

Impact of atmospheric circulation on streamflow in Southern Ontario

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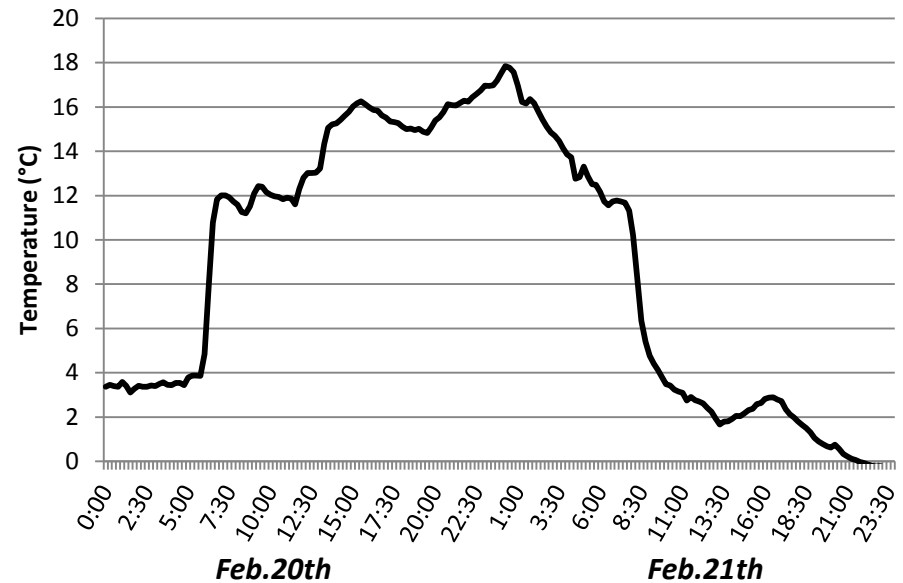
CGU Annual meeting, Niagara Falls, ON

June 12th, 2018

Introduction



Thames River Flood, London, ON, February 2018



Observed Air Temperature at McMaster University in February 2018

- A **widespread flood** occurred on **February 21st, 2018** in Southern Ontario.
- It was caused by **rainfall** and **snowmelt**.
- Thames River observed the **third biggest** flood event.
- It was **THE** biggest ever flooding event recorded in **February**.

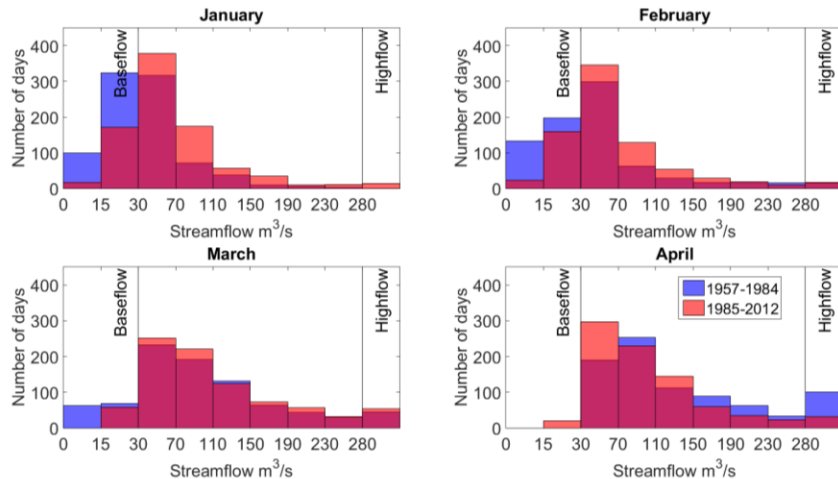
Introduction

- The most floods in Southern Ontario generally occur in March and April due to snowmelt coupled with spring rainfall events.
- However, there has been a shift in these trends over the last three decades with a decrease in streamflow in March-April and an increase in January-February.

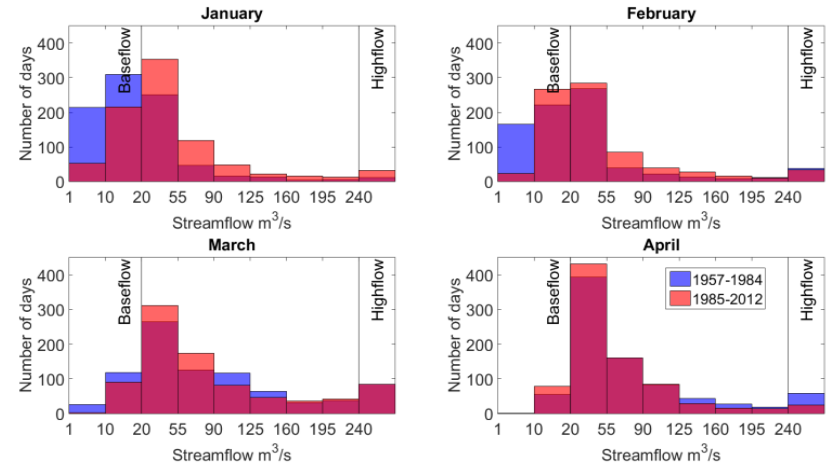
Introduction

- **Decrease in streamflow in March-April and increase in January-February**

Grand River



Thames River



Evolution of frequency of observed Streamflow for two watersheds in Southern Ontario

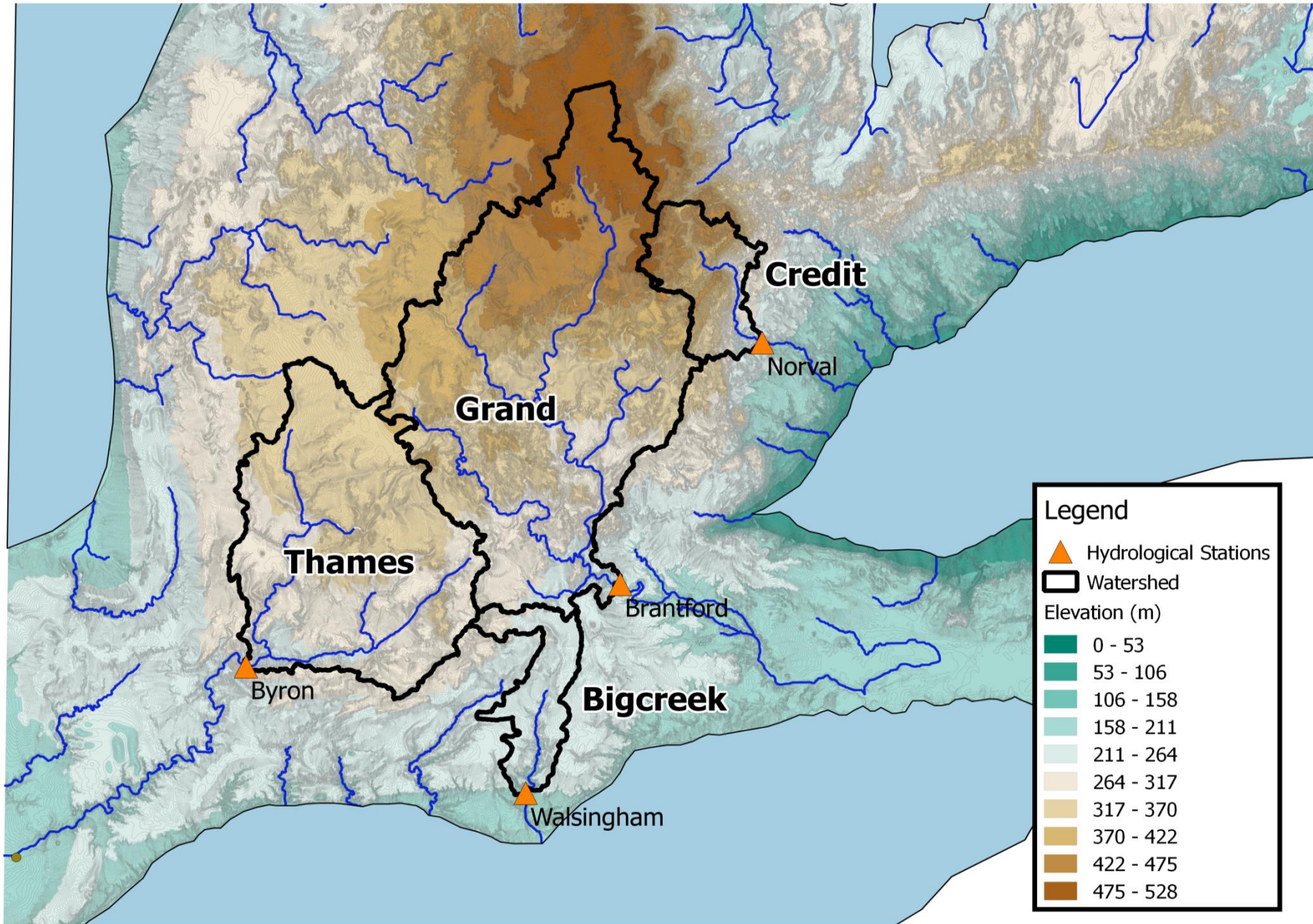
- Shift associated with **changes in snowmelt** or **increase in rainfall**

Is this shift in snowmelt/rainfall pattern caused by changes in large-scale atmospheric circulation?

Main Objectives

- Understand the role played by large-scale atmospheric circulation on variability of climate conditions and hydrologic regimes in Southern Ontario.
- Determine the contribution of atmospheric circulation to the shift in snowmelt, rainfall patterns and streamflow in Southern Ontario.

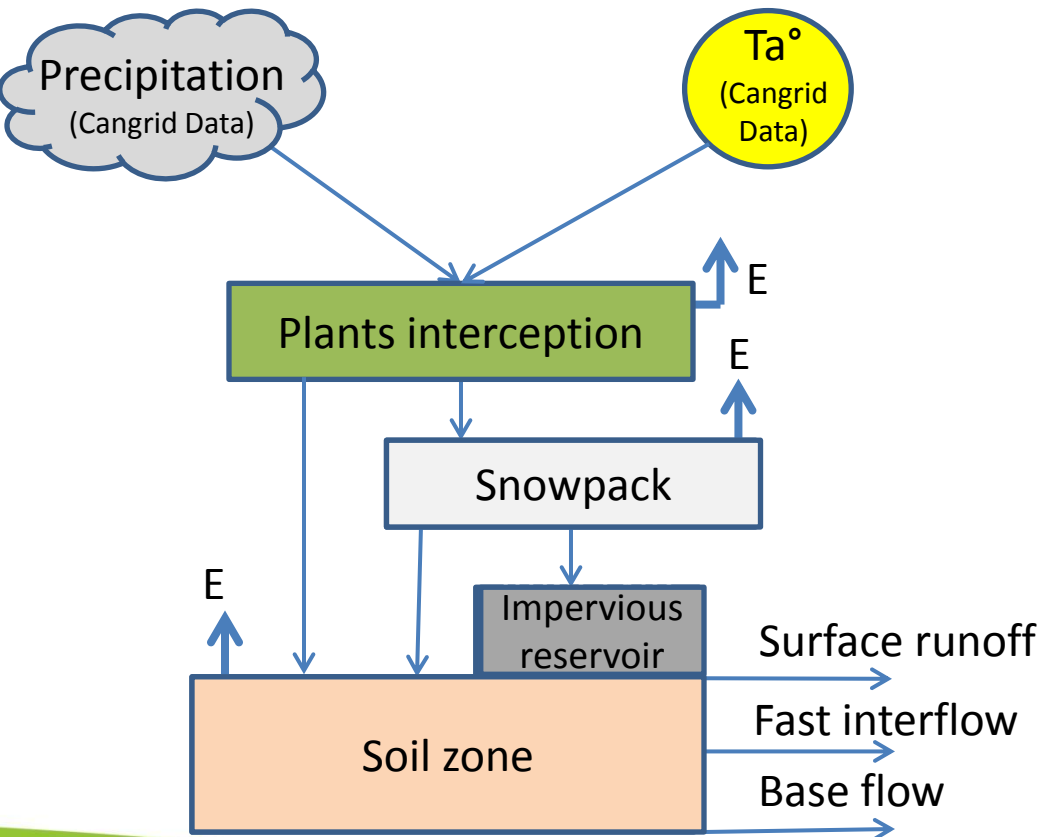
Study Area – Four Watersheds



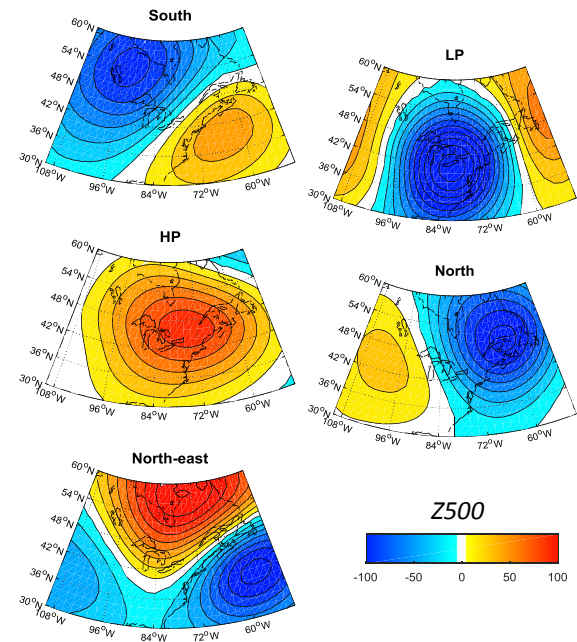
Methodology

Hydrological Simulations in Select Watersheds

Precipitations-Runoff Modelling System (PRMS)



Large scale Atmospheric Circulation Data



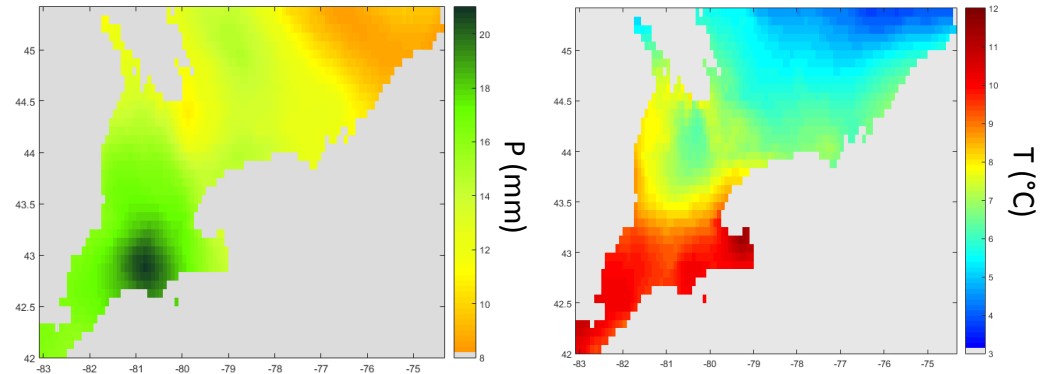
Weather regimes in Northeastern-North America

- Based on **daily geopotential height anomalies at 500 hPa** from 20th Century Reanalysis version 2 (1951-2014)

Methodology

- **New Regional Extreme Weather Index for January-February**

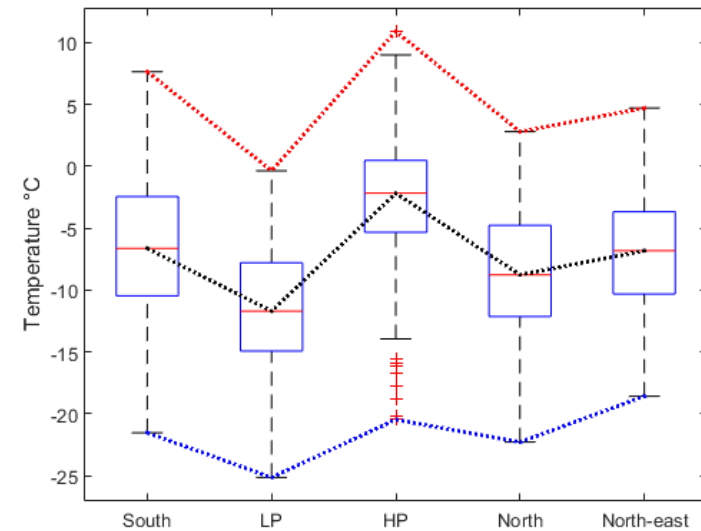
- Based on hydrological records
(Days with high-flow observed in all watersheds)
- $T_{\max} > 5^{\circ}\text{C}$ and $P > 10\text{mm}$



Average precipitations and temperatures for generalized high flow events in Southern Ontario in January-February

- **New method of analysis of streamflow sensitivity to the temporal shift in weather regime**

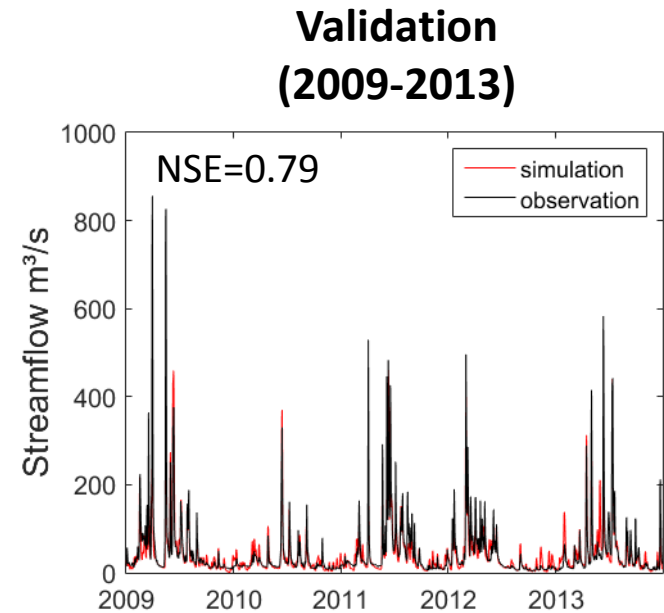
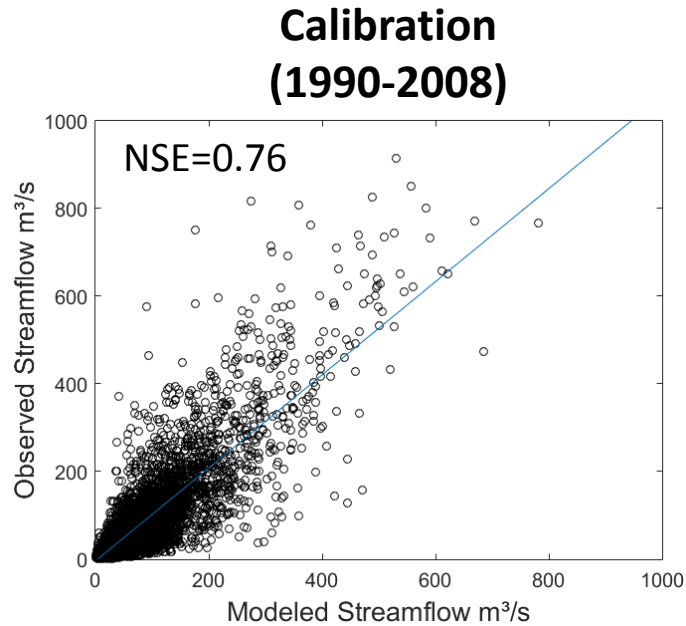
- Removed the monthly trend of the regime occurrence .
- Replaced the old weather conditions with new conditions selected from 1956-2012 data (similar intra-regime anomaly as the replaced regime).
- Simulations with PRMS model using these newly created dataset.



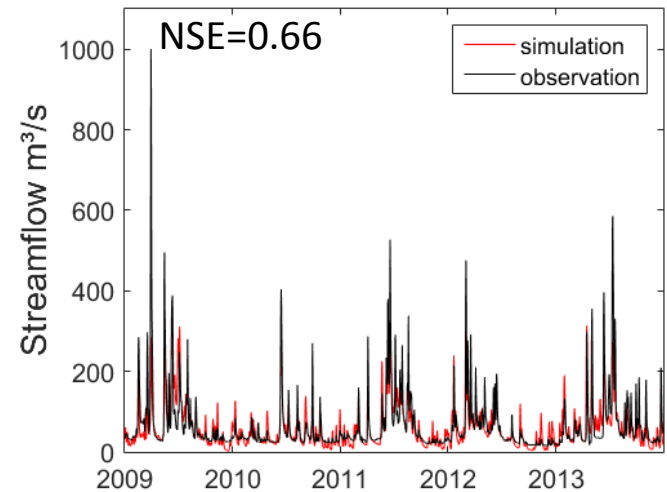
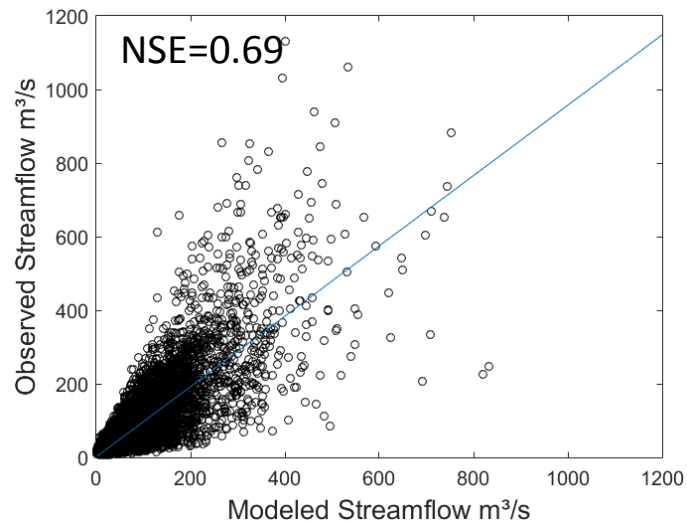
Temperature per regime in January in southern Ontario

Results: Modeled and Observed Streamflow

**Thames
River**

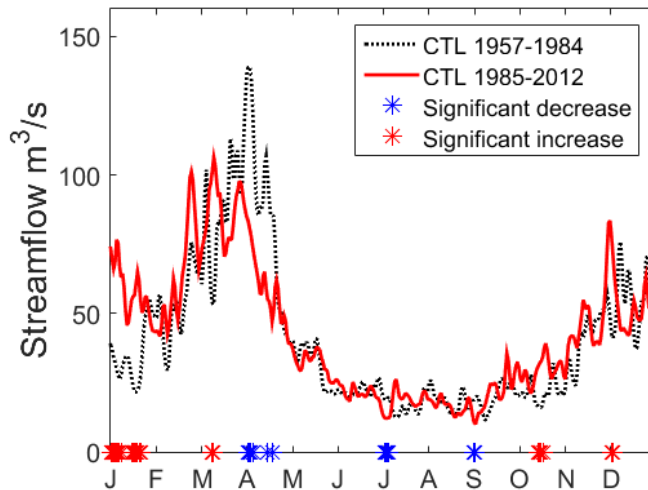


**Grand
River**

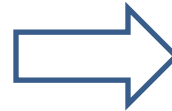
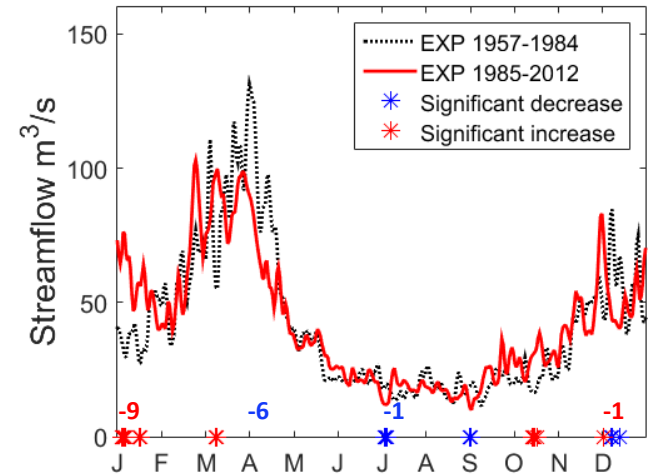


Results: Sensitivity of Streamflow to Regime Frequency

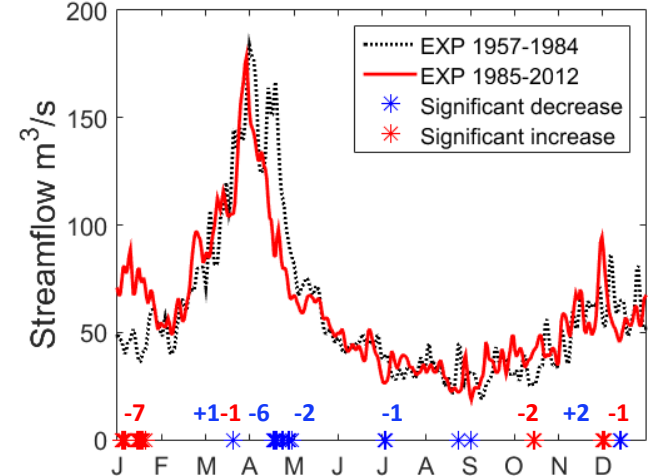
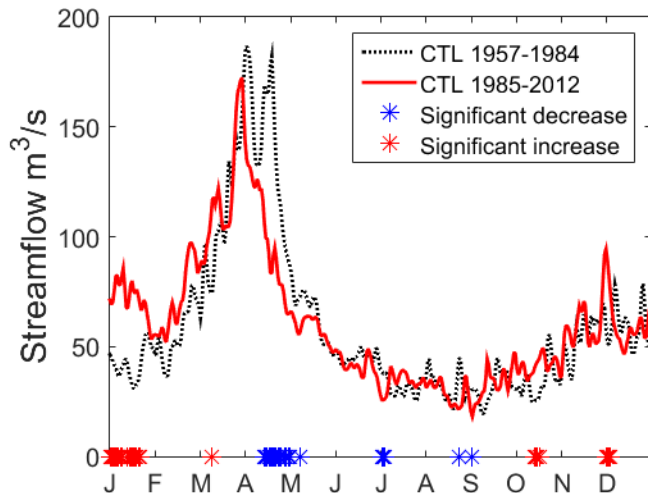
Trend



No Trend



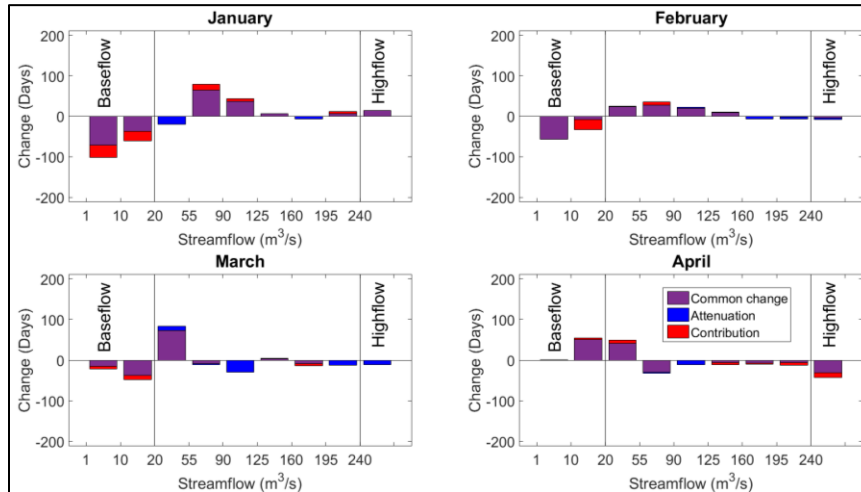
Thames
River



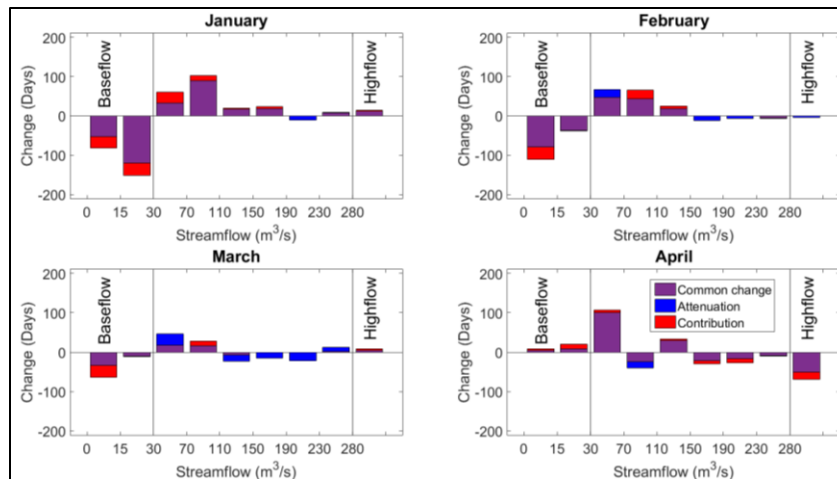
A part of the **shift in streamflow** is due to the **change in occurrence of weather regimes**.

Results: Low Flow or High Flow?

Thames River



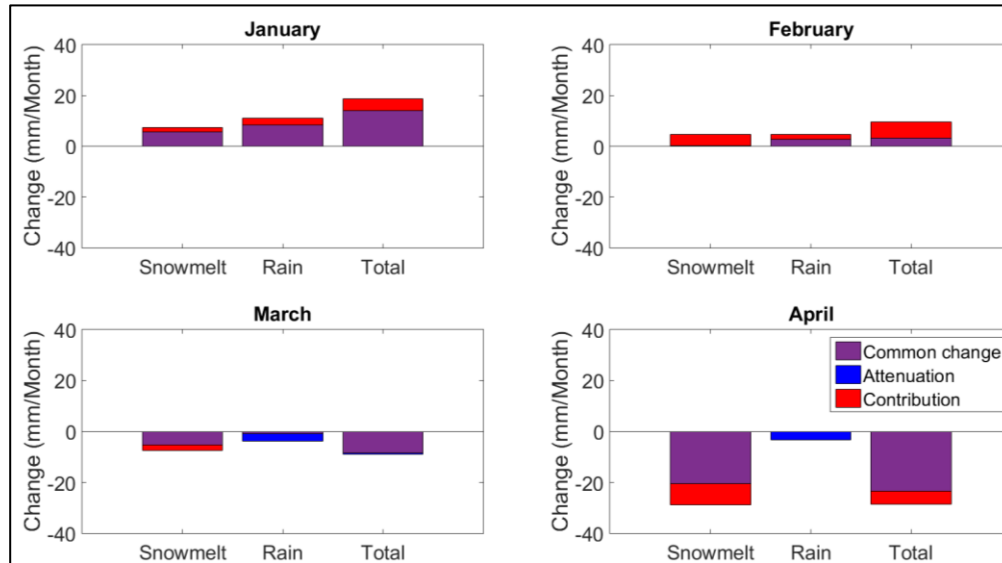
Grand River



- The largest contribution of weather regimes concerns the increase of low flow in **January**.
- The weather regimes also contribute to the decrease of high flow in **April**.
- No significant difference between the two watersheds

Results: Snowmelt or Rain?

Thames River



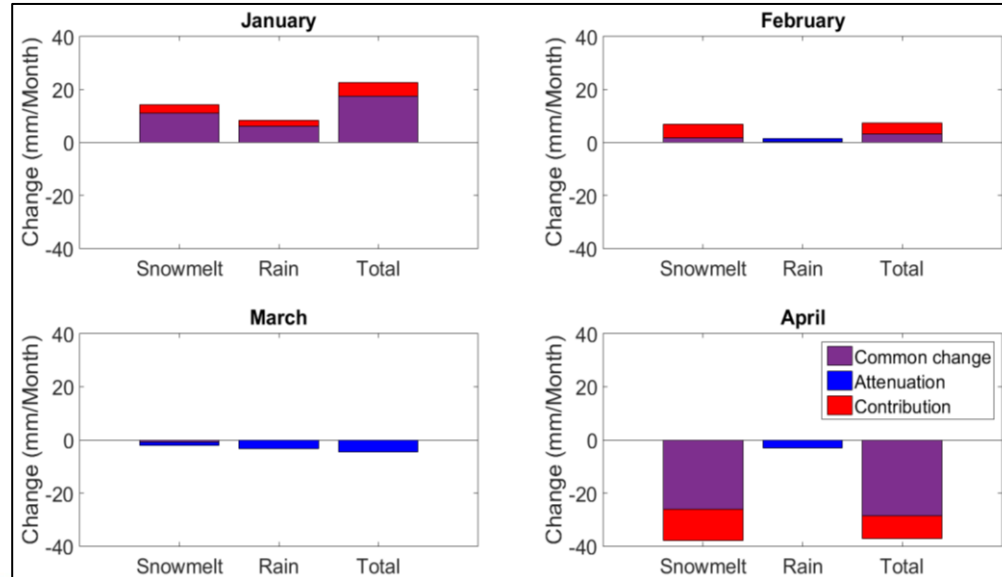
- Significant **contribution of weather regimes to the increase of snowmelt in February** and the **decrease in April**.

- Low contribution to the increase of Rain in January-February

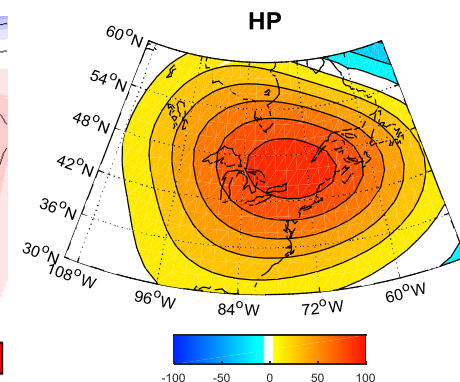
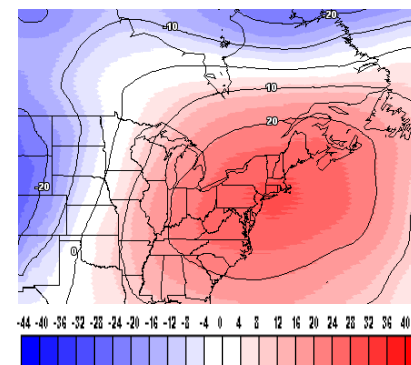
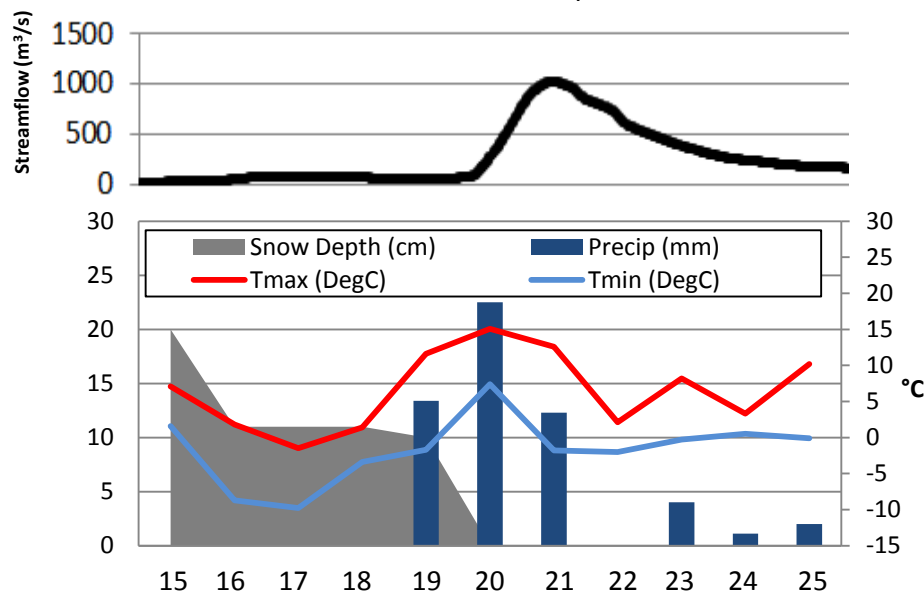
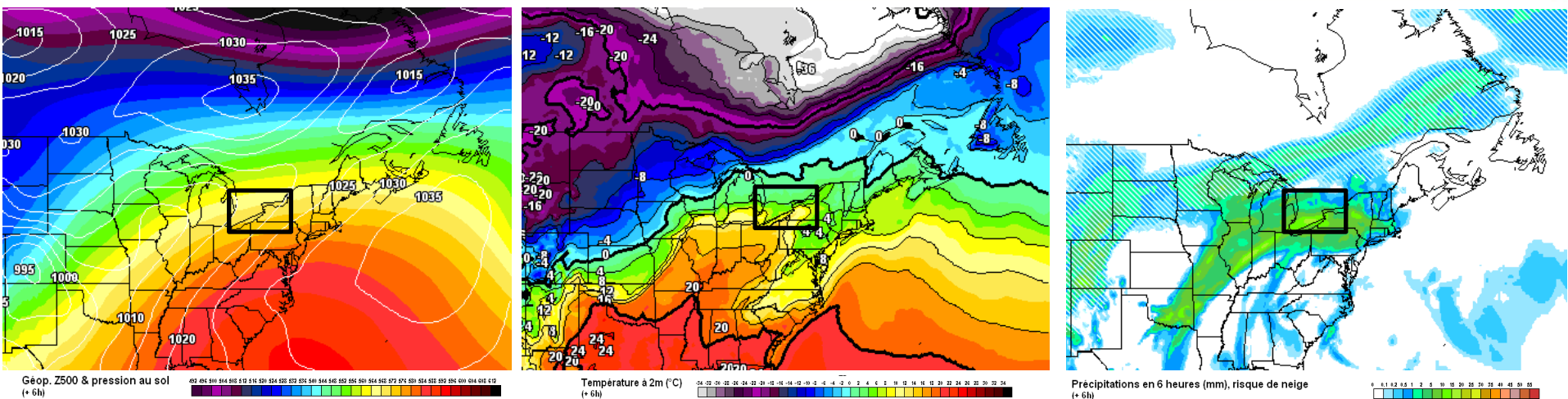
- Change of streamflow driven mostly by:

- **snowmelt in Grand River**
- **rain in Thames River**

Grand River



Results: Flooding Event of February 21st, 2018?



✓ Conditions similar to a HP regime

Conclusions

- **PRMS** and the **weather regimes** have been used to understand the **role on atmospheric circulation** on variability of **streamflow** in **Southern Ontario**:
 - ✓ **High streamflow** are associated to **warm and wet extreme conditions** due to **High Pressure anomalies** in the east coast.
 - ✓ The **increase of High Pressure anomalies** contributes to the increase of streamflow in January-February and a decrease in April.
 - ✓ The **Change in streamflow** is mostly driven by a **change in snowmelt** especially in the **Grand River** watershed
- The **atmospheric origin** of the **increase in wet and warm events and high flows** needs further investigations.
- This work highlighted the importance of studying **internal variability** of climate in the **future predictions**

Thank You

Questions?

Acknowledgments:



Environment
Canada

Environnement
Canada



Long Point Region
Conservation Authority



ONTARIO CLIMATE CONSORTIUM



Natural Resources
Canada

Ressources naturelles
Canada

Canada



Toronto and Region
Conservation
for The Living City



Ontario



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