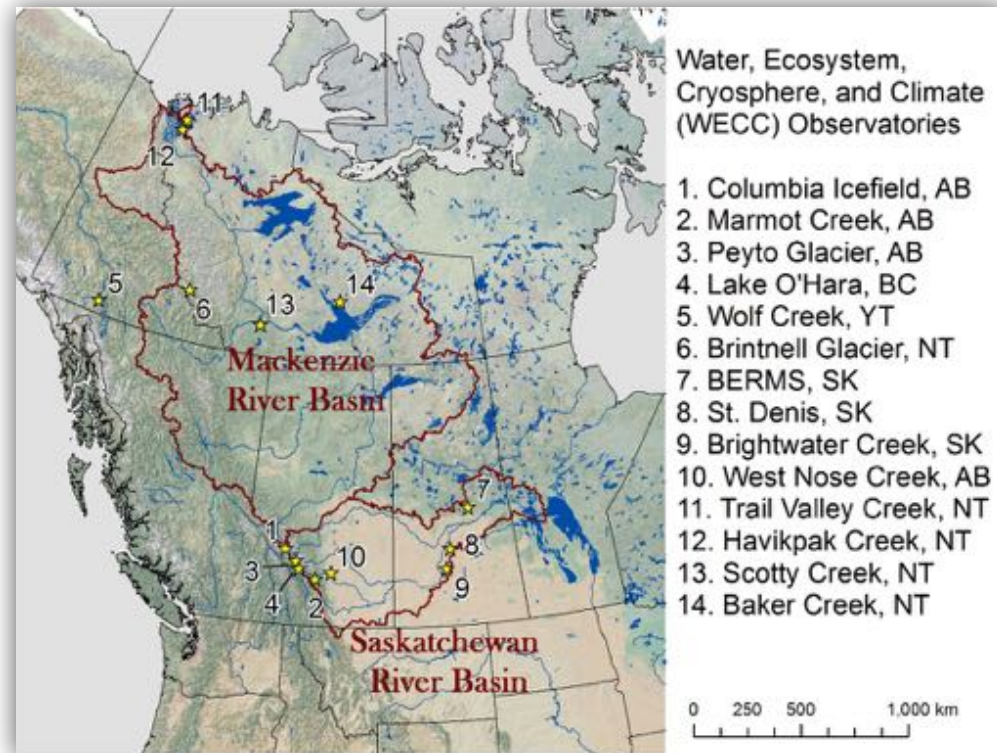
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8<sup>th</sup> GEWEX Open Science Conference, Canmore AB, May 8, 2018

# The Changing Cold Regions Network (CCRN)

- Focused on understanding, diagnosis, and prediction of changing Earth system in the interior of western Canada
- Funded by NSERC for five years (2013–2018)
- A large, diverse, interdisciplinary team (45 co-Investigators, 200+ HQP)
- Significant international collaboration and linkages



# The Changing Cold Regions Network (CCRN)

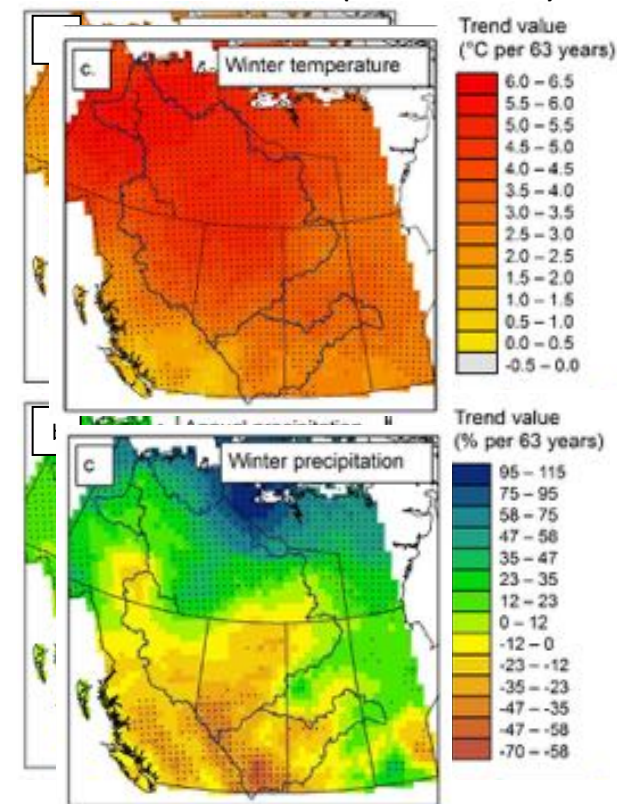
- The programme was organized around 5 Themes:
  - A. Observed Earth System Change in Cold Regions—Inventory and Statistical Evaluation (lead: Sean Carey);
  - B. Improved Understanding and Diagnosis of Local-Scale Change (lead: John Pomeroy);
  - C. Upscaling for Improved Atmospheric Modelling and River Basin-Scale Prediction (lead: Howard Wheeler);
  - D. Analysis and Prediction of Regional and Large-Scale Variability and Change (lead: Ron Stewart); and
  - E. User Community Outreach and Engagement (lead: Graham Strickert)

CCRN has ended and a final report can be found at  
<http://ccrnetwork.ca/outputs/reports>

# Recent Climatic and Environmental Change

- Over the interior of western Canada, systematic patterns of change in climatic regime and cryospheric response
  - Pervasive warming
  - Decreased fraction of precip. as snow
  - Decreasing snow cover depth, extent, duration; retreating glaciers
  - Warming, thawing permafrost
  - Declining ice cover period
  - Earlier spring freshet
- Most hydrological responses have been complex and varied, reflecting differing process interactions and drivers

*Climate trends  
(1950–2012)*



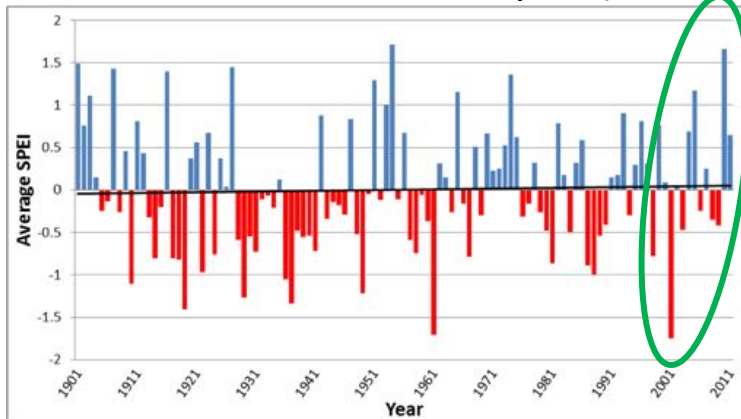
DeBeer, C. Wheeler, H., Carey, S., Chun, K., 2016: **Recent climatic, cryospheric, and hydrological changes over the interior of western Canada: a review and synthesis**, Hydrol. Earth Syst. Sci., doi:10.5194/hess-20-1573-2016.



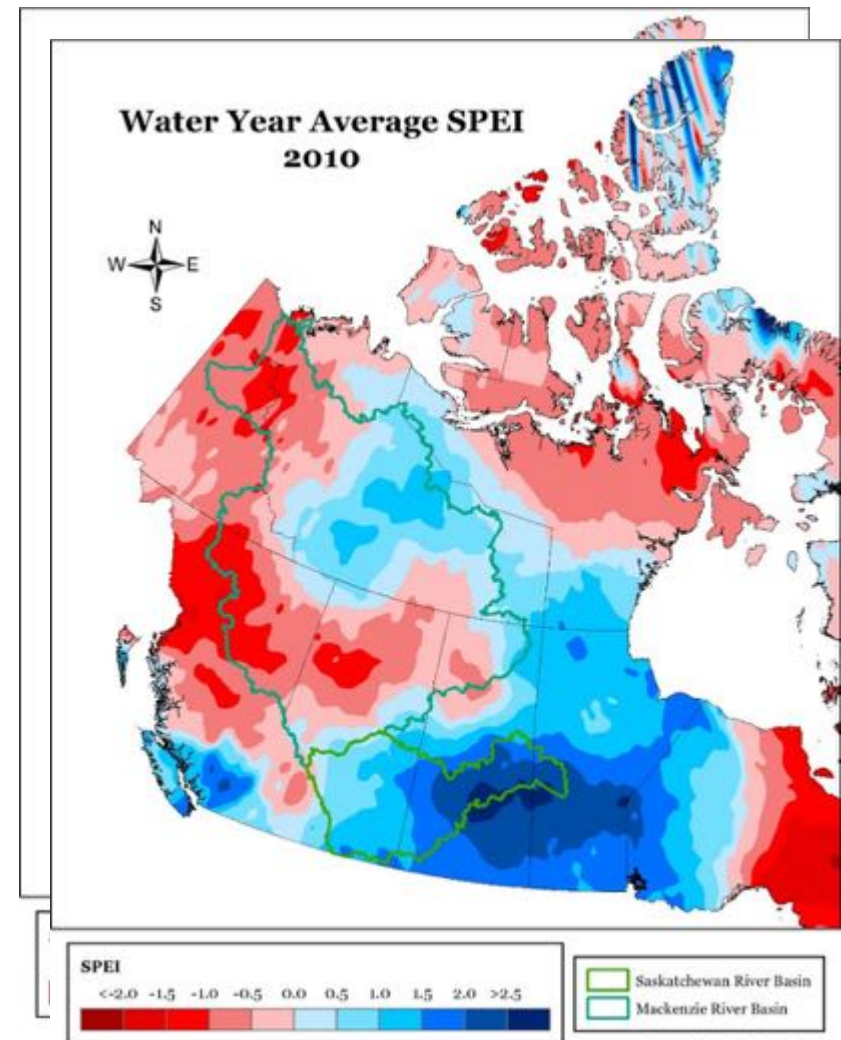
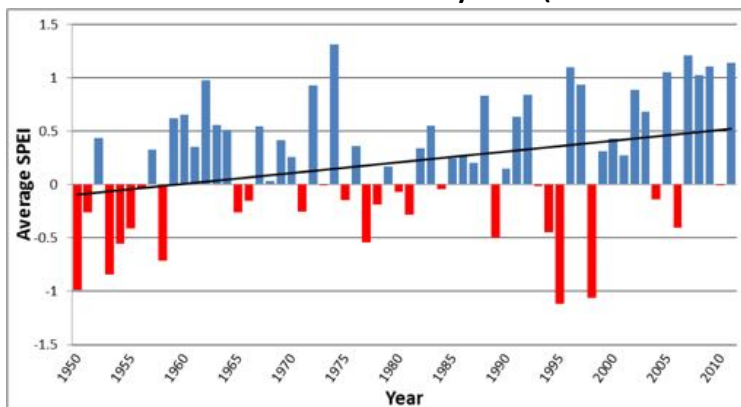
# Wet and Dry Cycles in Western Canada

Standardized Precipitation Evapo-  
transpiration Index (results by Barrie Bonsal)

Saskatchewan Basin – Water year (1900–2011)



Mackenzie Basin – Water year (1950–2011)

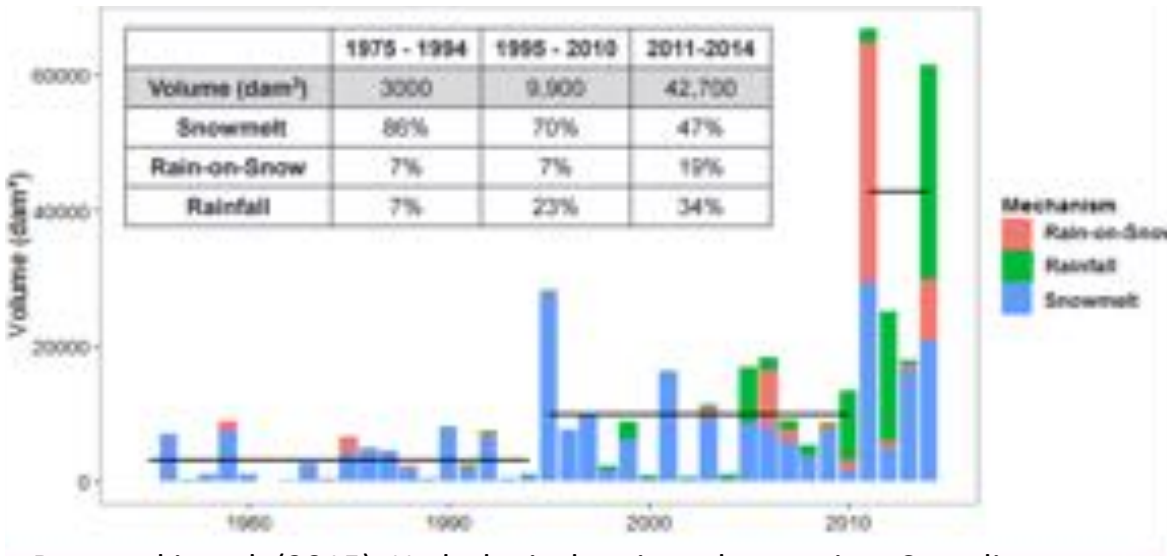
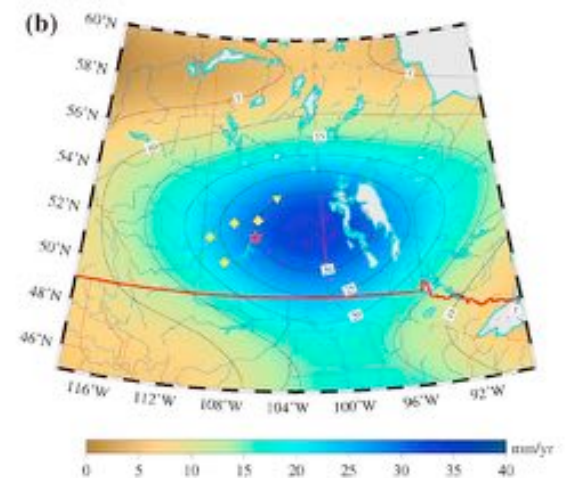
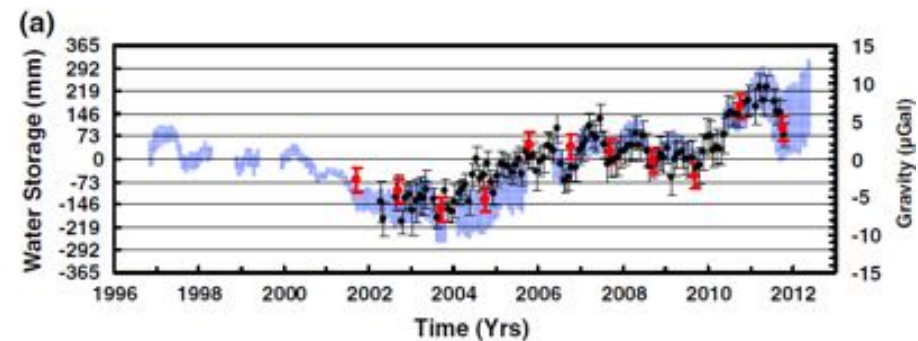


# Changing Hydrological Regime

## Hydrological “regime change” in the Prairies

- Smith Creek in eastern Saskatchewan showing 14-fold increase in flow volume (work by Stacey Dumanski)
- Increasing contributions from rain-on-snow and summer rainfall

## GRACE gravity field measurements



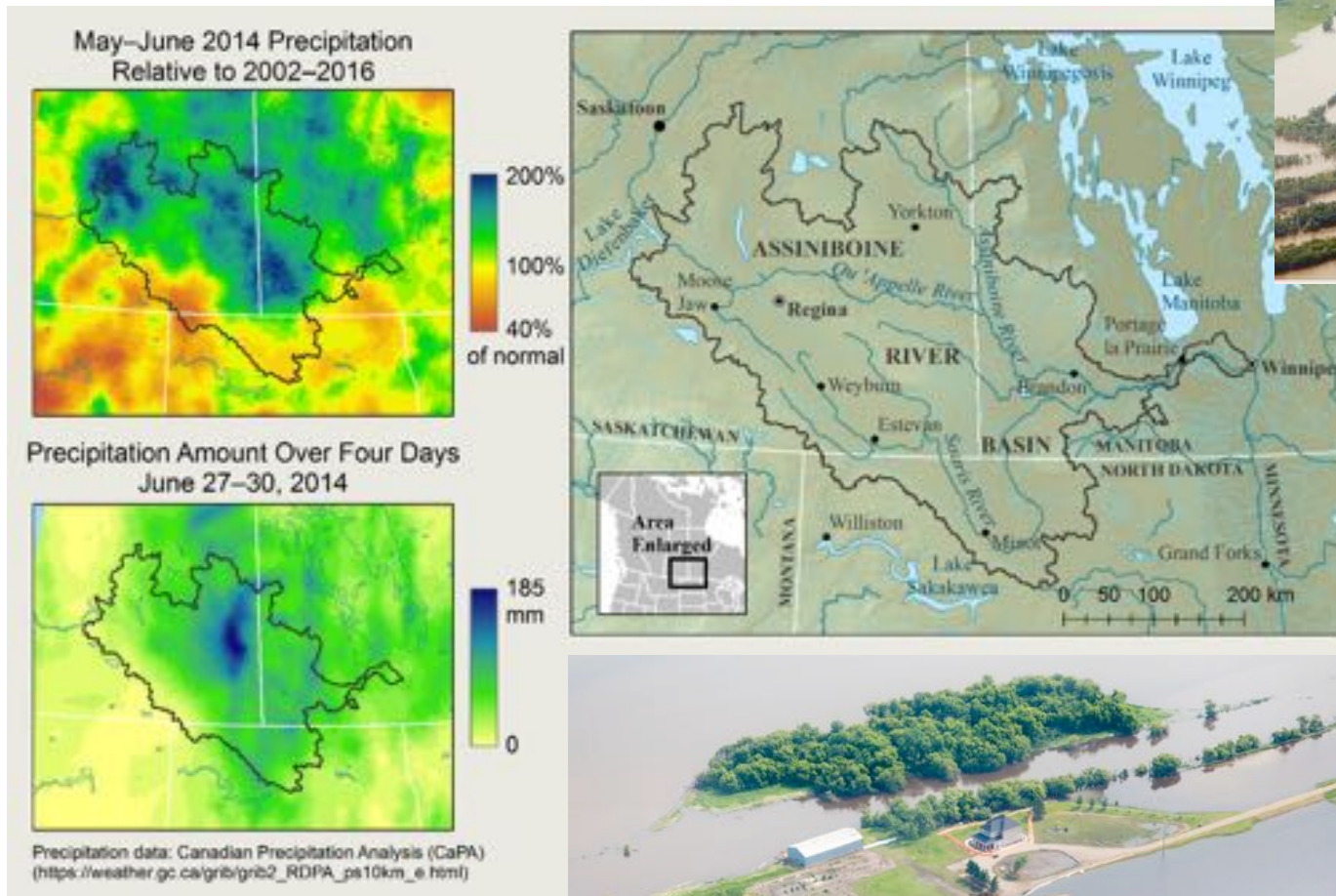
Dumanski et al. (2015). Hydrological regime changes in a Canadian Prairie basin. *Hydrological Processes*, 29(18), 3893-3904.

Lambert et al. 2013, *GRL*, **40**, 6118–6122



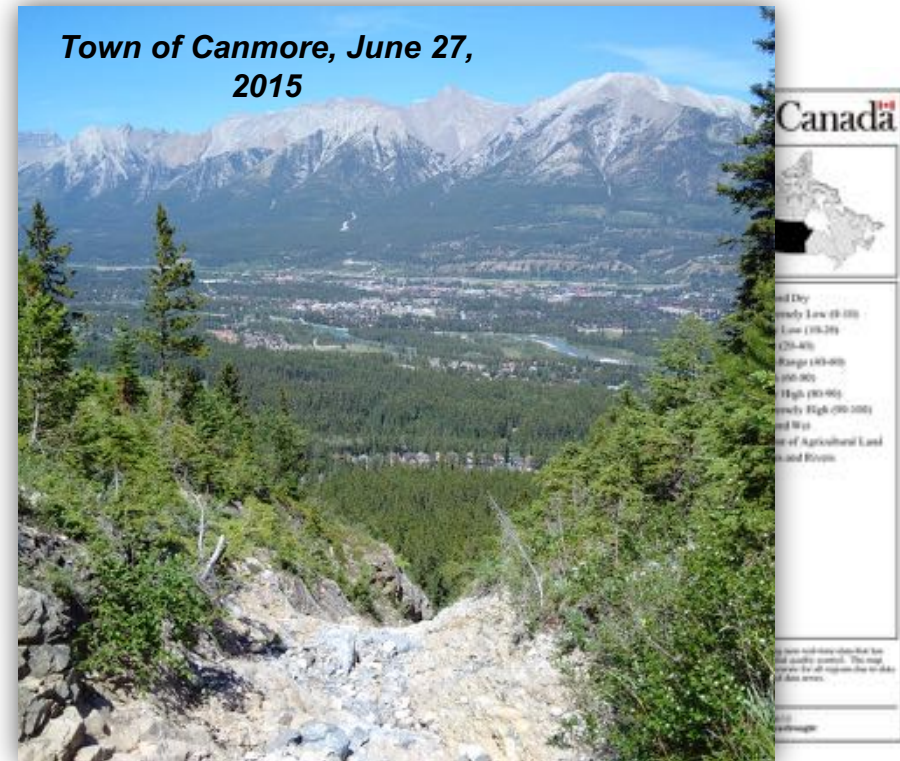
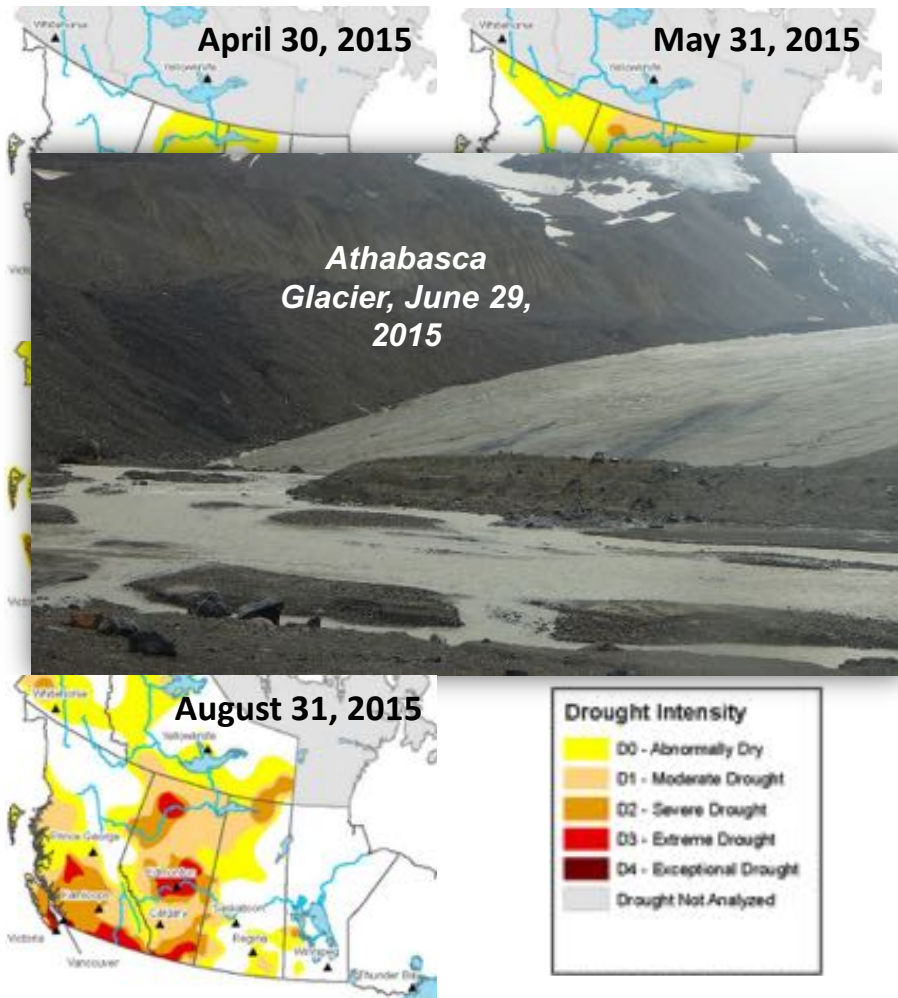
# 2014 Assiniboine River Flood

## Unprecedented summer flooding in the Prairies



- Heavy winter snowpack, large spring runoff
- Heavy rain in June
  - Multiple days, large area
- Very wet soils, filled depressions
- Intense rainfall event in late June

# 2015 Western Canadian Drought



Agriculture and Agri-Food Canada agro-climate map of precipitation percentiles over the Canadian prairies (April to early-July 2015)



# 2013 Canmore/Calgary Floods

**3. June 21, 2013: Mass Evacuations in Calgary**



**Downtown Calgary**

PHOTO: JOHNATHAN HAYWARD, THE CANADIAN PRESS

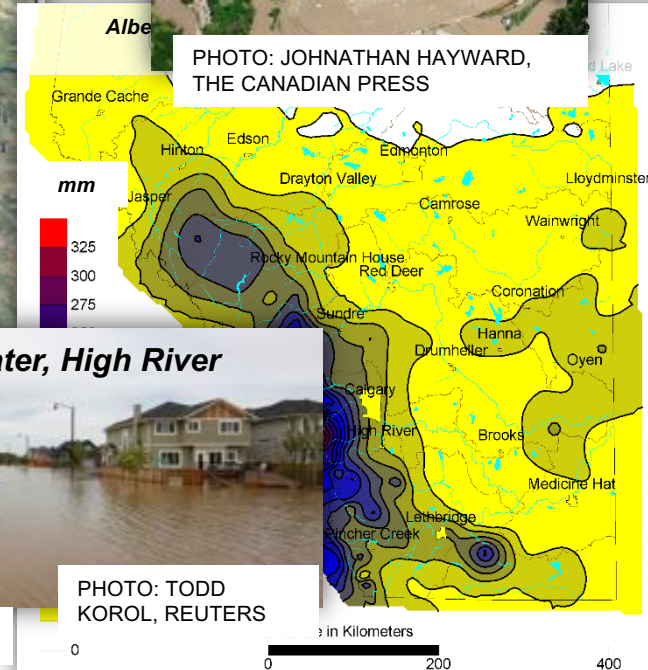
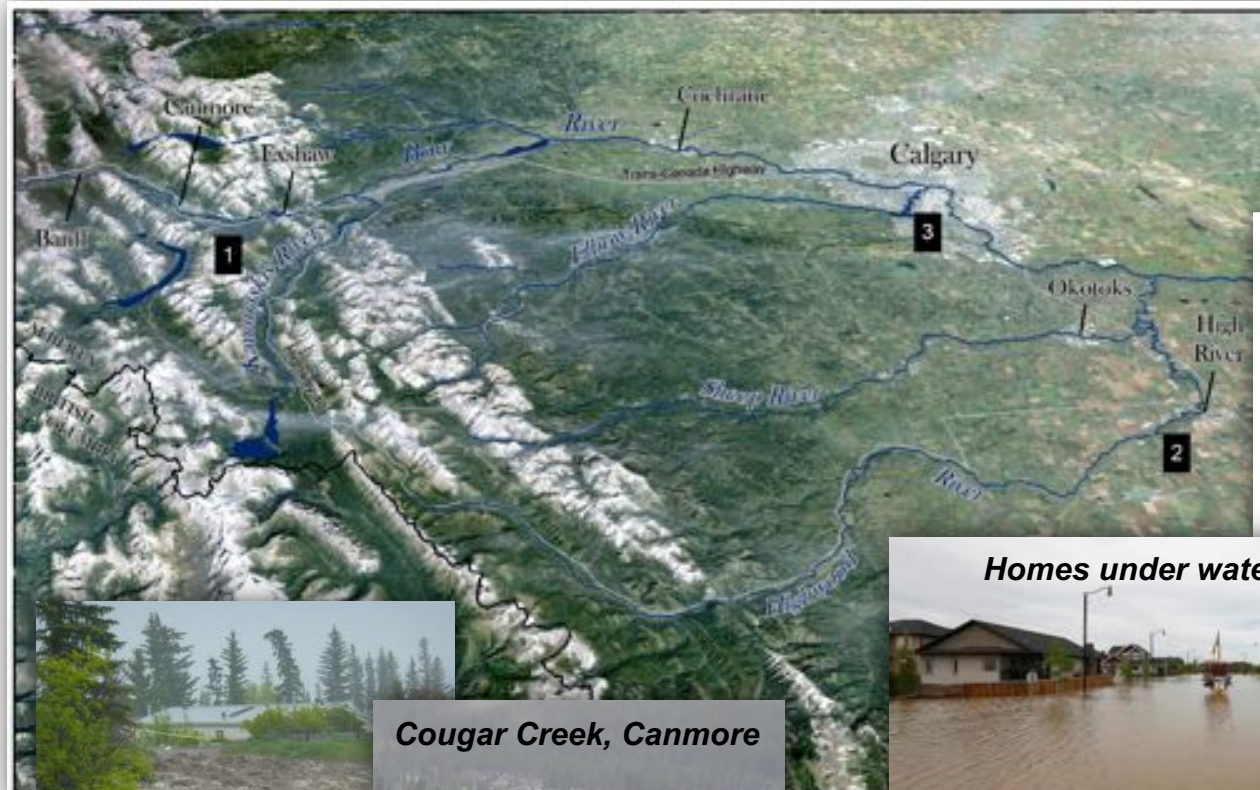


PHOTO: TODD KOROL, REUTERS

[HTTP://ENVIRONMENT.ALBERTA.CA/FORECASTING/DATA/PRECIPMAPS/EVENT\\_JUN19\\_22.PDF](http://environment.alberta.ca/forecasting/data/precipmaps/event_jun19_22.pdf)



**Cougar Creek, Canmore**

**Homes under water, High River**

**2. June 20, 2013: State of Emergency**

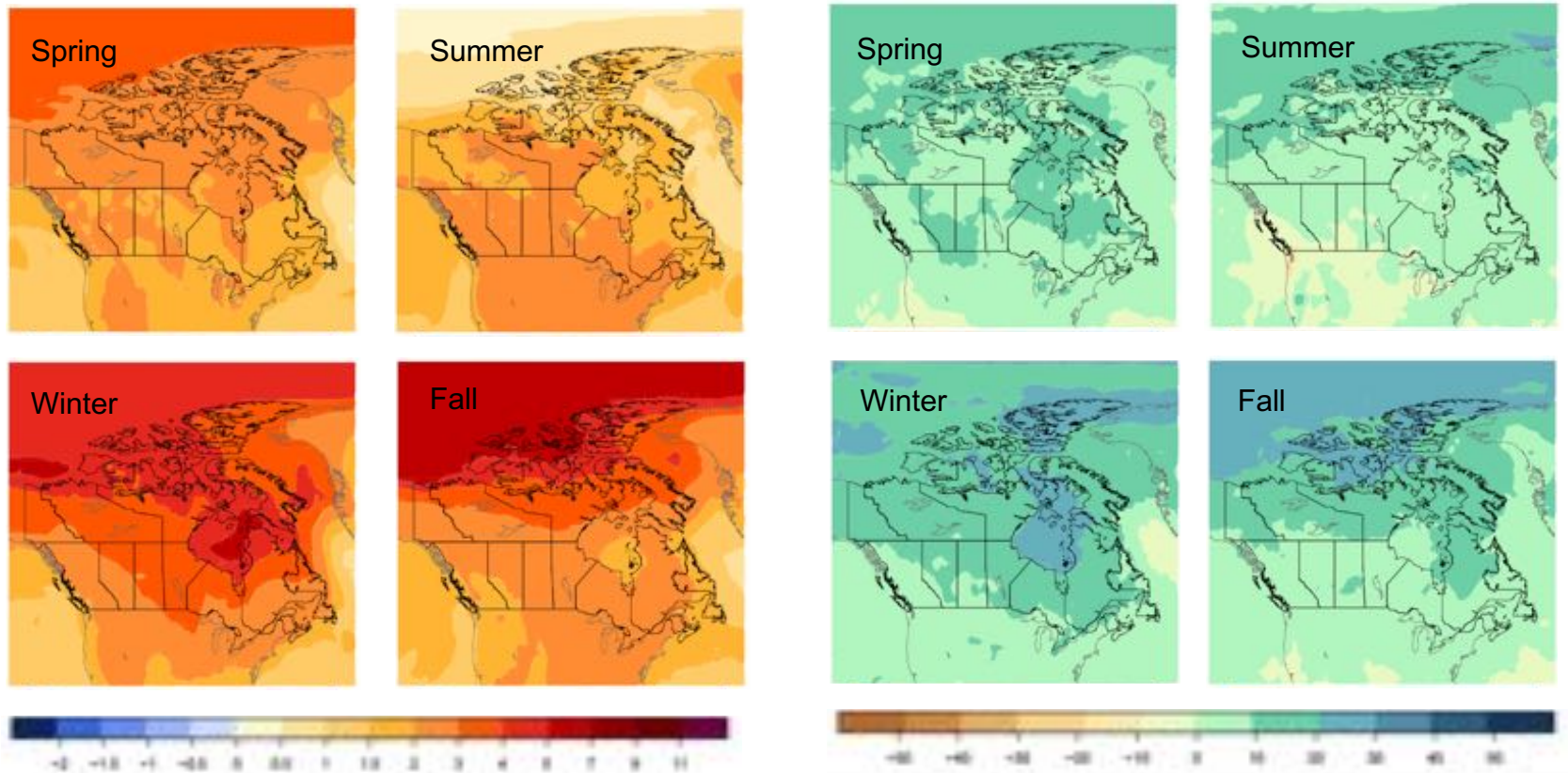
**1. Overnight June 19–20, 2013: Rain & Floods Begin**

PHOTOS: JOHN POMEROY

# What might the future hold?

# Canadian Climate Data and Scenarios

- CMIP5 Ensemble projections (29 models) for 2046–2065; RCP 4.5



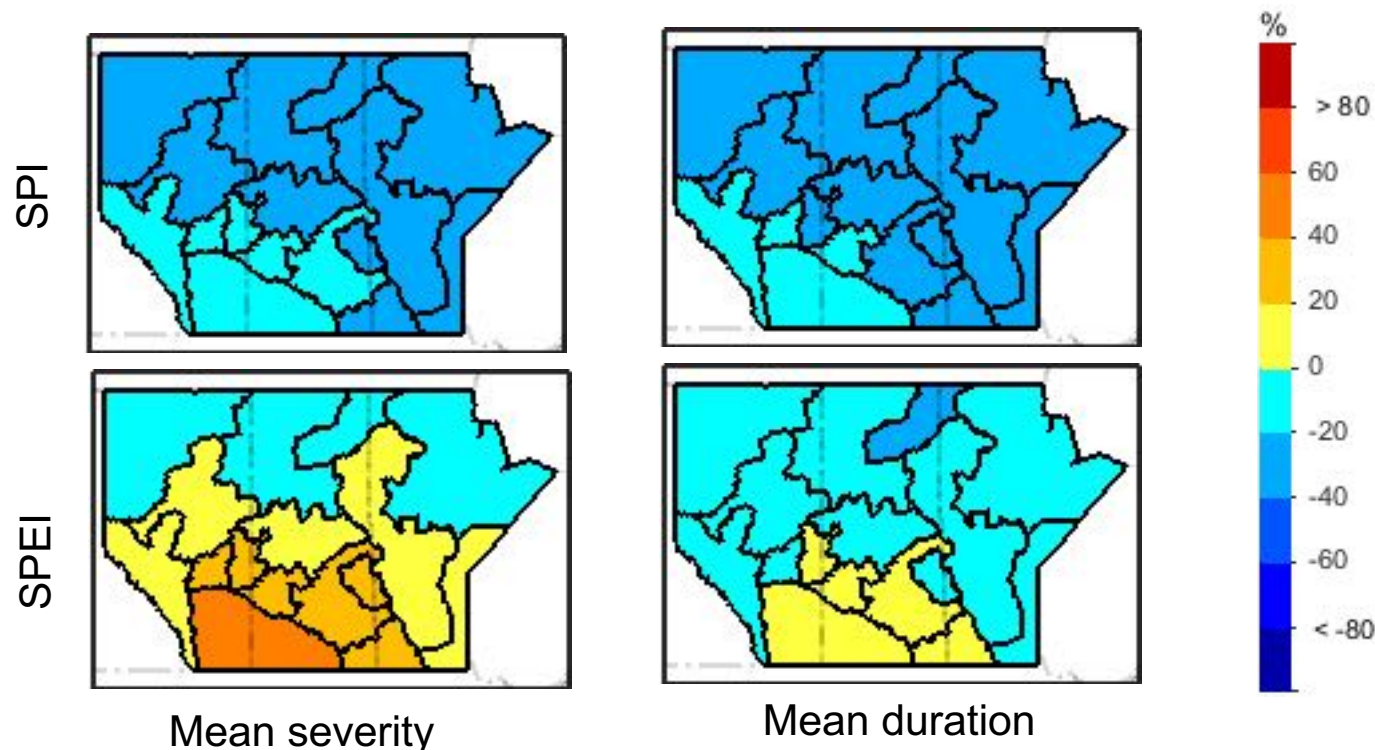
Temperature change relative to 1986–2005 (°C)

Precipitation change relative to 1986–2005 (%)



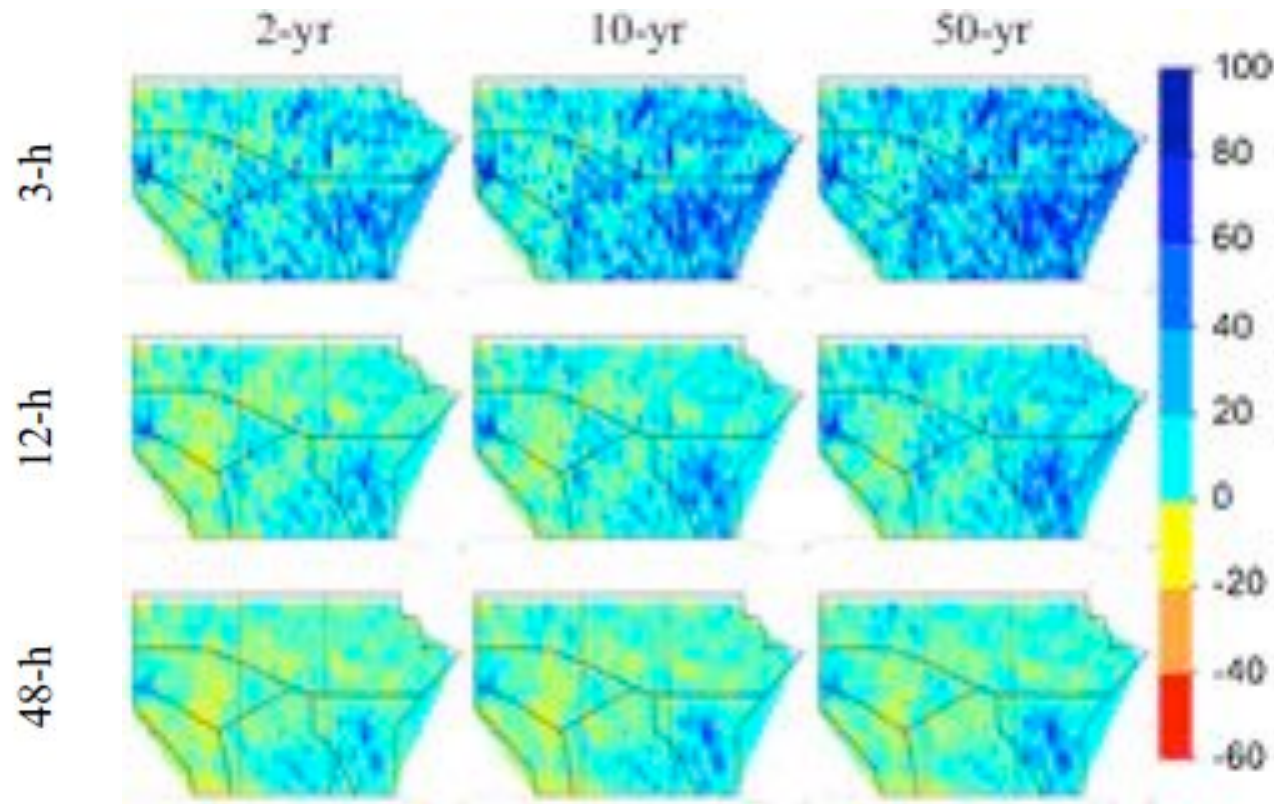
# Future Droughts

- Projected changes to SPI and SPEI mean drought severity and duration for 2041 – 2070, relative to 1970–1999.



# Future Extreme Precipitation

- Projected changes in 3-h, 12-h, and 48-h precipitation extremes for 2041 – 2070, relative to 1971–2000.



# Other Climatic/Meteorological Changes

- Increase in warm spells/heat waves
- Less snow, more rain, and more 'cold season' liquid precipitation
- North continues to get wetter, South drier
- More drying in the Summer
- Increased occurrence of freezing rain
- Potentially larger and more destructive hail
- More lightning
- Widespread increase in forest fire occurrence and dramatic landscape shifts in association
- Uncertain changes in variability – but increase in occurrence of extremes likely



# Future Terrestrial & Earth System Changes

- Alpine Regions
  - Sustained glacier loss, changing snow regime, valley forest cover change and treeline/shrub advance, extreme events
- Boreal Forest and the North
  - Shrub expansion, varying forest growth responses, migrating boundaries and fragmentation, FIRE, permafrost thaw and flow paths
- Prairies
  - Agricultural development, cropping patterns, land and water management



# Further Information

- CCRN documentary on YouTube and the CCRN website  
[www.ccrnetwork.ca](http://www.ccrnetwork.ca)



Changing Climate and Environment of Western Canada Documentary

- See CCRN > Data & Outputs > Information Products

Thank you

Questions?