The influence of the Pacific Decadal Oscillation on annual floods in the rivers of Western Canada

Sunil Gurrapu\textsuperscript{1, 2}, Jeannine-Marie St. Jacques\textsuperscript{1, 2}, David J Sauchyn\textsuperscript{1, 2}, Kyle R Hodder\textsuperscript{1}

\textsuperscript{1} Department of Geography, University of Regina, Regina, S4S 0A2
\textsuperscript{2} Prairie Adaptation Research Collaborative (PARC)
INTRODUCTION

- Hydrological extremes
- Planning and Design of Infrastructure
- Flood Frequency Analysis (Design Flood)
- Assumes that Peak flows are independent and identically distributed (i.i.d)
Teleconnections

Western Canada

- Pacific Decadal Oscillation
  - Negative PDO produce wet years
- El Niño-Southern Oscillation
  - La Niña events produce wet years
Study Area

- **127** Flow Gauges
  - 119 Natural
  - 8 Naturalised
- 1905 - 2010
- Minimum **30** years
Data & Methods

DATA

- **Observed Streamflow**: Water Survey of Canada
- **Naturalised Streamflow**: Alberta Environment
- **PDO**: Joint Institute for the study of Atmosphere and Ocean (JISAO), University of Washington
- **SOI (ENSO)**: Climate Research Unit (CRU), University of East Anglia

METHODS

- Correlation Analysis
- Quantile-Quantile (Q-Q) Plots
- Permutation Test on Q-Q Plots
- Flood Frequency Analysis
- Flood Ratio
Correlations

- PDO vs Annual Peak Flows
- Spearman’s Rank based correlation
- **Negative**
Correlations

- ENSO (SOI) vs. Peak Flows
- Spearman’s Rank based correlation
- Positive

Statistical Significance:
- 0.01
- 0.05
- 0.1
- NS
- Negative Correlations
Q-Q Plots

Peak Flows (m$^3$ s$^{-1}$) in Negative PDO Phase

Peak Flows (m$^3$ s$^{-1}$) in Positive PDO Phase

08FF001
47 yrs

05AA008
69 yrs

05BB001
102 yrs
Significant Q-Q plots

Correlations: PDO vs. Peak Flow
Flood Frequency Curves

- PDO stratified Peak Flows
  - Pos.: 1926-46, 1977-2008

- Log-Pearson III (LP3) Fit

- 90 % Confidence Intervals
Flood Frequency Curves

- Overlapped Confidence Intervals
- Approx. 51% of gauges show either clear or partial separation
- Higher magnitude floods in negative PDO phase
Flood Ratio

\[
\text{Flood Ratio} = \frac{Q_{neg}}{Q_{pos}}
\]

\(Q_{neg}\) - Flood Quantile in Negative phase
\(Q_{pos}\) - Flood Quantile in Positive phase
Impacts

Statistical Significance
- 0.01
- 0.05
- 0.1
- NS

- Higher Peaks in Positive Phase
- Northern Gateway Pipeline
CONCLUSIONS

• **Flood risk** in western Canada is **modified by the PDO**

• The **stationary climate** assumption **not valid** in Western Canada

• **Large-scale climate** should be considered during infrastructure **planning and design**

• Regions with **strong teleconnection** to large-scale climate may be subject to **underestimation** of flood risk.

• The extent of this problem in others regions needs to be explored.