Stochastic Modeling of Daily Rainfall Process in a Non-Stationary Context

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Outline

- **Objective:** Stochastic Modeling of Extreme Rainfall Events
- **Methodology:** Stochastic Approach: MCME model
  - **Results**
- **Future work:**
  - **Linking with Climate Variables**
- **Conclusion**

Objective

Stochastic Modeling of Daily Rainfall Processes in a Non-Stationary Context

- **Stochastic Approach**
  - Another modelling technique besides the statistical approach
- Will take full daily rainfall series as input
  - Will generate accurate synthetic series

METHODOLOGY

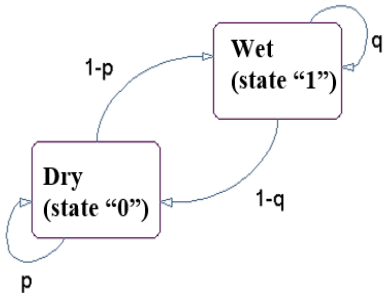
Stochastic Approach: MCME model

MCME model

- MCME = Markov Chain Mixed Exponential

- 2 components:
  - 1) **Rainfall Occurrence:** Markov chain
  - 2) **Rainfall Amount:** Mixed Exponential Distribution

1st order 2-state Markov Chain



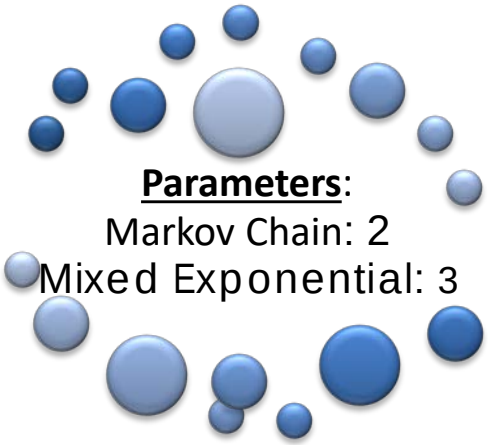
Mixed Exponential Distribution

$$f(x) = \left(\frac{p}{\mu_1}\right) e^{-x/\mu_1} + \left(\frac{1-p}{\mu_2}\right) e^{-x/\mu_2}$$

$$\begin{cases} x > 0 \\ p: mixing\ probability; 0 < p < 1 \\ \mu_1: scale\ parameter; 0 < \mu_1 < 30 \\ \mu_2: scale\ parameter;\ 0 < \mu_1 < \mu_2 \end{cases}$$

- Seasonality variation accounted by **Fourier Series**
- The **Shuffled Complex Evolution (SCE)** technique was used for global optimization of the maximum likelihood

MCME model



MCME model

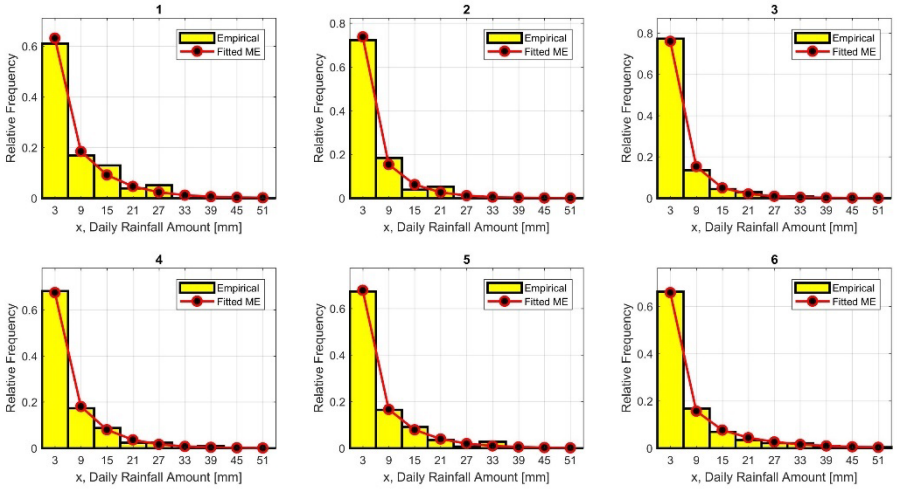
Similar statistical properties as the observed series

Observed Series

100 Synthetic Series

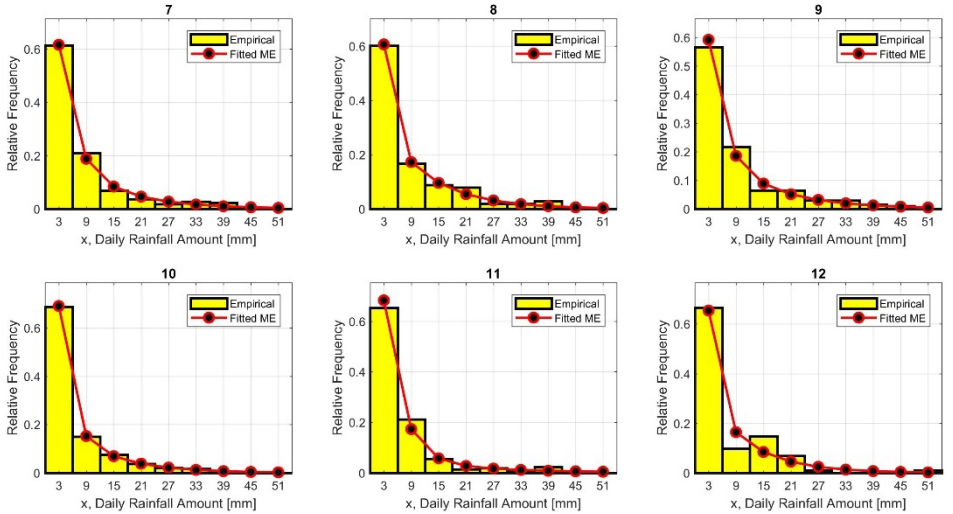
Results

Monthly histograms of the observed series with the fitted theoretical mixed exponential distribution

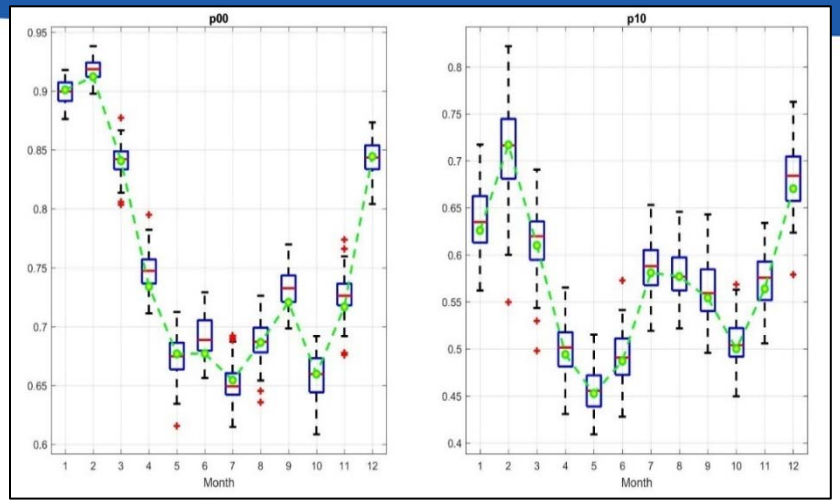


Dorval Station

Observed data: 31-year daily data; 1985-2015

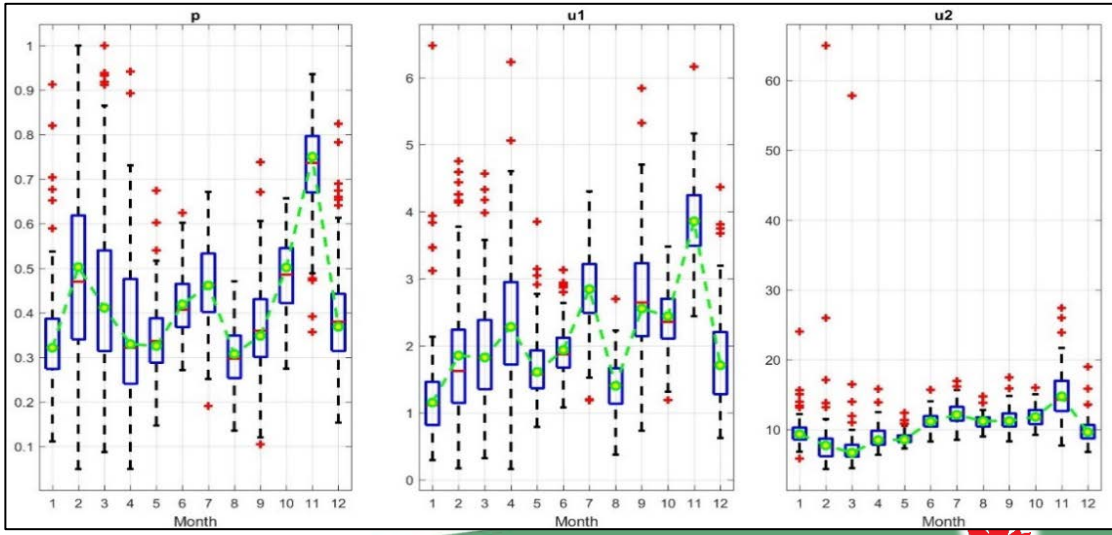


Results
Monthly boxplots of parameters variation



Markov chain parameters

Mixed Exponential parameters

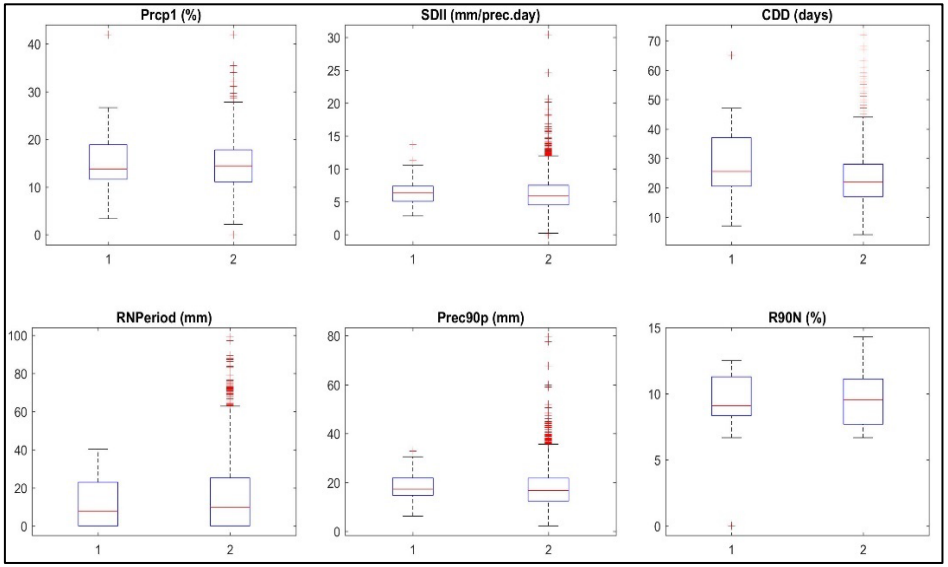


MCME model
Model Evaluation

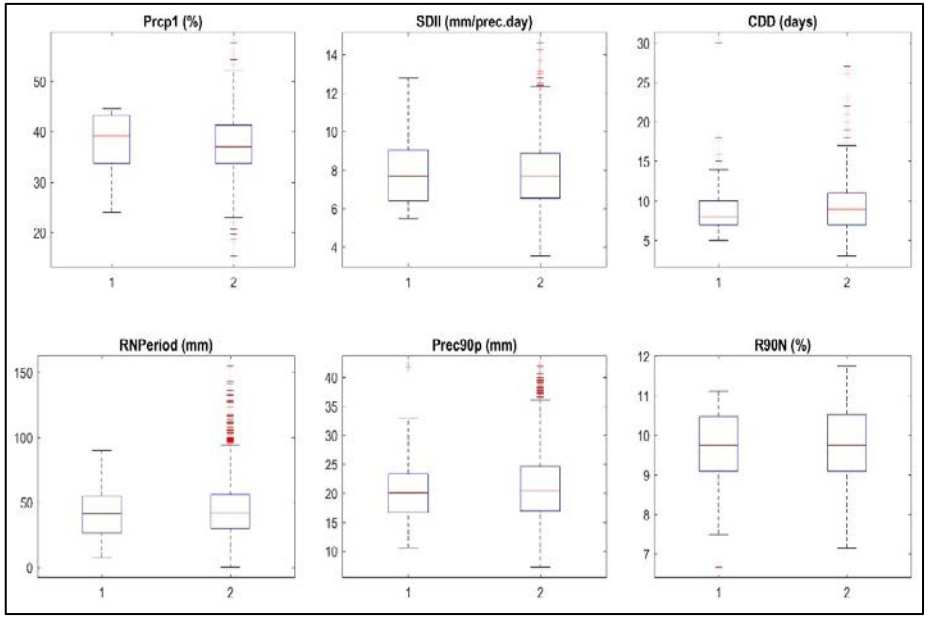
Rainfall Property	Index	Definition	Unit
Frequency	Prcp1	Percentage of wet days (Threshold≥1 mm)	%
Intensity	SDII	Mean precipitation amount at wet days	mm
Extremes	CDD	Maximum number of consecutive dry days	days
	R3Days	Maximum 3-days precipitation total	mm
	Prec90p	90^{th} percentile of rain day amount	mm
	R90N	% days with precipitation > 90^{th} percentile	%

(Gachon et al., 2005)

Results
Model Evaluation



Winter indices- 1: Observed – 2: Simulated



Summer indices- 1: Observed – 2: Simulated

FUTURE WORK

Linking with Climate Variables

Future Work

- One statistical downscaling technique:

  Stochastic Weather Generators

  - Example**: LARS-WG**
    - Generates **synthetic daily time series** of climate variables, statistically identical to the observed series, taking into account $\Delta change$ between the **baseline period** and the selected **future period**

- **Future Challenges**:
  - Linking MCME with Global Climate Models
  - Comparing with LARS-WG
  - But, how to account for **non-stationarity**??

Conclusion

- Main Objective:
  - **New Methodologies for Updating IDF curves**
- The **stochastic approach** is adopted
- The MCME is developed to generate synthetic rainfall series statistically identical to the observed ones
- Including the **climate variables** in the MCME model will help taking into consideration **the climate change**

THANK YOU!

Questions?