Characterization of precipitation time series using copulas: the case of the Jakarta Observatory and proposal for YMC

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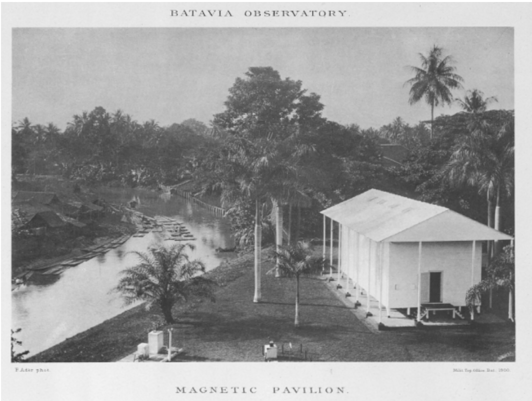
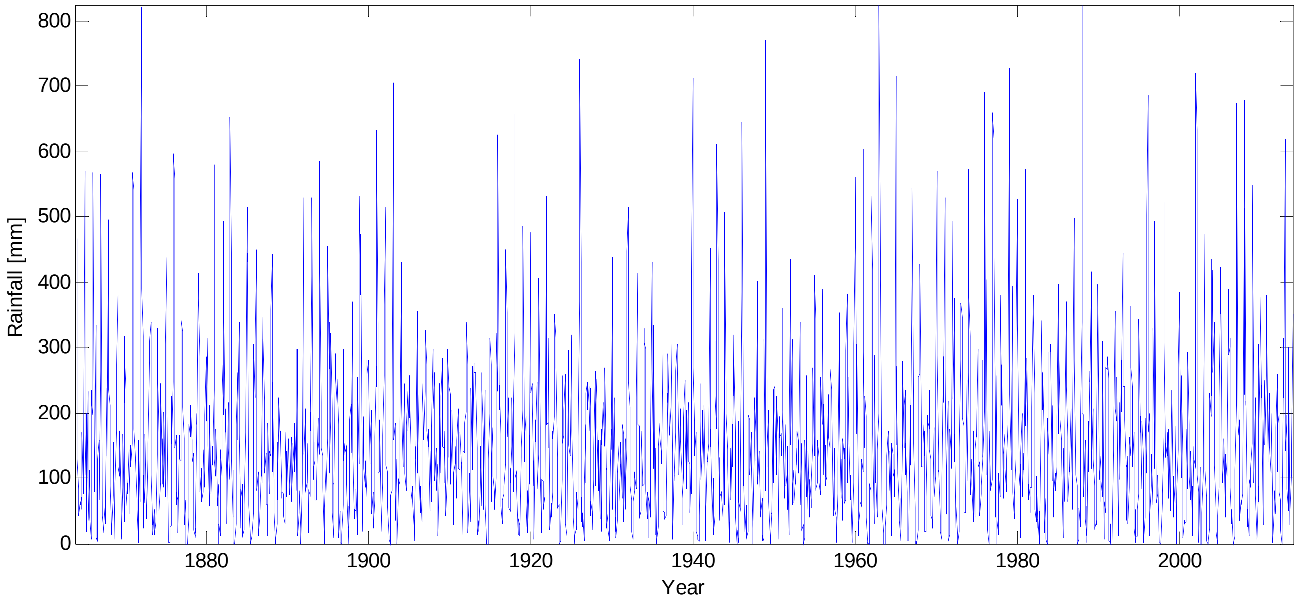
Contents

Idea: characterizing wet events using bivariate distribution approach: severity and intensity

Data for this study





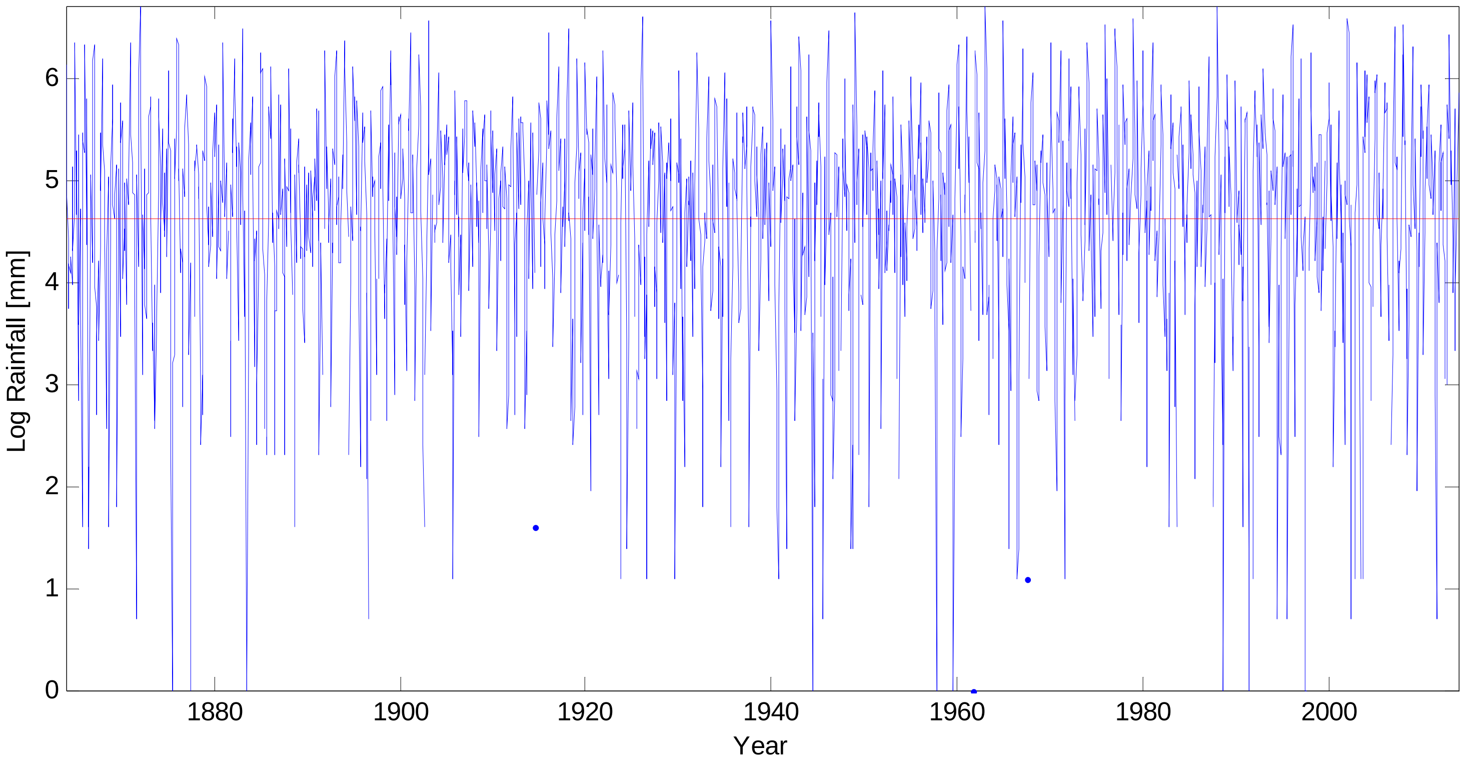
Time series for this study:

Monthly data from 1864 – 2013
[150 years]

Homogeneity

Homogeneity testing was carried out using the **Penalized Maximal F-test** method with RHtestV4 from Wang et.al.

The testing **finds no inhomogeneity** of the (log-transformed) monthly precipitation values.

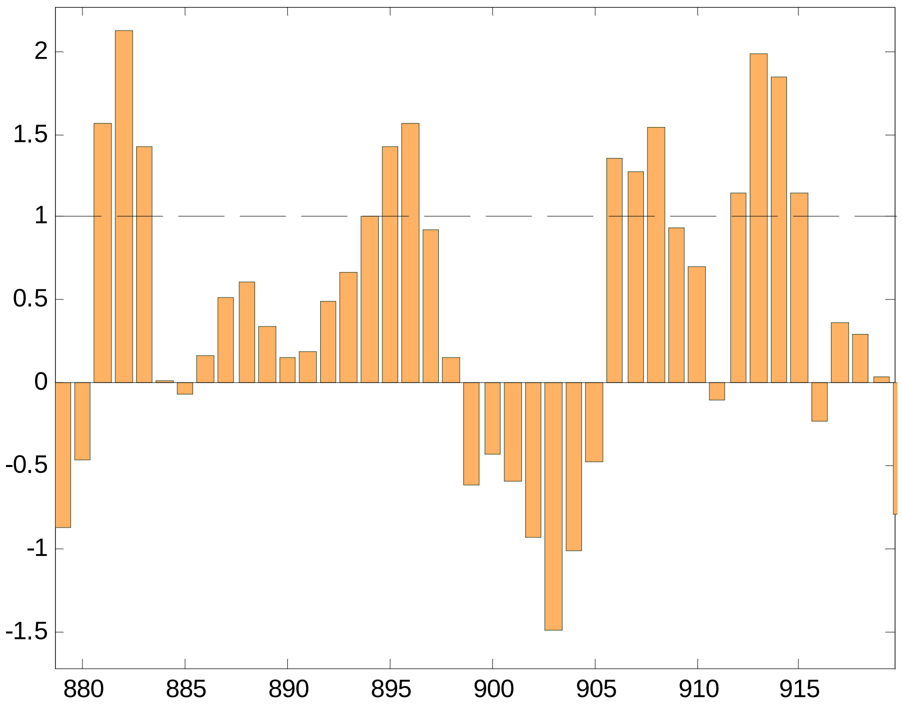


SPI category & characteristics of wet months

SPI value range	Category
SPI > 2	Extremely wet
1.5 < SPI <2	Severely wet
1 < SPI <1.5	Moderately wet
-1< SPI <1	Normal
-1.5 < SPI < -1	Moderately dry
-2 < SPI < -1.5	Severely dry
SPI < -2	Extremely dry

McKee, 1993

In this study we are interested to study the **characteristics of wet months**, with SPI > 1, for two periods:
Period1: 1864 – 1963, and
Period2: 1964 – 2013



Definitions of wet characteristics

Wet event: months with SPI > 1

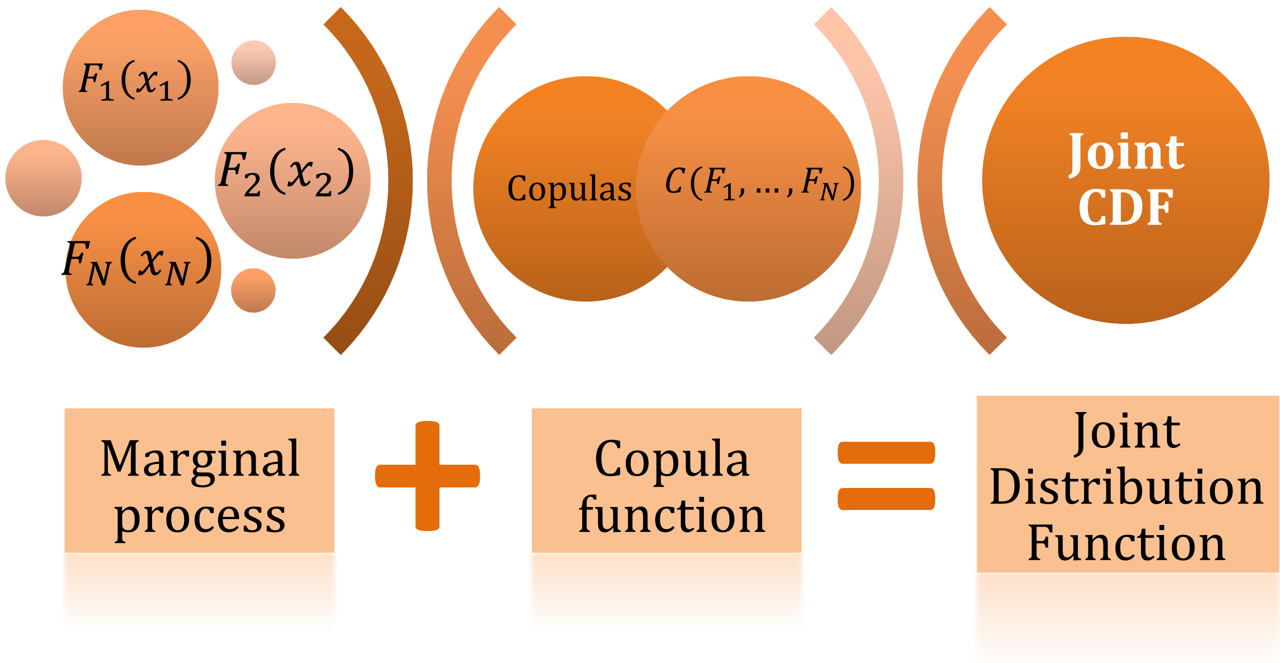
Duration of a wet event:
number of months with SPI > 1

Severity of a wet event:
Sum of SPI values, each SPI > 1

Intensity of a wet event:
Severity/Duration

"COUPLING" of Severity – Duration – Intensity:

Copulas are mapping functions that capture the dependence structure among random variables, by joining marginal distributions



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Case study of Jakarta

- Considers the wet episodes from SPI3 distributions of the months DJF
- Characterize severity, duration, intensity, return period, (conditional) probabilities for two different periods: **1864-1963** and **1964-2013**

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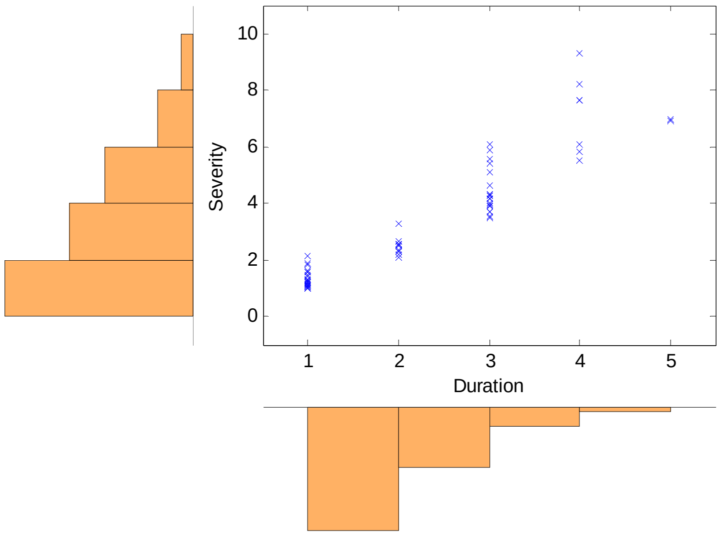
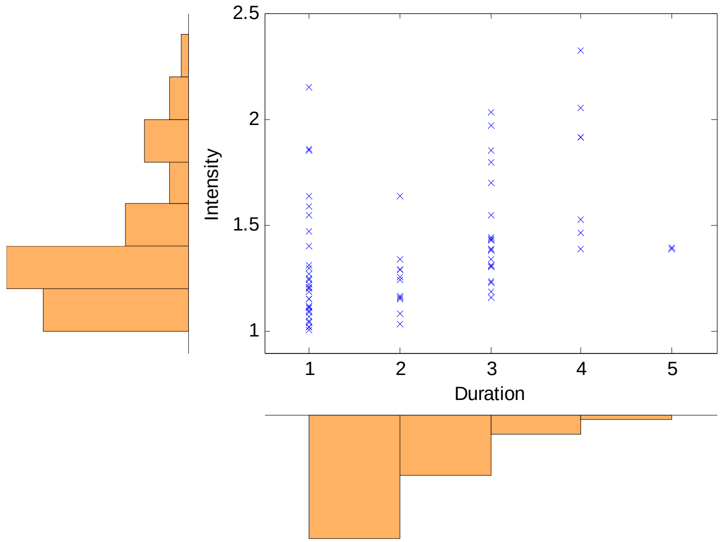
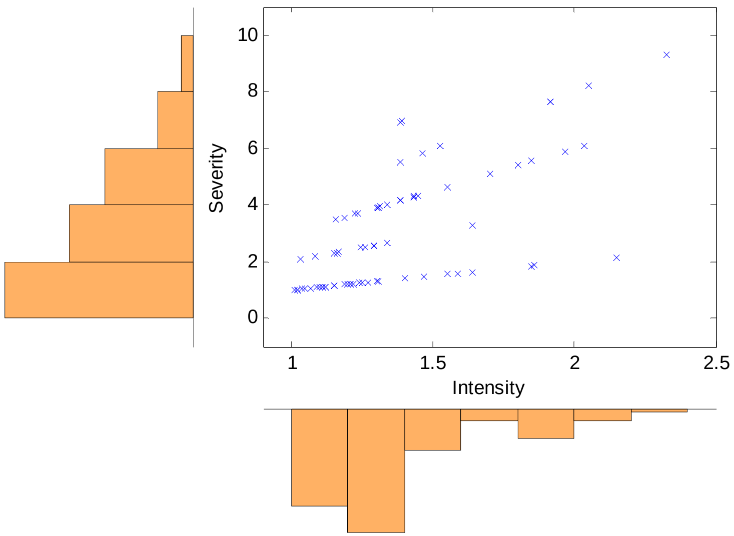
Scatterplot and histogram of duration, severity and intensity







Period: **1864 - 1963**

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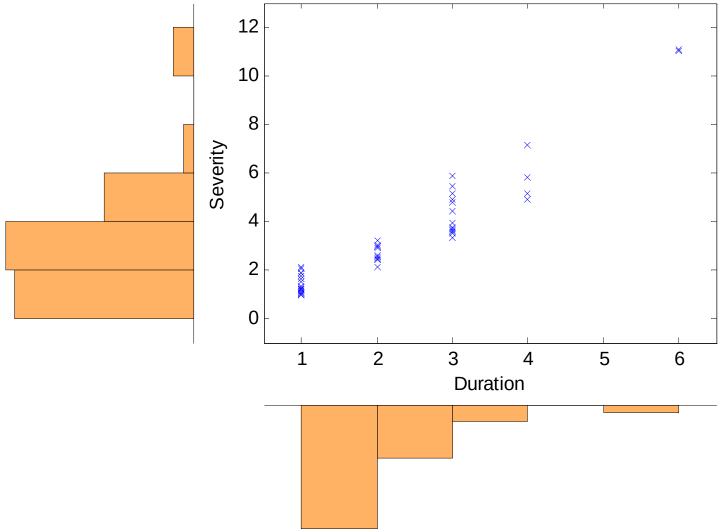
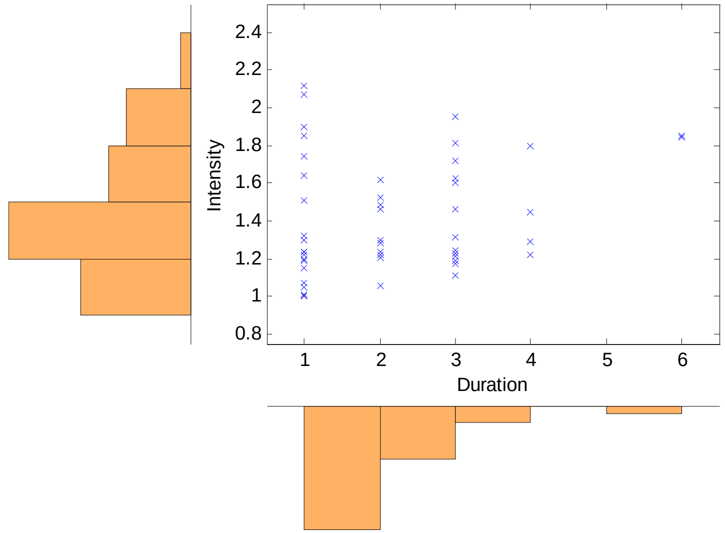
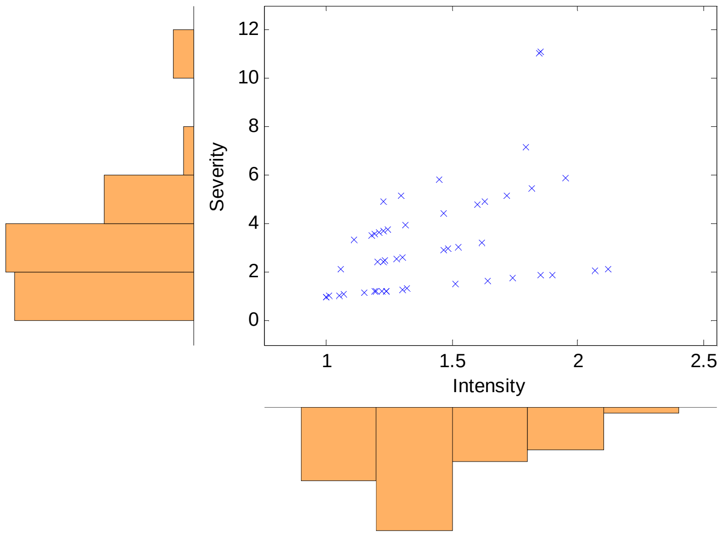
Scatterplot and histogram of duration, severity and intensity





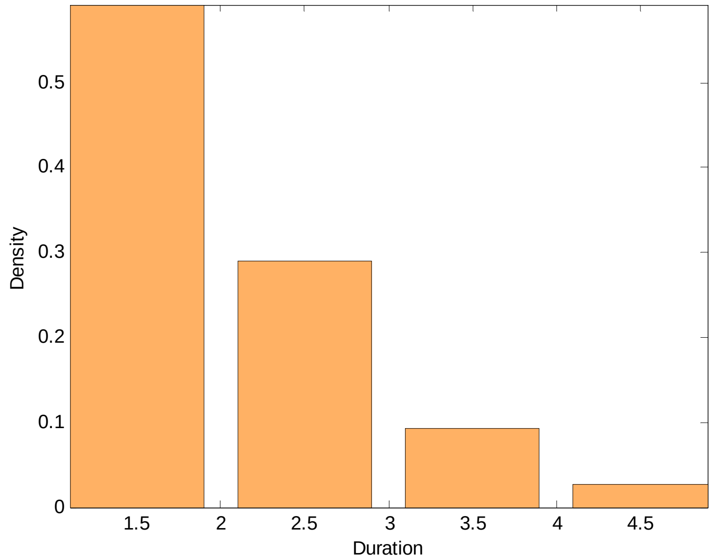


Period: **1964 - 2013**

Marginals fitting

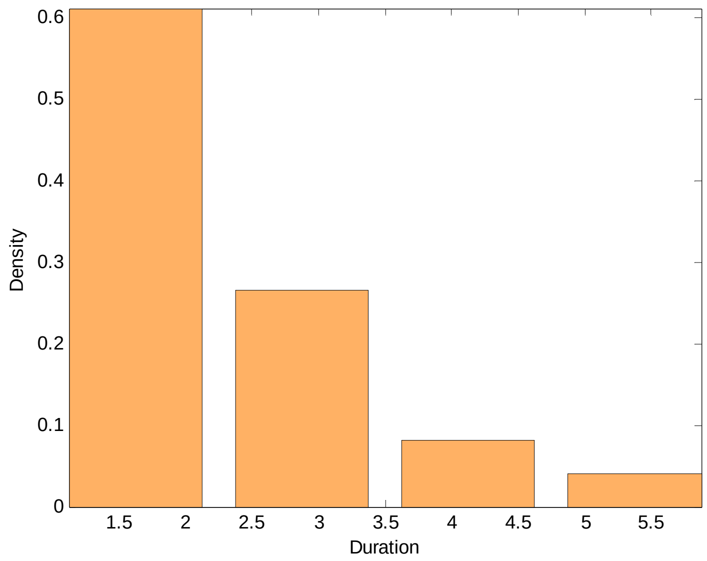
Duration 1864 - 1963

Marginal Distribution	MLE's Parameters	Log-likelihood
Exponential	$\mu = 2.118$	-133.05
Weibull	a = 2.405; b = 1.960	-111.53
Gamma	a = 3.421; b = 0.619	-110.18
Log-normal	**$\mu = 0.597$; $\sigma = 0.563$**	**-109.16**



Duration 1964 - 2013

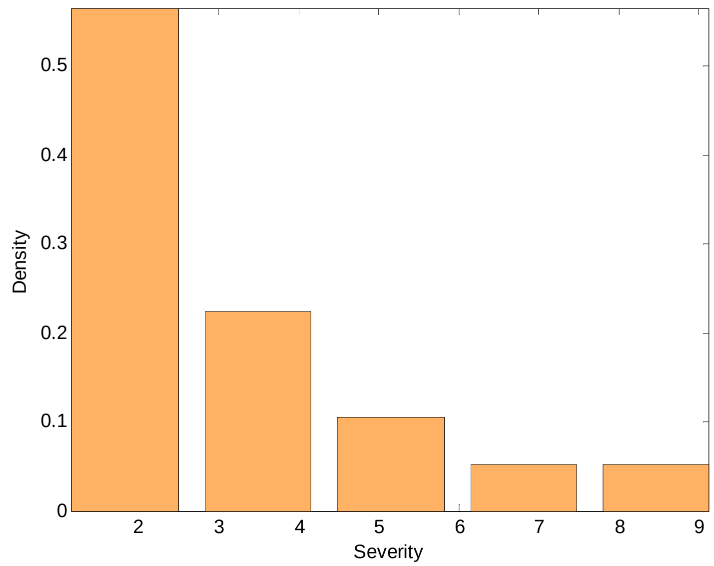
Marginal Distribution	MLE's Parameters	Log-likelihood
Exponential	$\mu = 2.183$	-87.26
Weibull	a = 2.475; b = 1.846	-75.26
Gamma	a = 3.247; b = 0.672	-75.50
Log-normal	**$\mu = 0.619$; $\sigma = 0.574$**	**-72.16**



Marginals fitting

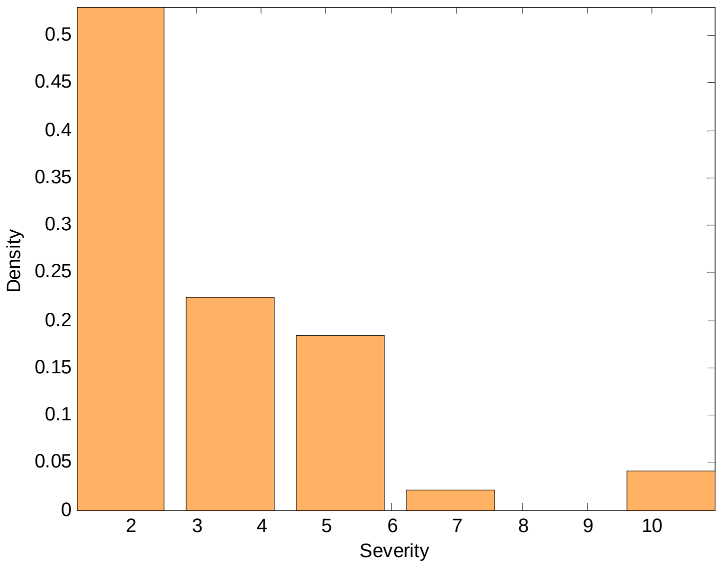
Severity 1864 - 1963

Marginal Distribution	MLE's Parameters	Log-likelihood
Exponential	μ = 3.062	-161.05
Weibull	a = 3.439; b = 1.586	-149.92
Gamma	a = 2.392; b = 1.279	-148.00
Log-normal	**μ = 0.895; σ = 0.675**	**-145.59**



Severity 1964 - 2013

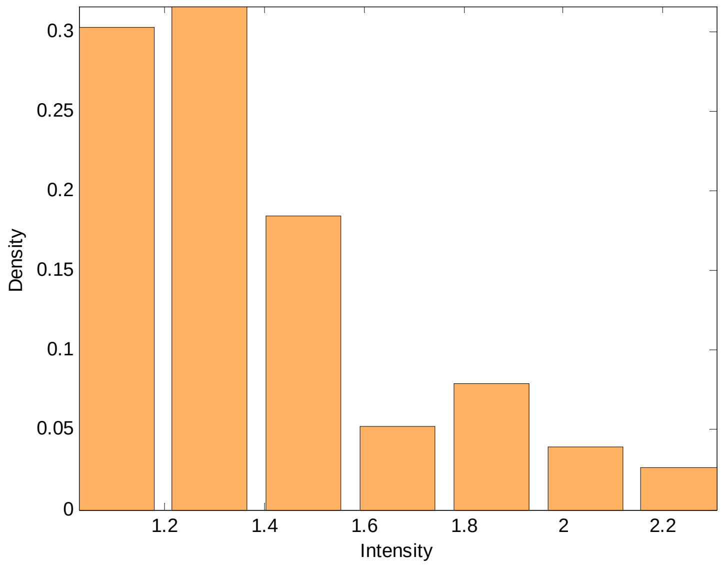
Marginal Distribution	MLE's Parameters	Log-likelihood
Exponential	μ = 3.182	-69.04
Weibull	a = 3.439; b = 1.586	-149.92
Gamma	a = 3.581; b = 1.631	-63.63
Log-normal	**μ = 0.955; σ = 0.651**	**-61.75**



Marginals fitting

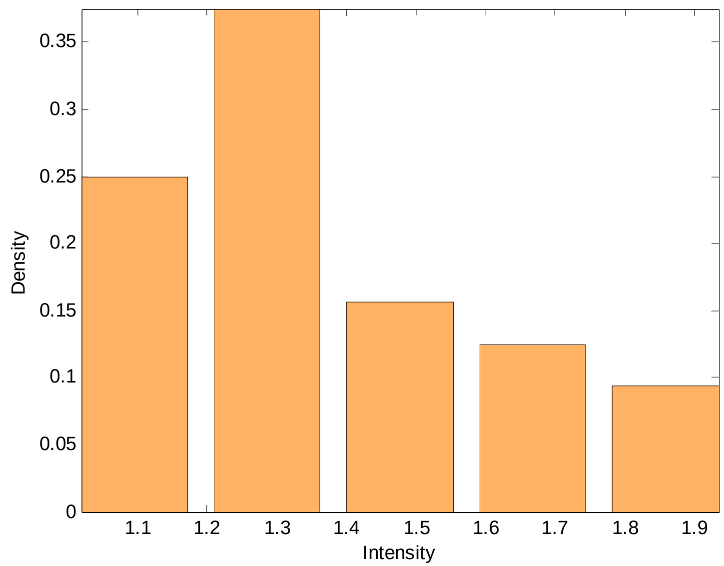
Intensity 1864 - 1963

Marginal Distribution	MLE's Parameters	Log-likelihood
Exponential	μ = 1.391	-166.27
Weibull	a = 1.514; b = 4.655	-33.18
Gamma	a = 23.796; b = 0.058	-18.77
Log-normal	**μ = 0.309; σ = 0.202**	**-15.93**



Intensity 1964 - 2013

Marginal Distribution	MLE's Parameters	Log-likelihood
Exponential	μ = 1.354	-41.69
Weibull	a = 1.460; b = 5.540	-2.66
Gamma	**a = 31.401; b = 0.043**	**-0.38**
Log-normal	$\boldsymbol{\mu}$ = 0.287; $\boldsymbol{\sigma}$ = 0.179	-0.83



Return period

Return period of certain wet event usually associates with a specified exceedence probability.

Joint return period for duration and severity can be characterized in two cases:

Return period for $D \geq d$ AND $S \geq s$

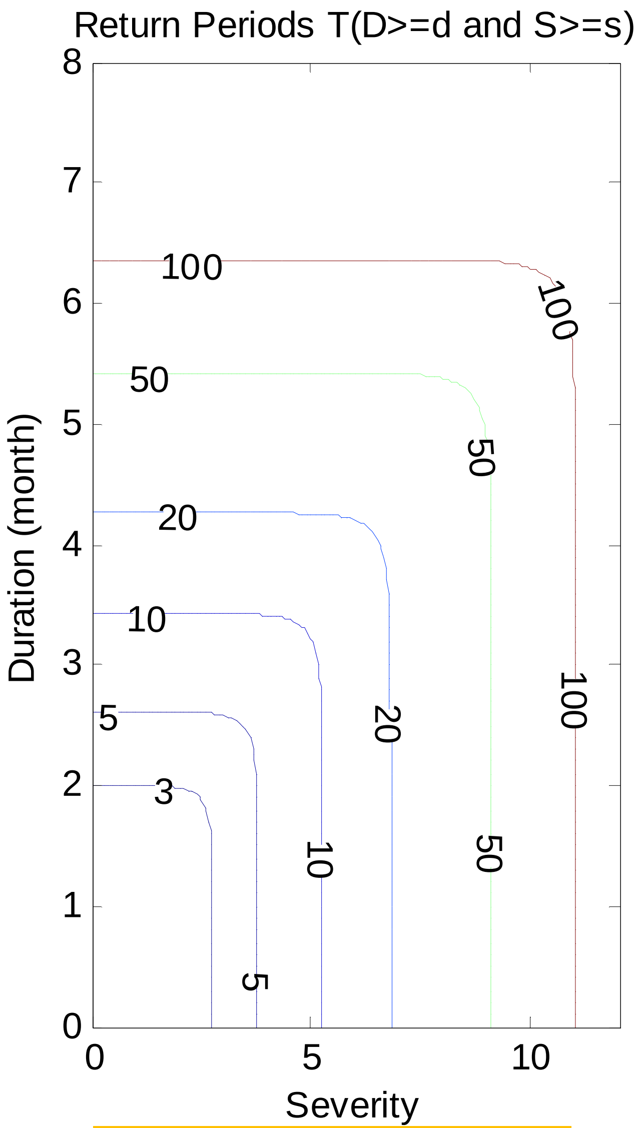
- $$T_{DS} = \frac{E(L)}{P(D \geq d, S \geq s)} = \frac{E(L)}{1 - F_D(d) - F_S(s) + C(F_D(d), F_S(s))}$$

Return period for $D \geq d$ OR $S \geq s$

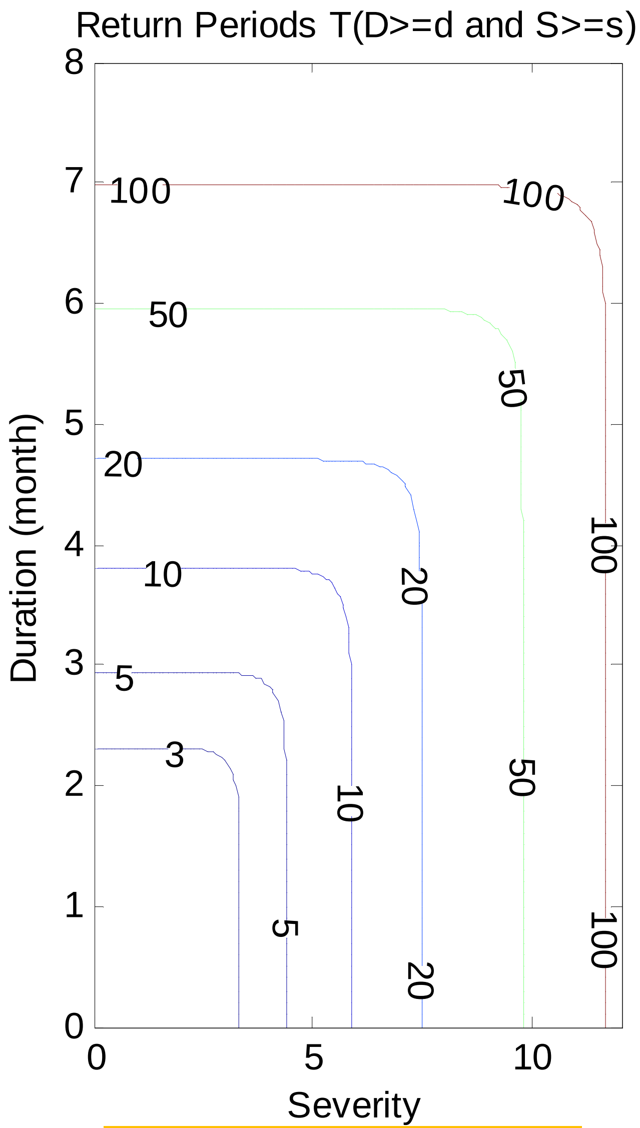
- $$T'_{DS} = \frac{E(L)}{P(D \geq d \ OR \ S \geq s)} = \frac{E(L)}{1 - C(F_D(d), F_S(s))}$$

Shiau, 2006

Return period for $D \geq d$ AND $S \geq s$



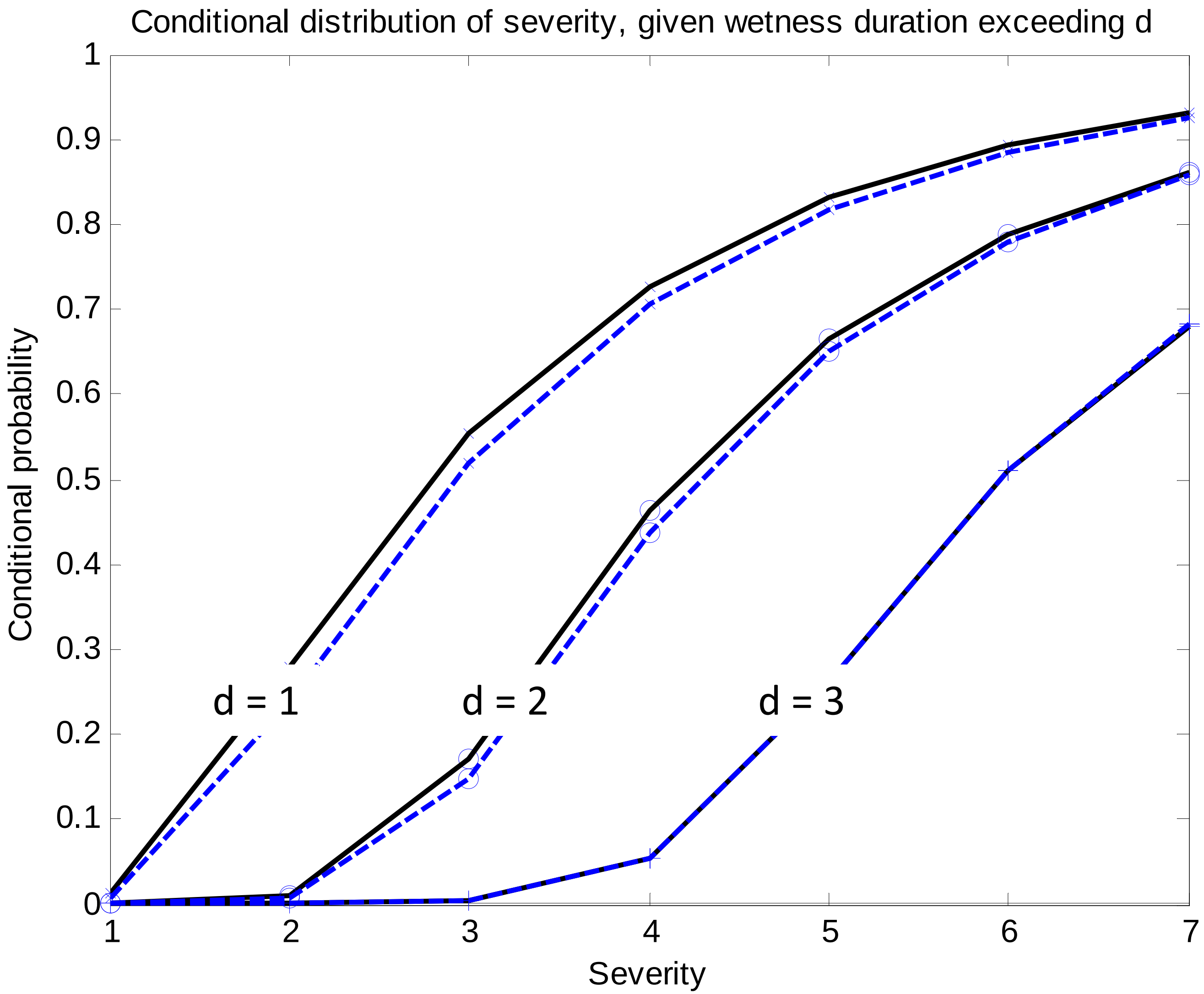
Period: 1864 - 1963



Period: 1964 - 2013

Using Gumbel copula

Conditional probability



For the same value of probability, and a given duration, **severity of wet events are increasing** for the period of **1964 – 2013** compared to the period **1864 – 1963**.

Black: 1864 – 1963

Blue: 1963 - 2013

Conclusions and remarks

- Copula based approach makes it possible to create joint (bivariate) distribution from predetermined marginals.

- Characterization of wet events in terms of their joint distribution was presented. The characterization was done for two different periods, 1864 – 1963 and 1964 – 2013.

- Result shows that for the latter period, for a fix probability of occurrence of a prescribed wet event duration, the severity increases, compared to the former period.

- This means that in the latter period, the climate in DJF is wetter.

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Proposal for YMC research activity

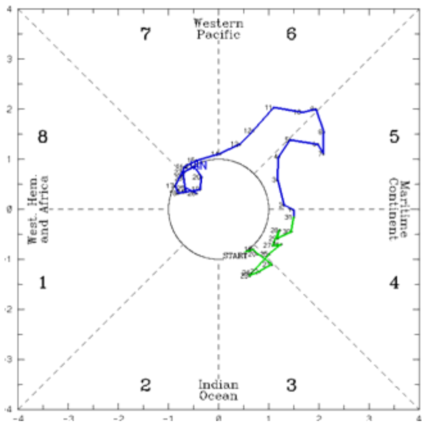
- Using bivariate distributional approach to see the impact of MJO (through the MJO index) to in-situ daily precipitation (anomaly).

- Previous studies by numerous authors using satellite data, using 'traditional correlation' approach.

- Model the joint distribution of MJO index – precipitation and see "upper tail dependence (UTD)" in the joint distribution. Intuitively UTD means:

- That with large values of MJO index also large values of rainfall (anomalies) are expected: when, where and under what conditions, …

Proposal for YMC research activity



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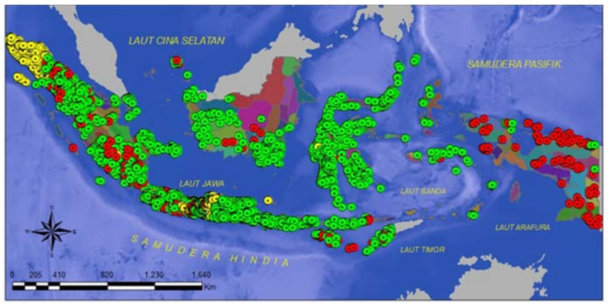

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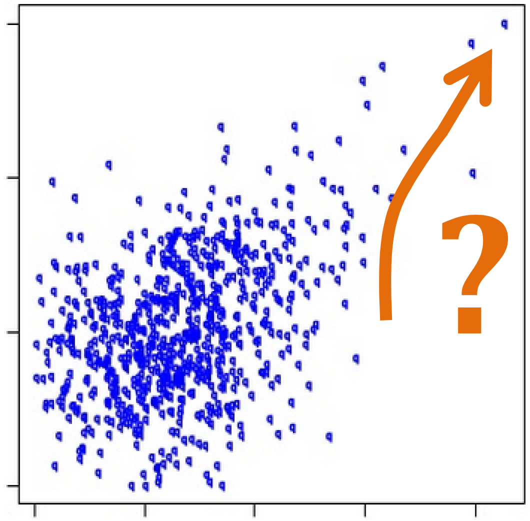

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Thank you

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