Impact of atmospheric circulation on streamflow in Southern Ontario

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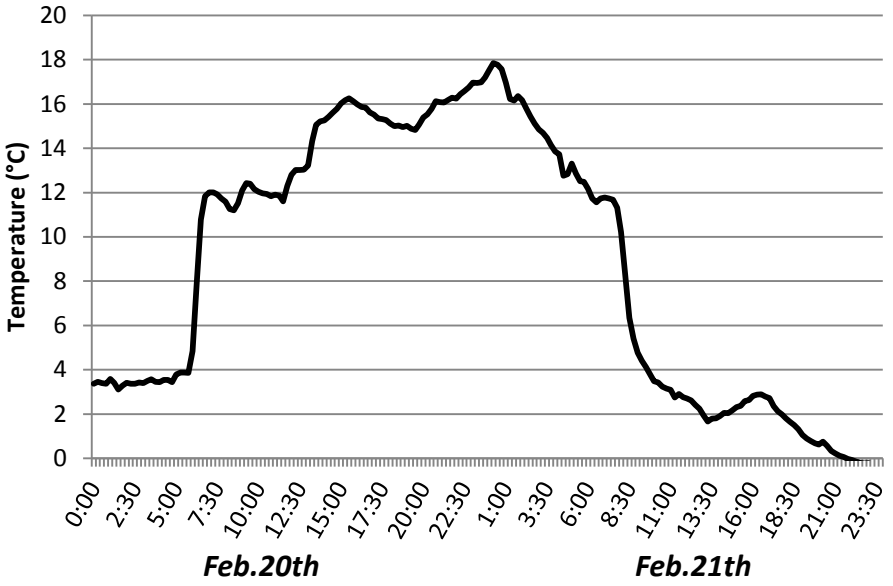
Introduction

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**.

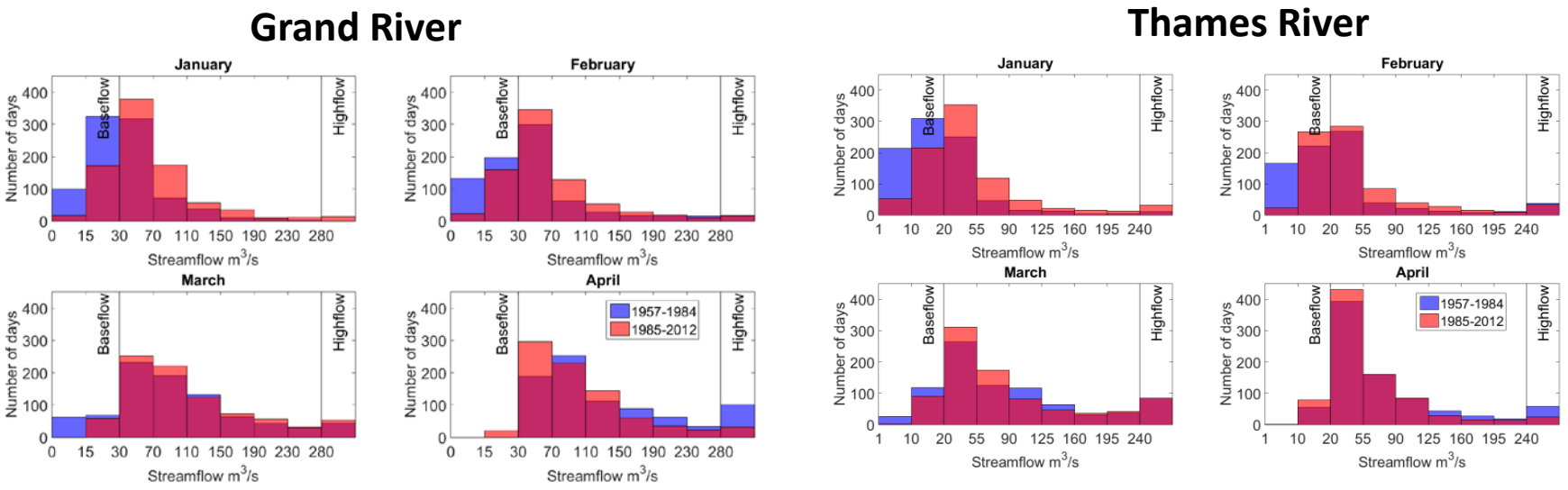
Introduction

- The most significant floods in Southern Ontario generally occur in March and April due to snowmelt coupled with extreme 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**



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

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

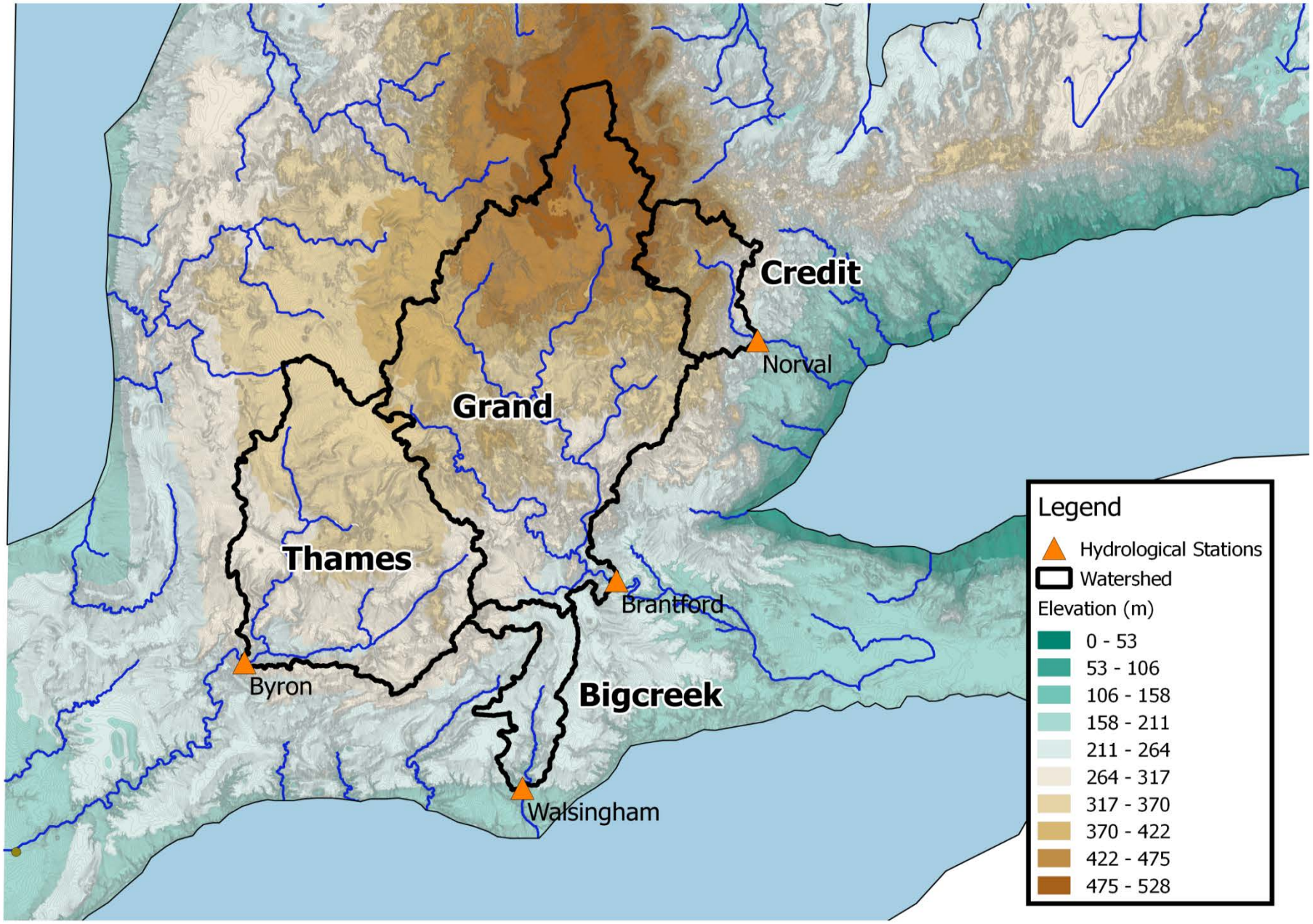
Is this shift in snowmelt/rainfall pattern caused by changes in large-scale atmospheric circulation?

Main Objectives

- Understand the role played by large-scale atmospheric circulation on variability of climate conditions in Southern Ontario.

- Determine the contribution of atmospheric circulation to the shift in observed streamflow in Southern Ontario.

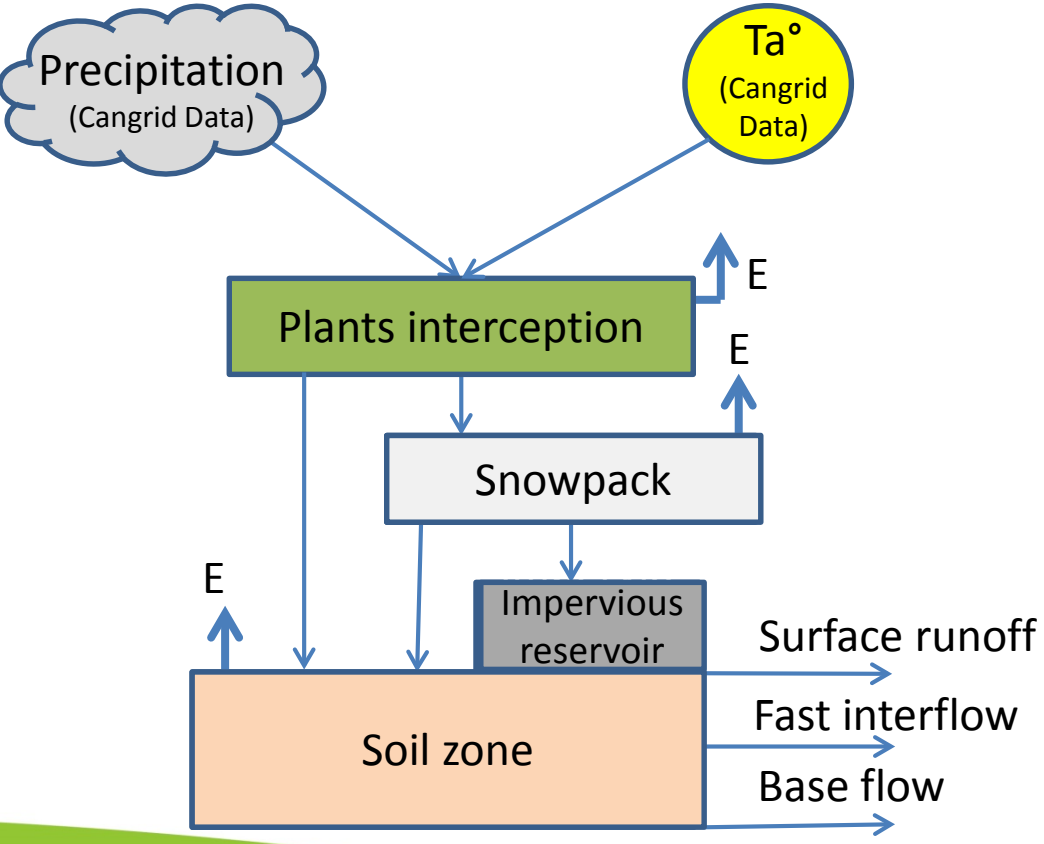
Study Area – Four Watersheds



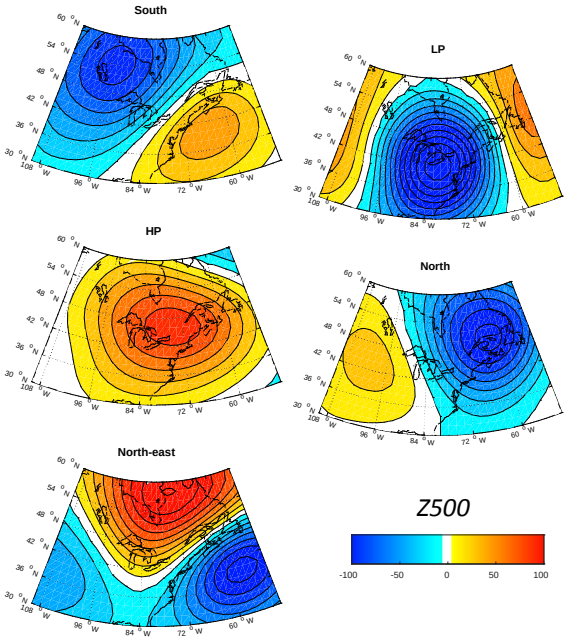
Methodology

Hydrological Simulations in Select Watersheds

Precipitations-Runoff Modelling System (PRMS)



Large scale Atmospheric Circulation Data



Weather regimes in Northeastern-North America

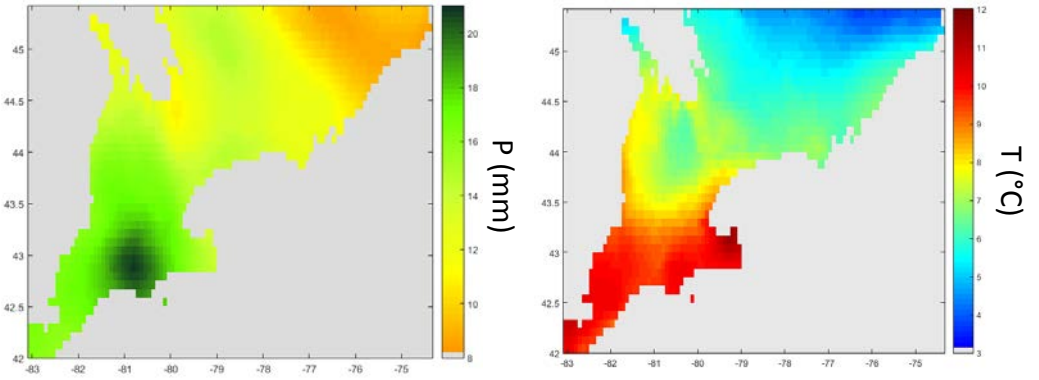
- Based on **daily geopotential height anomalies at 500 hPa** from 20th Century Reanalysis version 2 (1951-2014)

Methodology

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

➢ Based on hydrological records
(Days whit high-flow observed in all watersheds)

➢ T_{max} > 5°C and P > 10mm



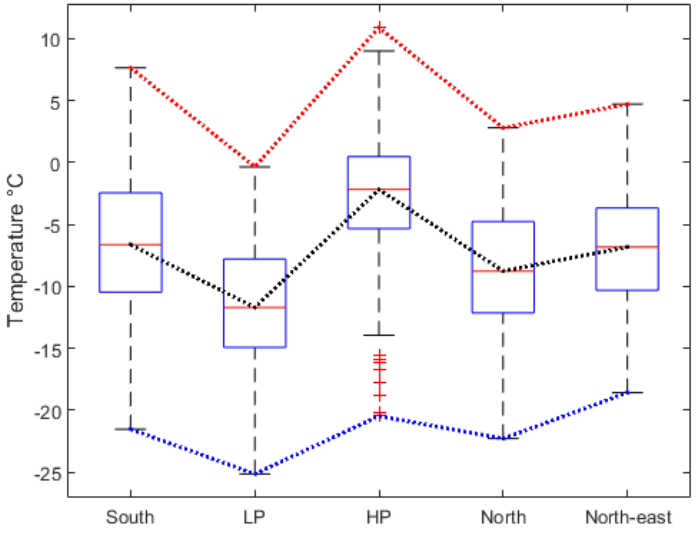
Average precipitations and temperatures for generalized high flow events in Southern Ontario in January-February

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

➢ Removed the monthly trend of the regime occurrence

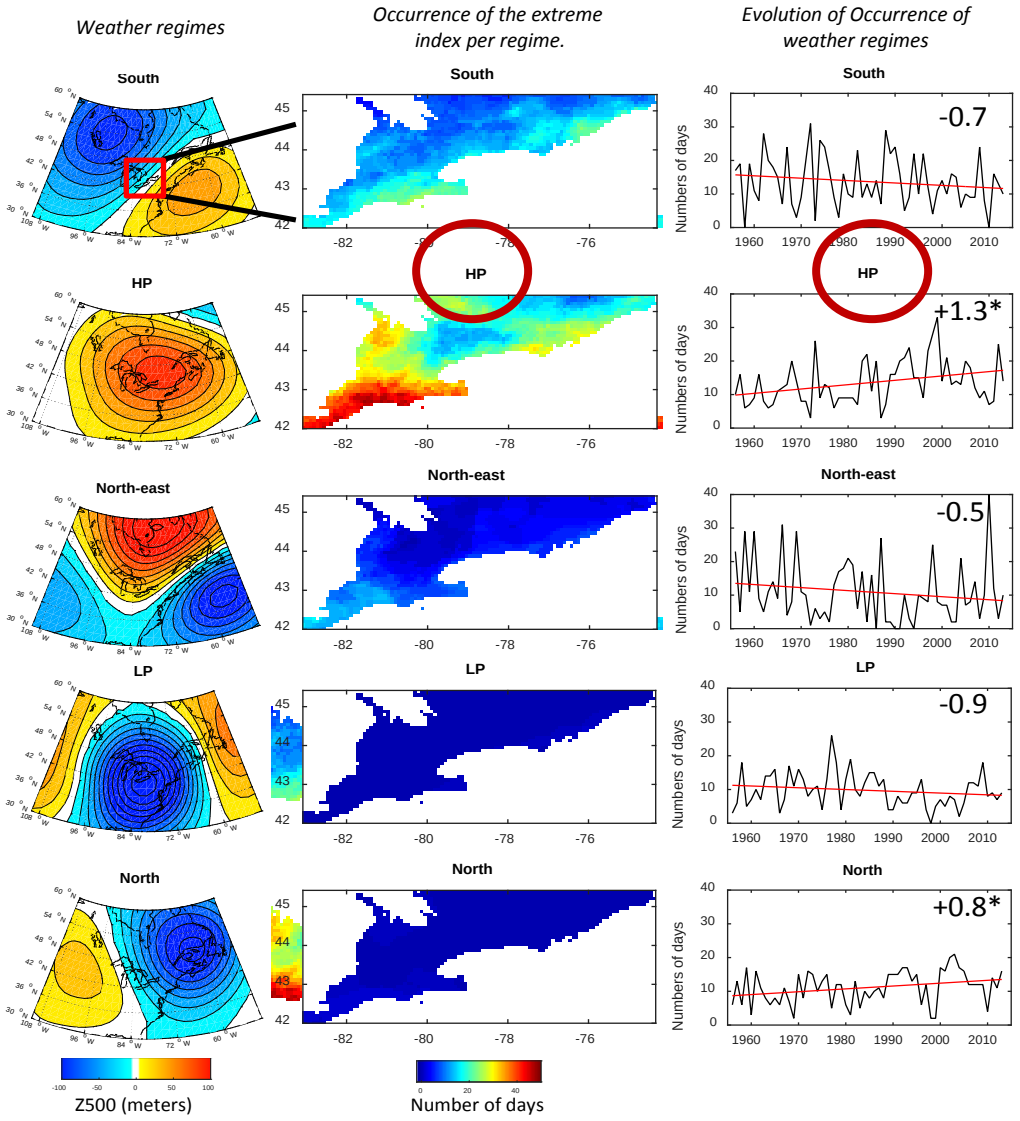
➢ Replaced the old weather conditions with new conditions selected from 1956-2012 data (similar intra-regime anomaly as the replaced regime).

➢ Simulations with PRMS model using these newly created dataset



Temperature per regime in January in southern Ontario

Results: Weather Regimes & Extreme Rainfall Events



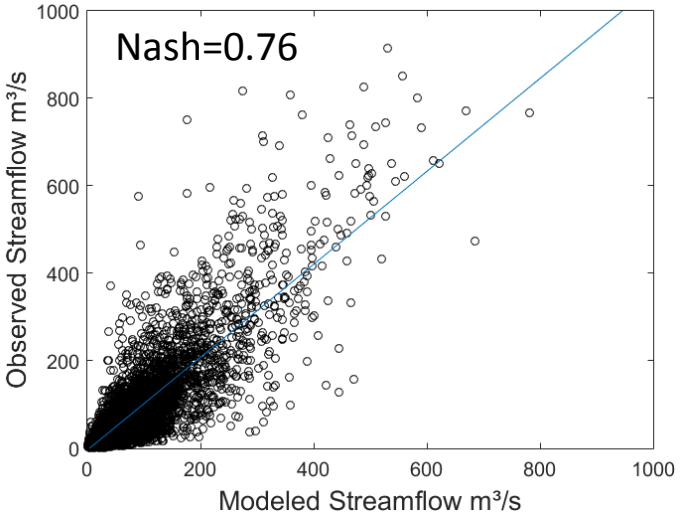
- Warm and wet events in January-February occur mostly during **High Pressure (HP) regime causing advection of warm and wet air masses from the south**.
- Regime HP has become significantly more frequent in recent years (shift in 1984)
- **Large scale atmospheric conditions favoring high flow are now more frequent**

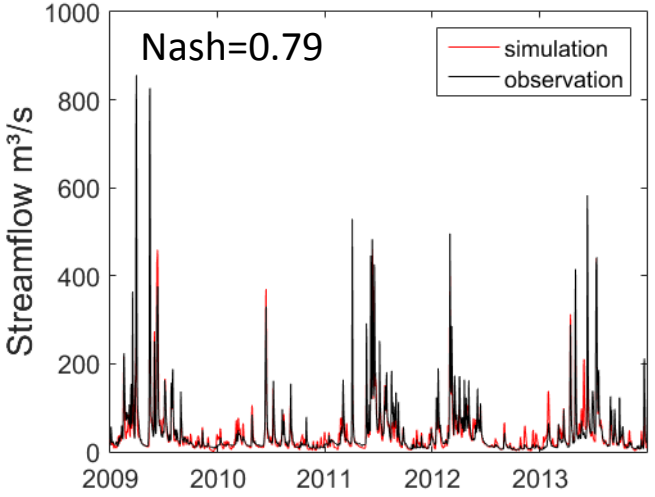
Results: Modeled and Observed Streamflow

Calibration (1990-2008)

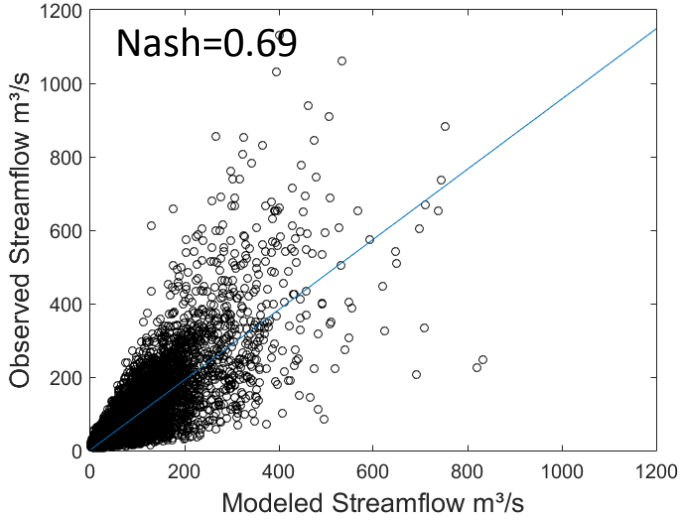
Validation (2009-2013)

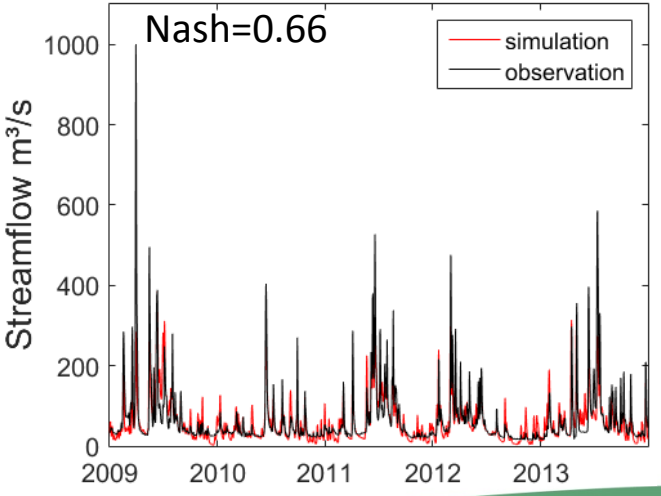
Thames River





Grand River

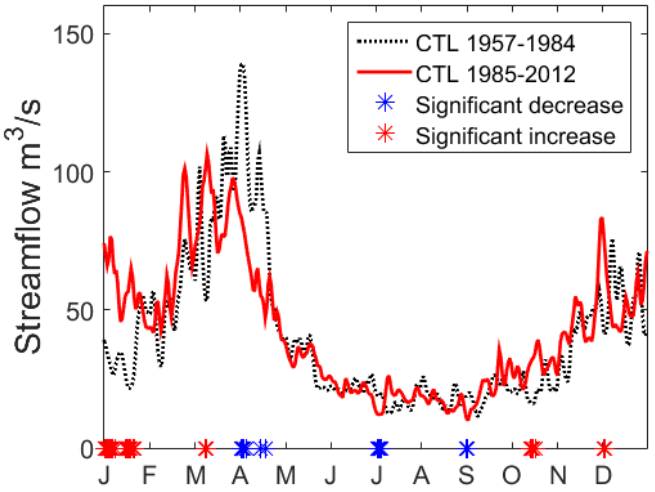


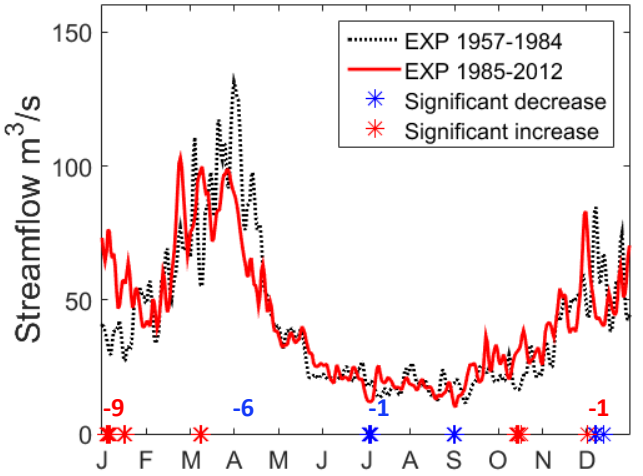


Results: Sensitivity of Streamflow to Regime Frequency

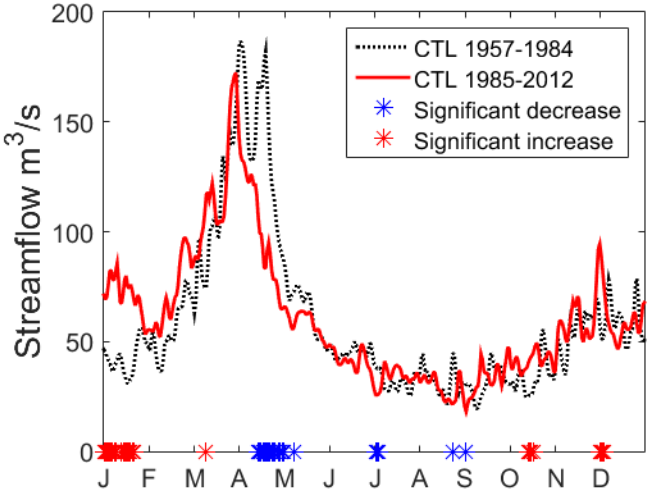
Trend ***No Trend***

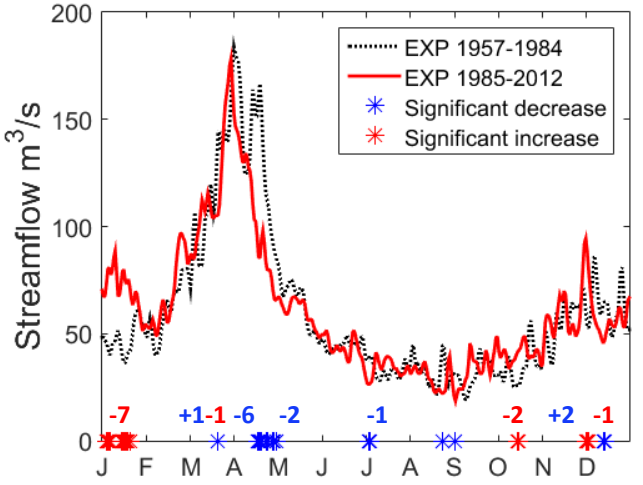
Thames River





Grand River

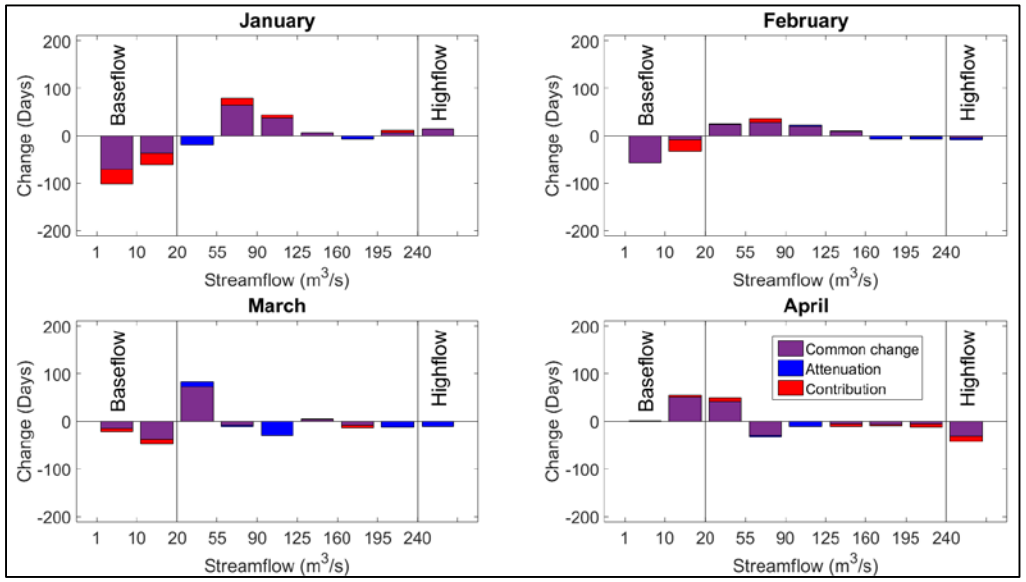




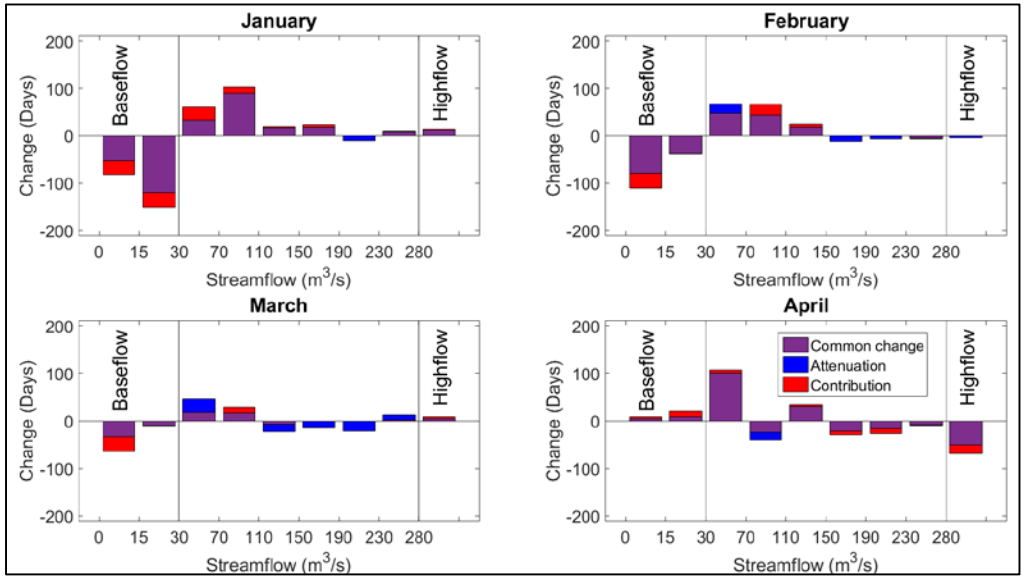
A part of the **shift in streamflow** is due to the **change in occurrence of weather regimes.**

Results: Low Flow or High Flow?

Thames River

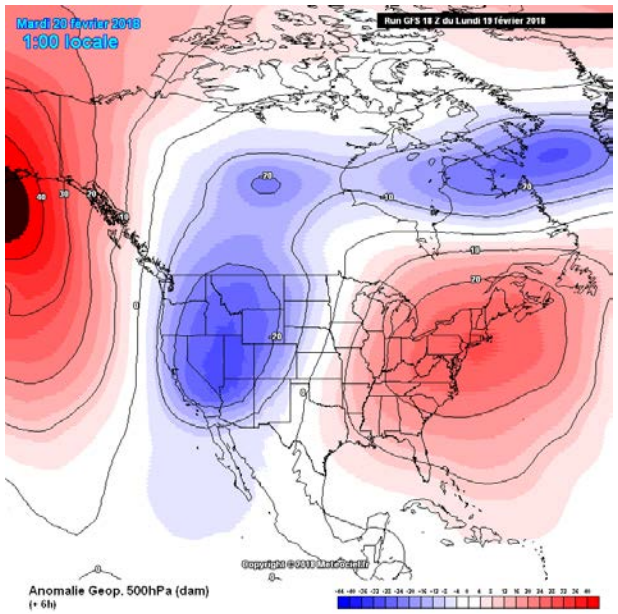


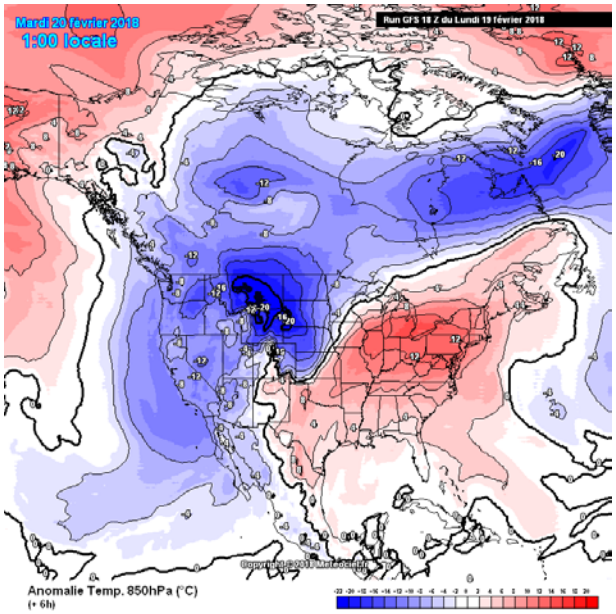
Grand River

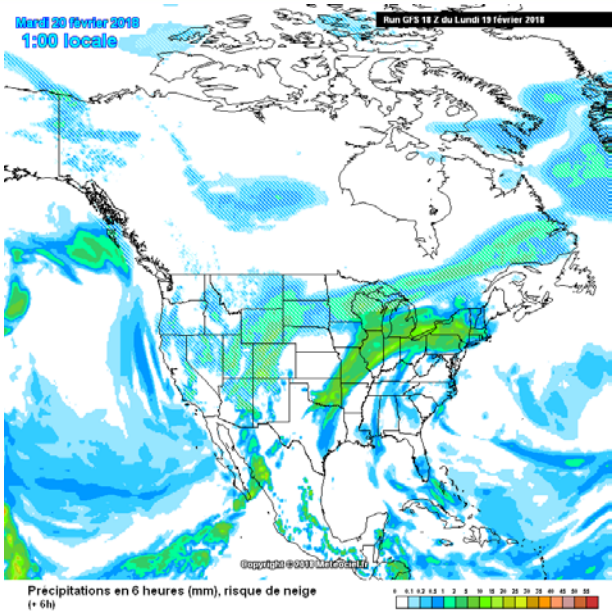


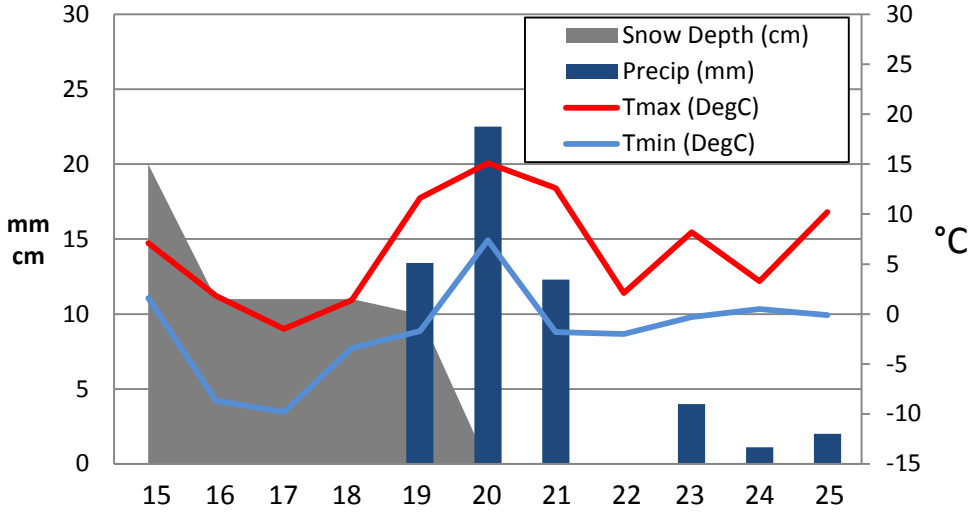
- The largest contribution of weather regimes concerns the increase of low flow **in January**.
- The weather regimes also contribute to the decrease of high flow in **April**.
- No significant difference between the two watersheds

Results: Flooding Event of February 21st, 2018?

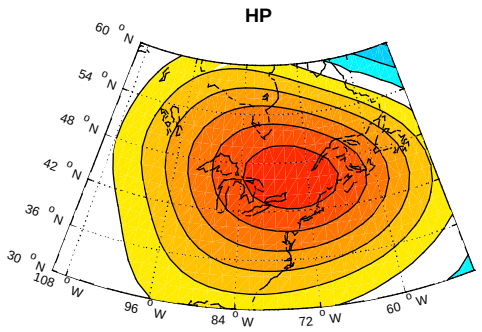








Weather conditions in London (15-25 February 2018)

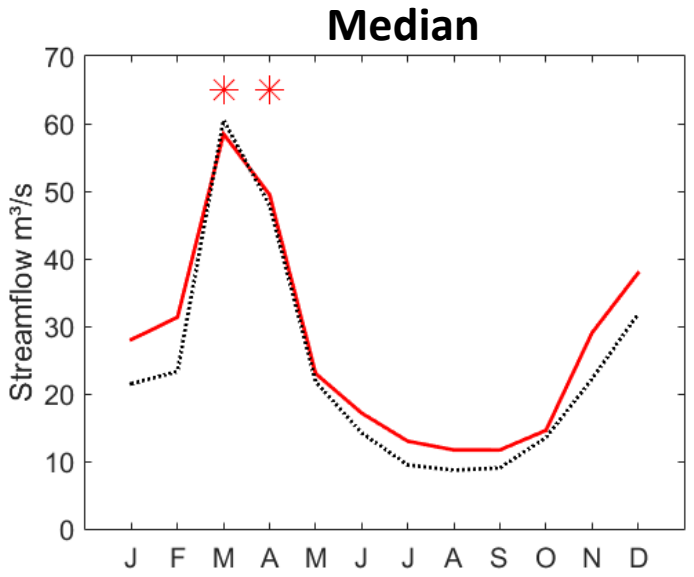


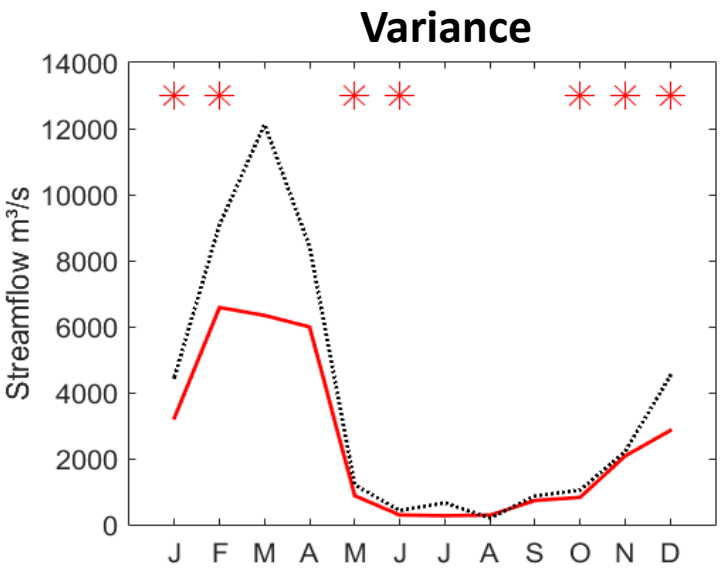
Conditions similar to a HP regime

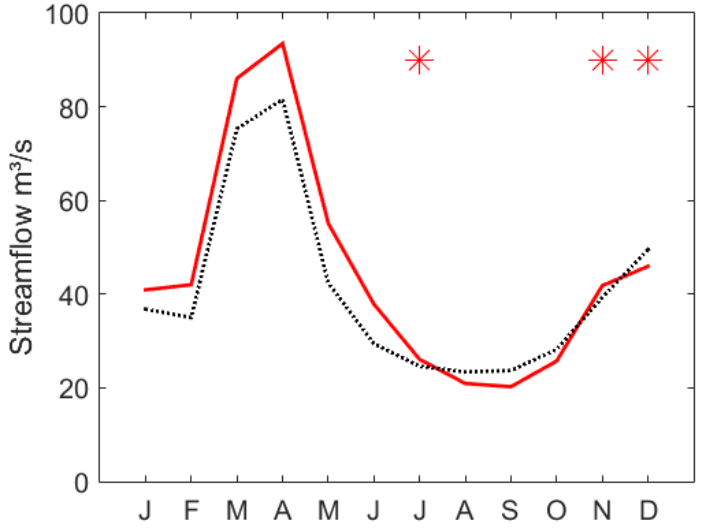
Discussion: Uncertainty in PRMS Simulations

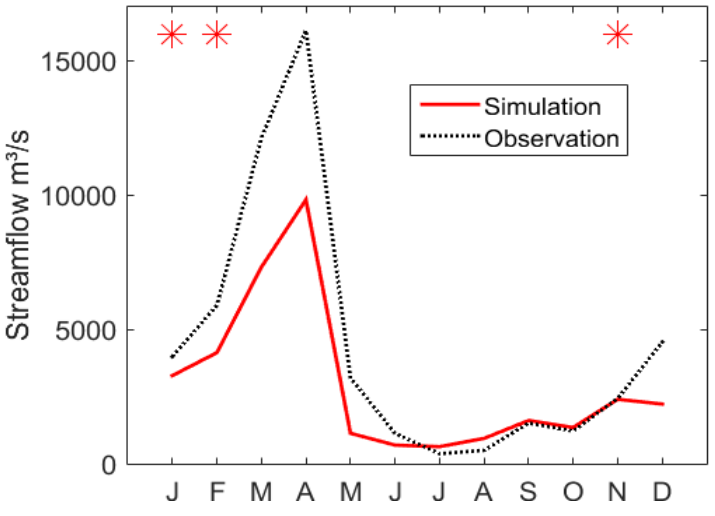
Thames River

Grand River









Conclusions

- **PRMS** and the **weather regimes** have been used to understand the **role on atmospheric circulation** on variability of **streamflow** in **Southern Ontario**:

  1) **High streamflow** are associated to **warm and wet extreme conditions** due to **High Pressure anomalies** in the east coast.

  2) The **increase of High Pressure anomalies** contributes to the increase in streamflow in January and a decrease in April**.**

- 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: