Investigating Techniques for Flood Quantile Estimation in Canada

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Outline of Presentation

1. Introduction
2. Flood frequency analysis
3. Regional analysis
4. Seasonality measure
5. Region of influence
6. Case study
7. Future work

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Introduction

- Effective mitigation requires reliable flood estimation
- Floods estimation: concerns the longer period of time
- Accurate estimation of probability of exceedance
- Requirement for design of flood protection infrastructure

Flood Frequency Analysis

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Flood Frequency Analysis

- Statistical method of estimation
- Studying past events
- Determine the probability of future occurrences
- Theoretical frequency distribution

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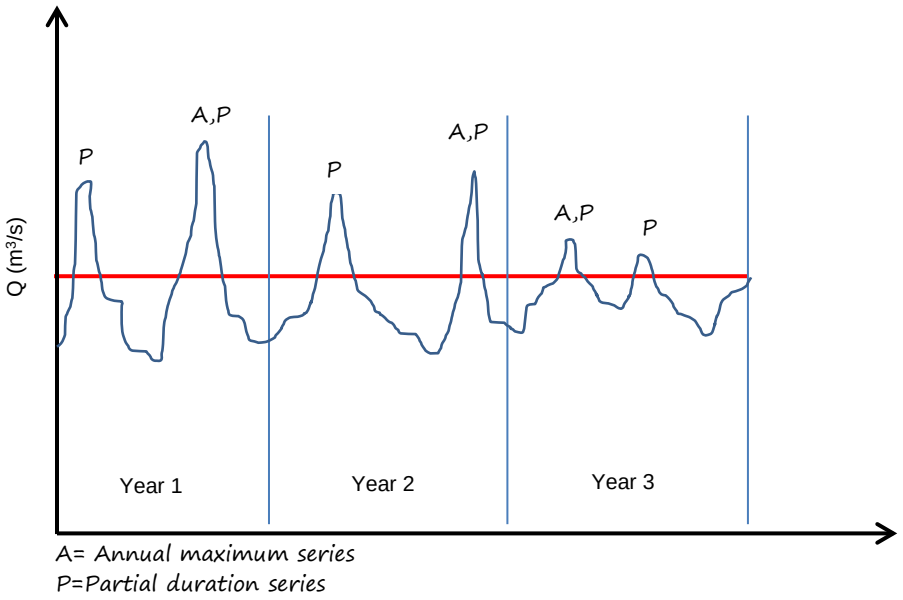
Flood Events

- Two types of flood series
- Annual maximum & peaks-over-threshold
- Advantages & disadvantages



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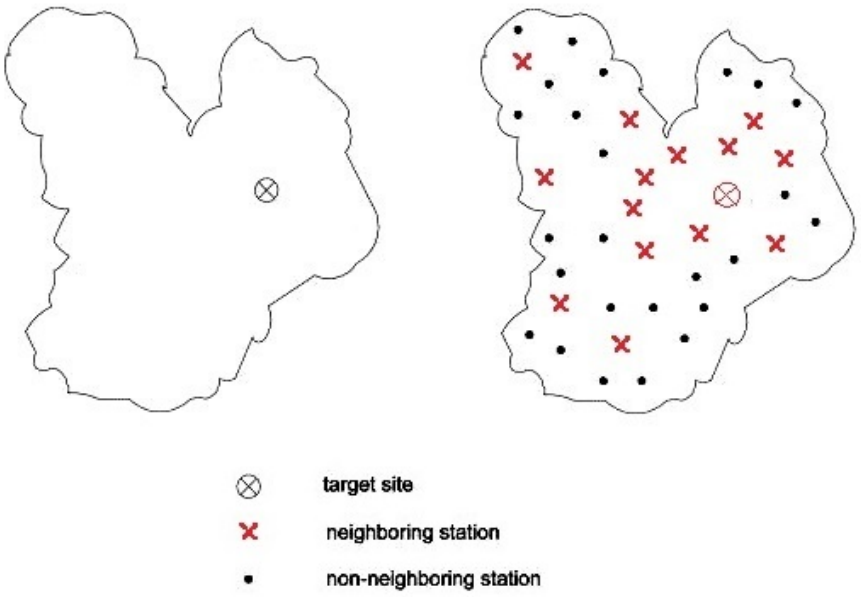
Flood Frequency Analysis

- At-site flood frequency analysis
- Reliable for sufficiently long flow records
- Insufficient gauging network/data record

Resolution: Trading space for time

Regional Frequency Analysis



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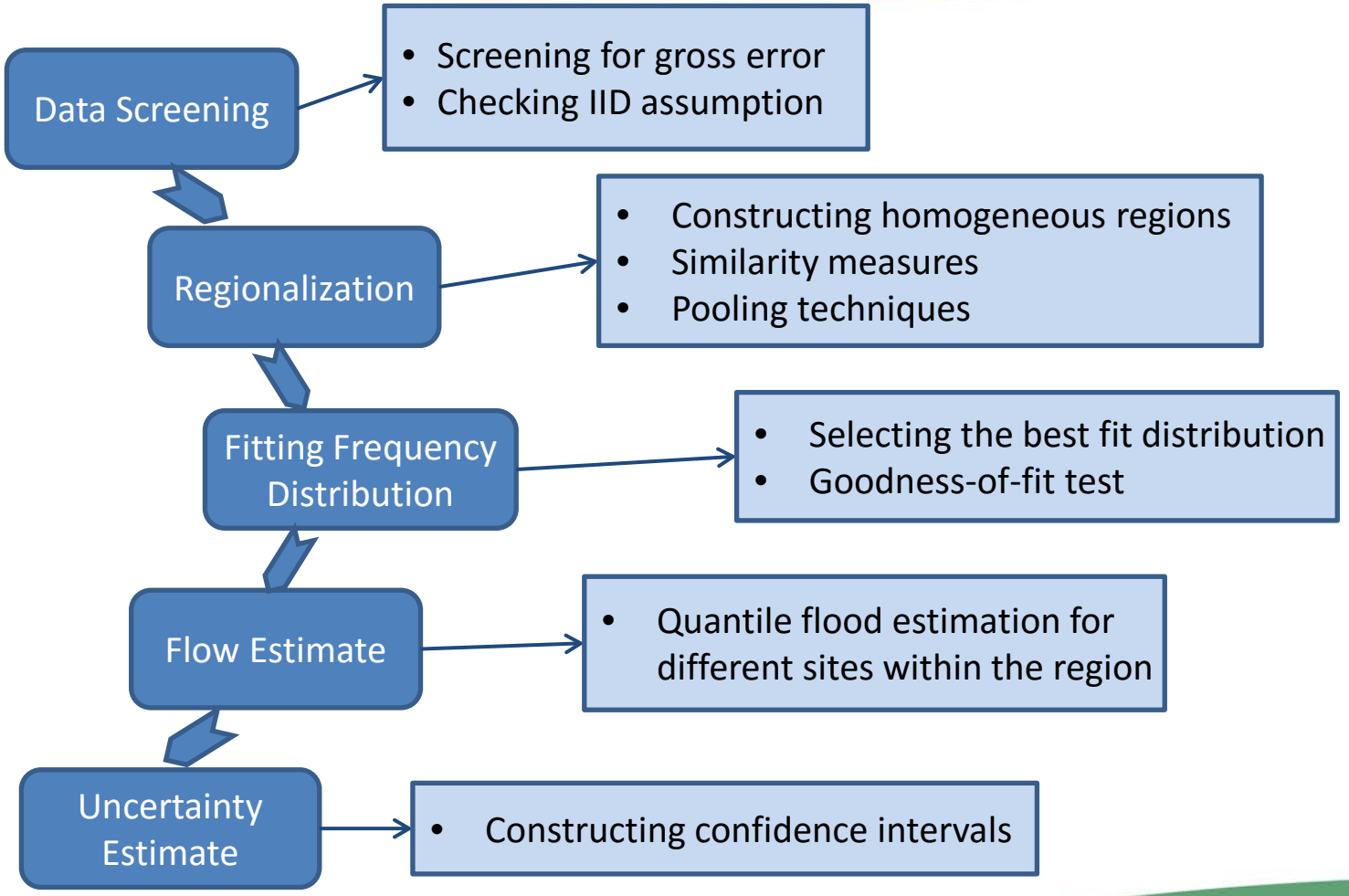
Regional Flood Frequency Analysis



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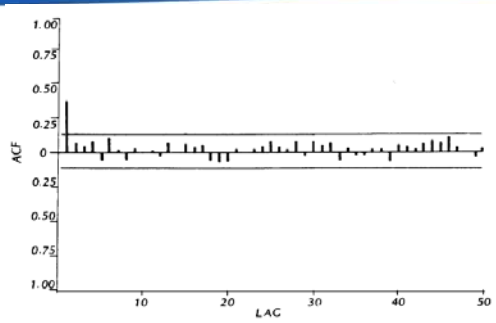
Regional Flood Frequency Analysis

- Data Screening
- Regionalization
- Fitting Frequency Distribution
- Flow Estimate
- Uncertainty Estimate

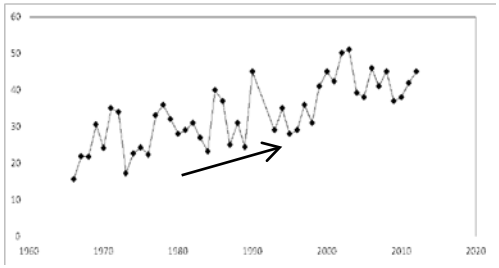
Examination of serial correlation

- Lag-one serial correlation
- Effects the power of trend detection
- Mitigate the impact of serial correlation



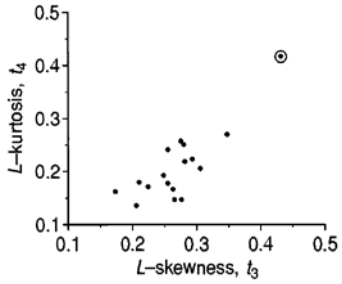
Temporal trend analysis: Mann-Kendall test

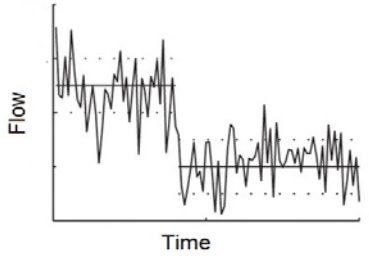
- Nonparametric rank-based test
- Significance of monotonic trend
- False trend detection in case of positive correlation
- Block bootstrap test/ resample data in block



Change-point detection

- Nonparametric rank-based test
- Sudden shift in the mean of data





Checking for gross errors

- Incorrect data values
- Outliers

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Regional Flood Frequency Analysis

Data Screening

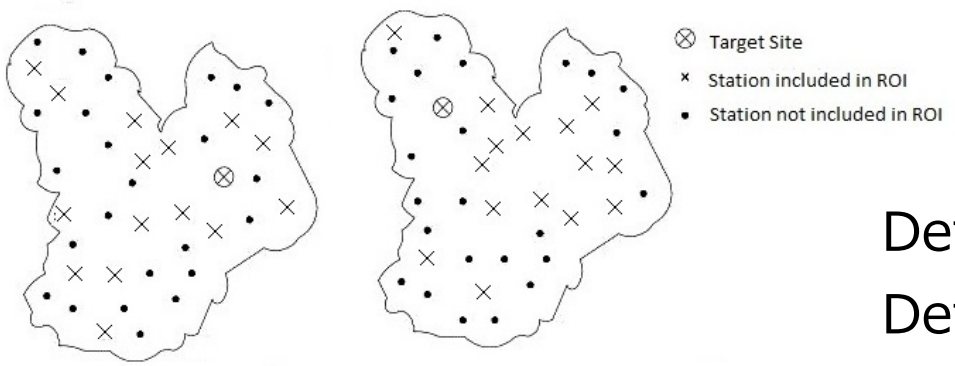
Regionalization

Fitting Frequency Distribution

Flow Estimate

Uncertainty Estimate

- Regionalization approaches
- Formation of homogenous regions
- Based on site focused approach
- Region of Influence approach (ROI)



Define similarity

Define cut-off point

Define weight

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Regional Flood Frequency Analysis

Data Screening

Regionalization

Fitting Frequency Distribution

Flow Estimate

Uncertainty Estimate

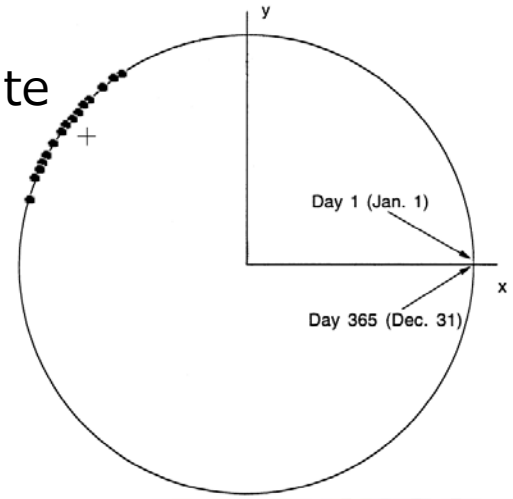
Similarity measure:
- physiographic characteristics
- flood statistics
- **flood seasonality**

Seasonality measure:

- Julian date of peak flow event *i*
- Converted to angular value
- Calculate coordinates of mean flood date

$$\theta_i = (Julian\ Date)_i \frac{2\pi}{365}$$

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} \cos(\theta_i) \quad \bar{y} = \frac{1}{n}\sum_{i=1}^{n} \sin(\theta_i)$$



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Regional Flood Frequency Analysis

Data Screening

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Fitting Frequency Distribution

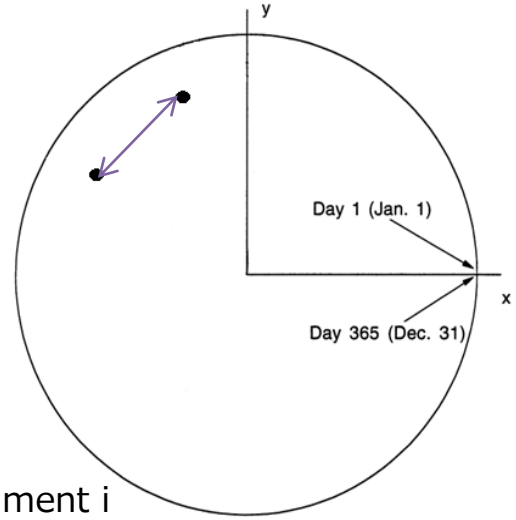
Flow Estimate

Uncertainty Estimate

Similarity measure:

- Distance metric (Euclidian distance)
- Defining closeness of each station to every other
- Seasonality measure is employed in defining similarity between sites

$$d_s^{ij} = [(\bar{x}_i - \bar{x}_j)^2 + (\bar{y}_i - \bar{y}_j)^2]^{0.5}$$



d_s^{ij} is the dissimilarity between catchment i and j

$\bar{x}_i$, $\bar{y}_i$ are the coordinated of the mean flood date for catchment i

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Regional Flood Frequency Analysis

Data Screening

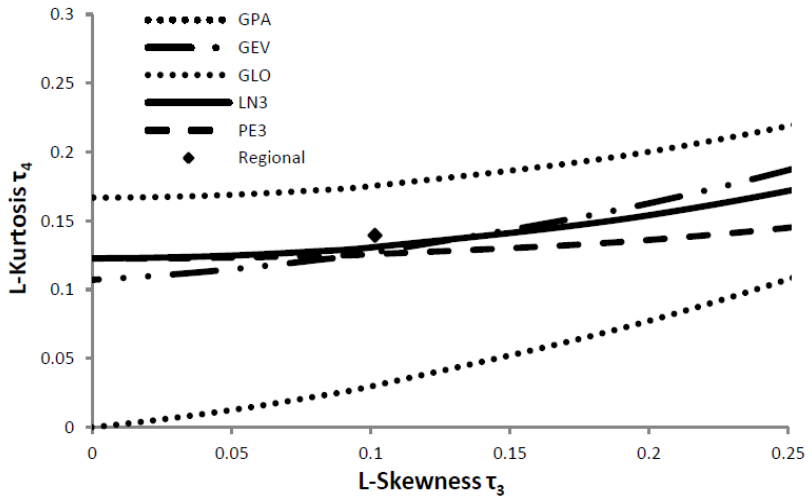
Regionalization

Fitting Frequency Distribution

Flow Estimate

Uncertainty Estimate

- Using the L-moments approach
- Check goodness-of-fit test
- Compare fit of different distributions to regional average
- Select best fitted regional distribution



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Regional Flood Frequency Analysis

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Fitting Frequency Distribution

Flow Estimate

Uncertainty Estimate

- Approach based on index-flood
- Flow quantile at each site
- Product of pooled quantile and index flow

$$Q_i(F) = \mu_i q(F)$$

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Regional Flood Frequency Analysis

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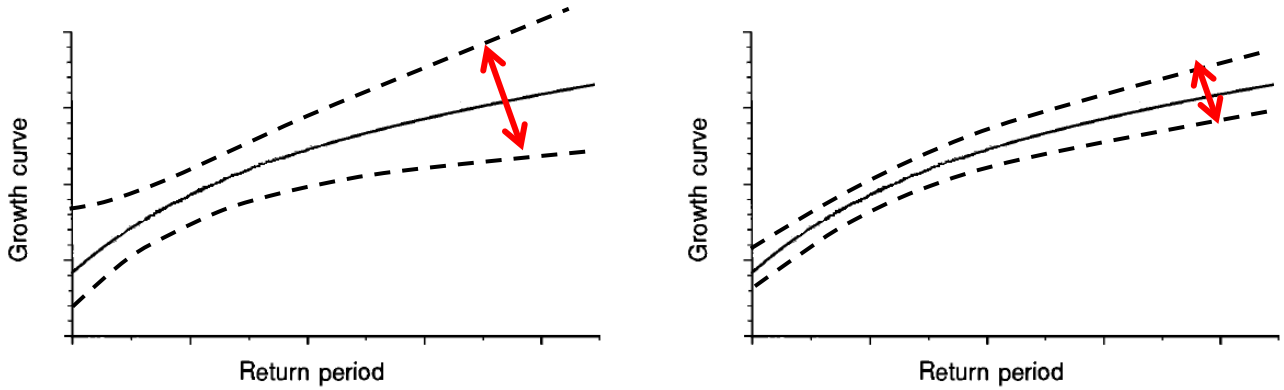
Fitting Frequency Distribution

Flow Estimate

Uncertainty Estimate

Estimating quantile uncertainty:

- Based on confidence interval for quantile estimates
- Bootstrap approach was used
- For both at-site and pooled quantiles
- Narrower CI, lower uncertainty



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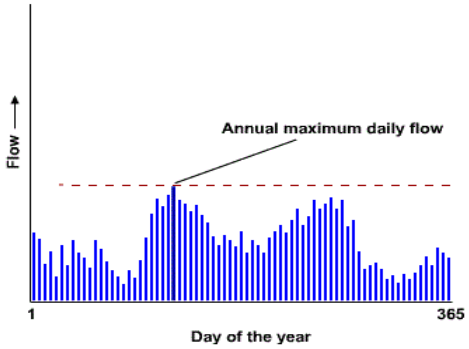
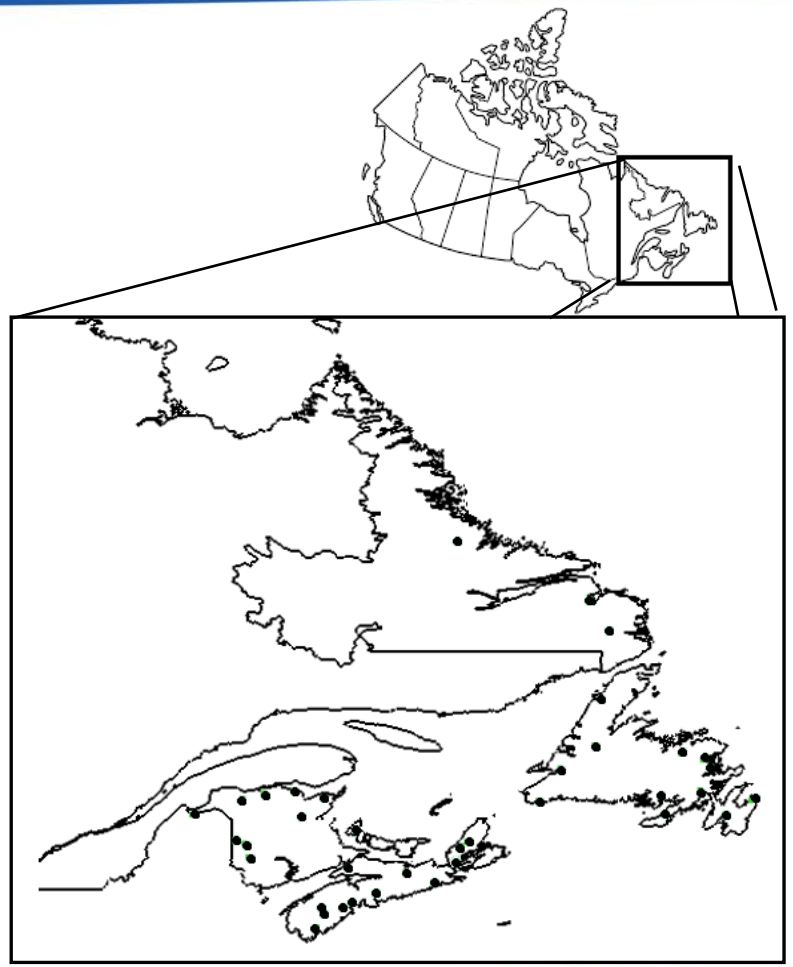
Case Study

- 45 Hydrometric stations- RHBN sites
- Minimum 30 years of recorded flows
- Active and continuous
- No missing flows
- 31 to 97 years range of records





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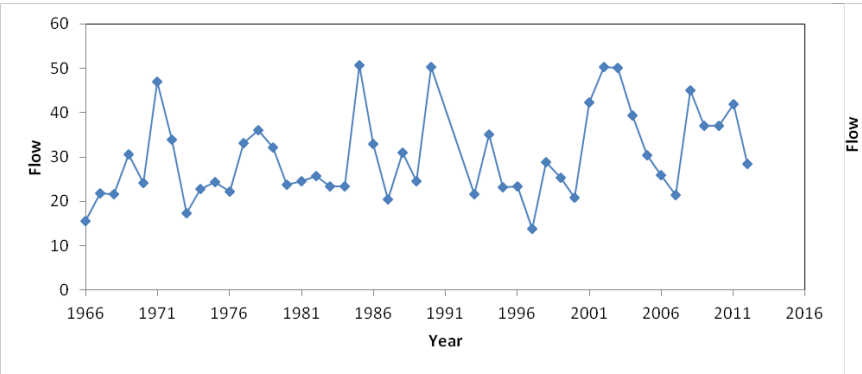
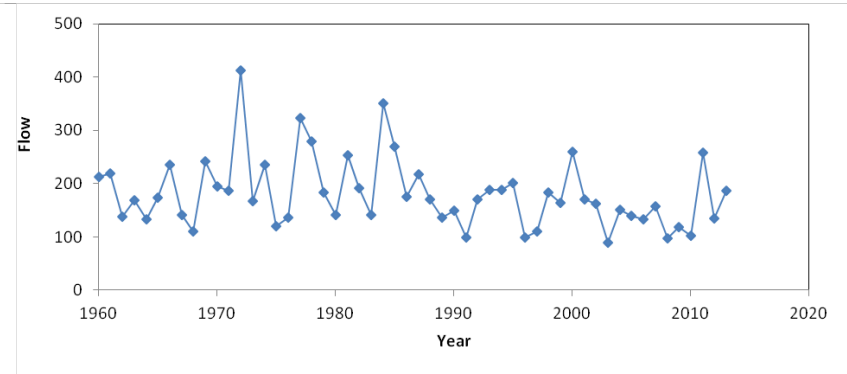
Case Study

- Performed Pettitt test for change point analysis
- Trends in data were examined
- Two sites exhibited trend in their data series





Nonstationarity analysis should be performed for these sites

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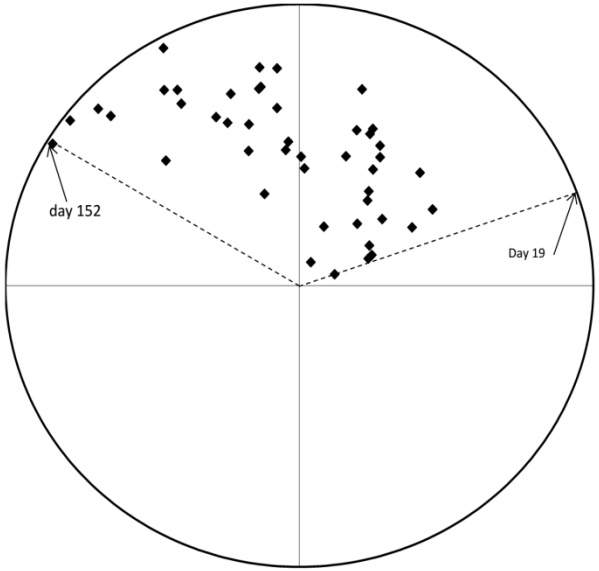
Case Study

Steps in the analysis:

- ✓ Seasonality measures estimated for each site
- ✓ Euclidian distance was used to define dissimilarity between sites
- ✓ Sites were arranged in descending similarity order

Seasonality space representation of the gauging stations



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Case Study

Steps in the analysis:

- ✓ for each target site the first 25 similar sites were identified
- ✓ Initial ROI for the target site
- ✓ Homogeneity of ROI was checked
- ✓ Heterogeneous ROIs were revised
- ✓ Most discordant sites were sequentially removed
- ✓ Homogeneity of ROI was reevaluated

Case Study

Identified ROIs for each catchment:

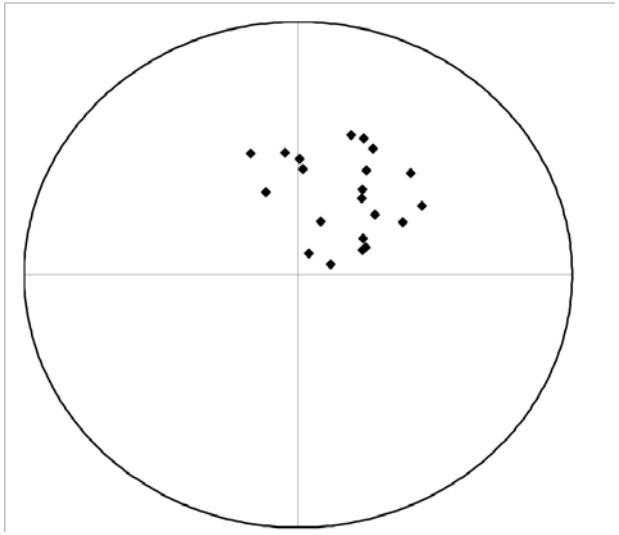
- ✓ 33 homogenous ROIs
- ✓ 9 possibly heterogeneous ROIs

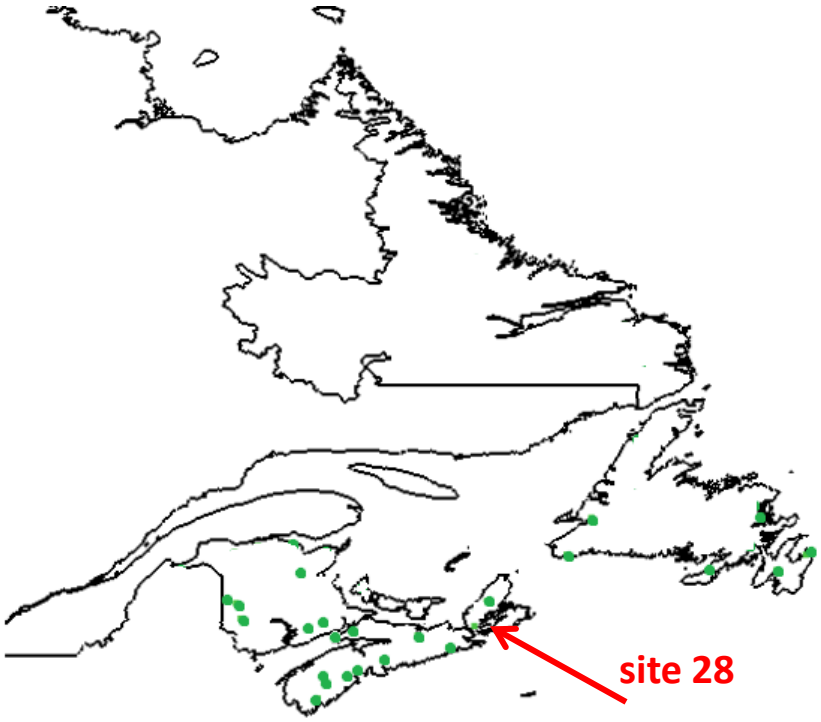
Regional distribution fitting:

- ✓ 21 ROIs with GLO
- ✓ 10 ROIs with GEV
- ✓ 11 ROIs with GNO

Case Study

Region of Influence for site 28 (most heterogeneous region):





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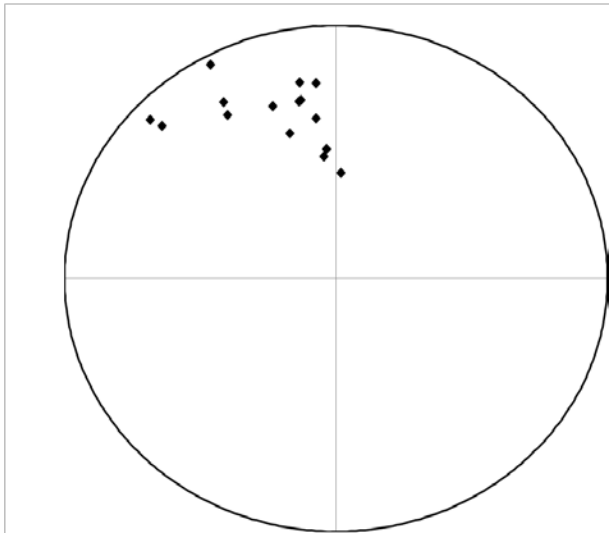
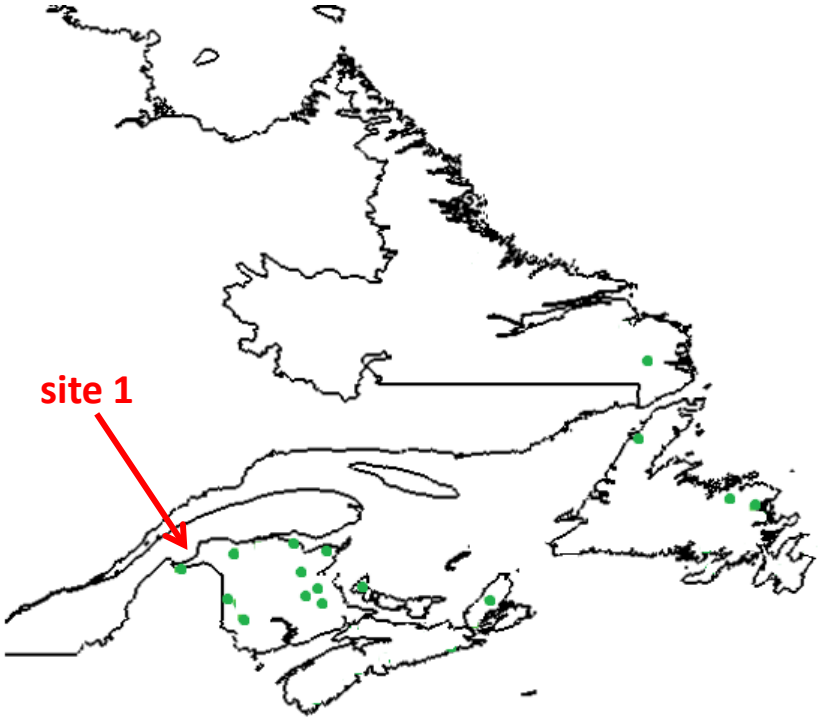
Case Study

Region of Influence for site 1(most homogeneous region):





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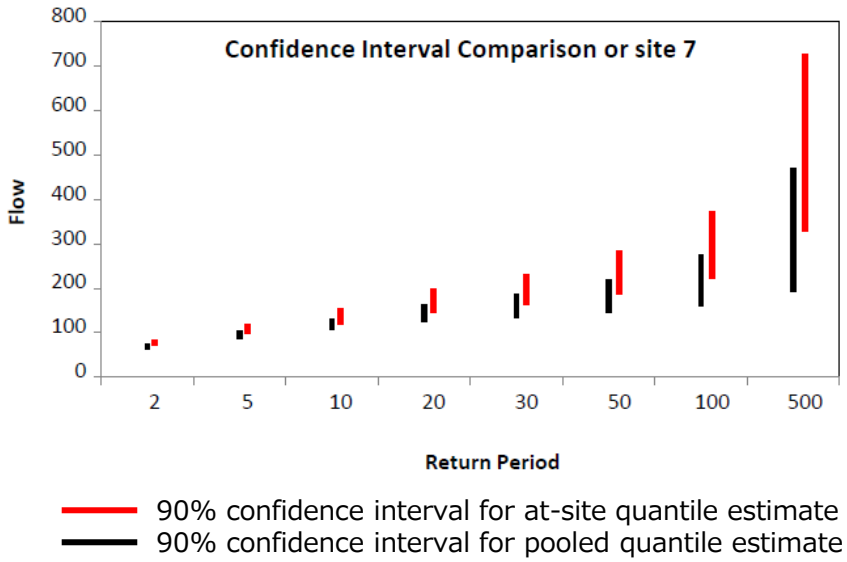
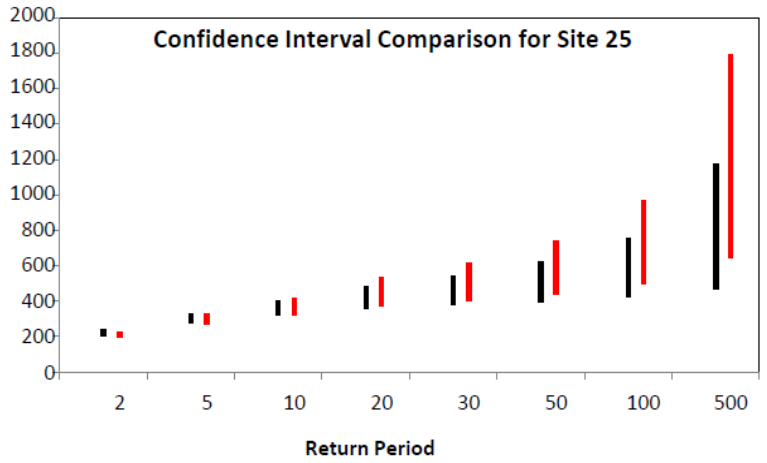
Case Study

Quantile estimation and confidence interval comparison:

- For both at-site and regional quantile estimates
- Width of 90% confidence interval





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Case Study

Future work:

- Using different distance metrics to define dissimilarity
- Using different metric as seasonality measure
- Expand the study for different locations across Canada
- Performing regional analysis using POT series
- Conducting pooled nonstationarity analysis

Thank You

Questions

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