



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



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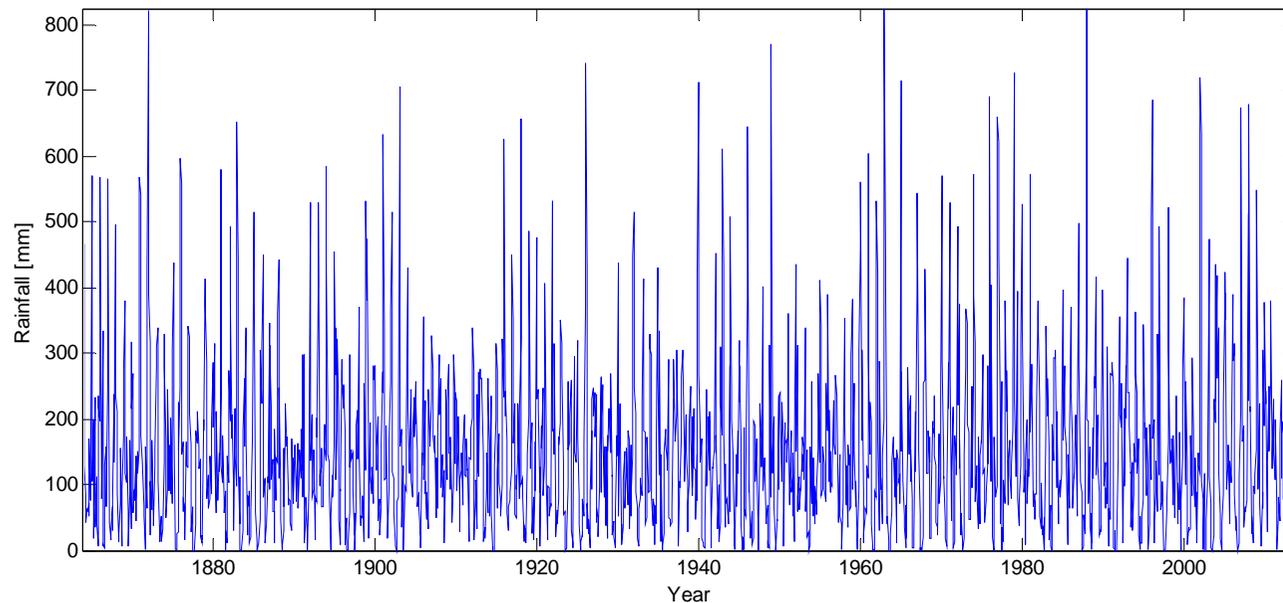
Contents

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





Data for this study



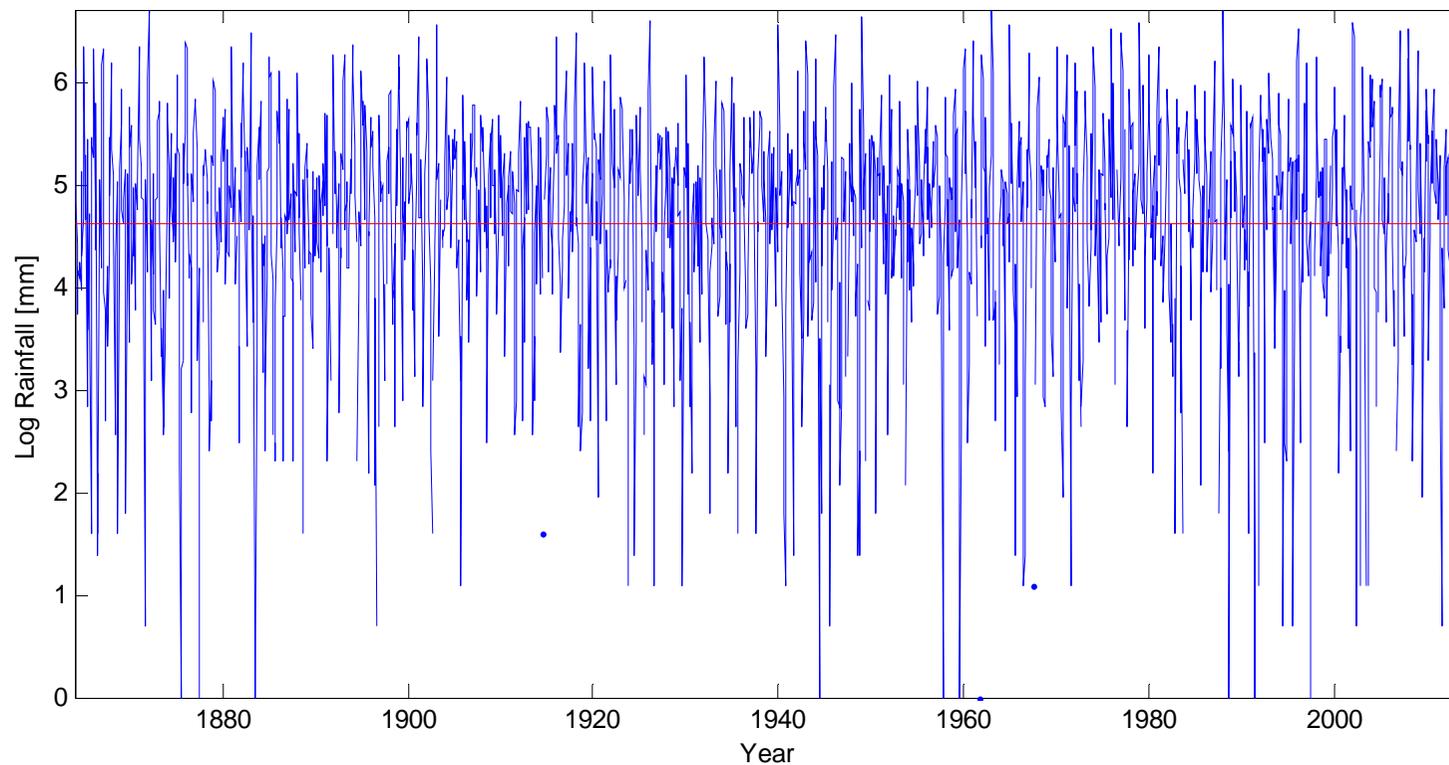
Time series for this study:

Monthly data from 1864 – 2013

[150 years]

Homogeneity 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.



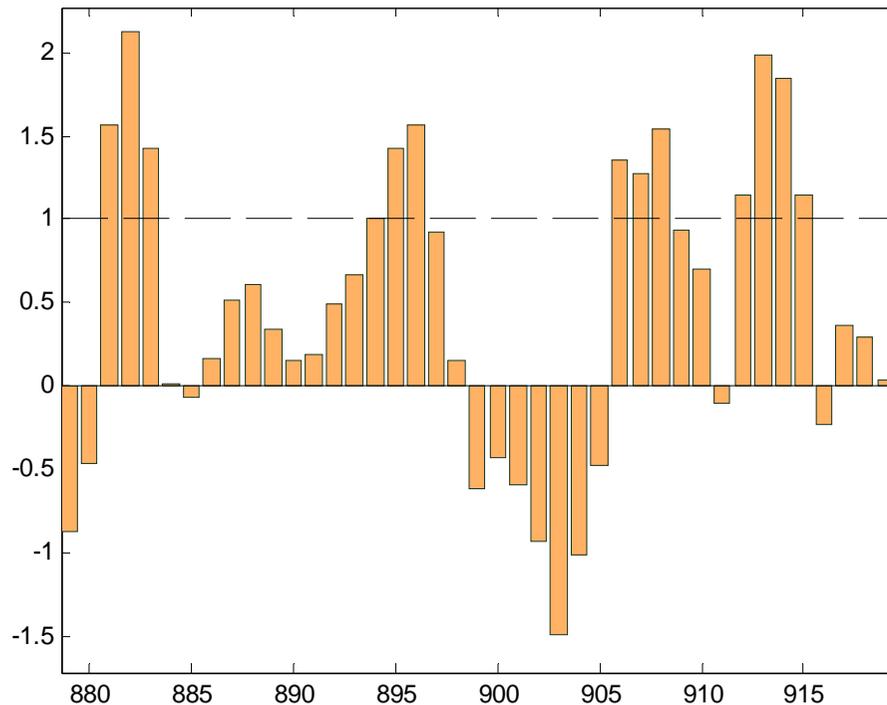


SPI category & characteristics of wet months

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 $SPI > 1$

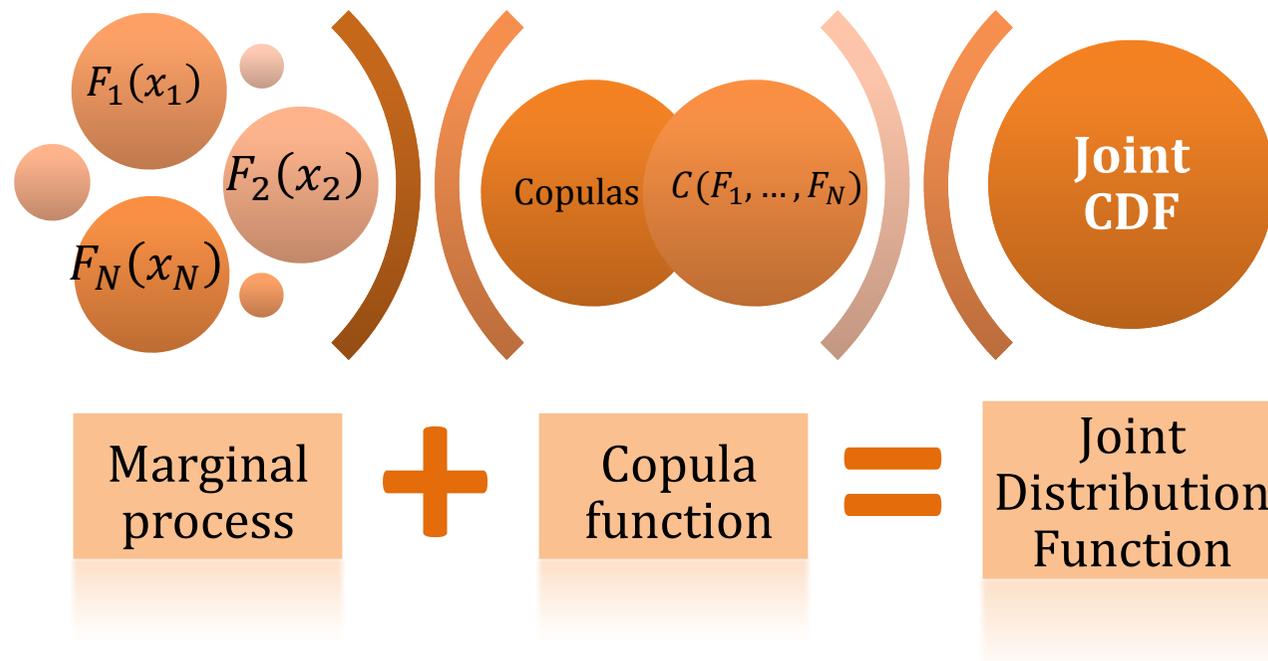
Duration of a wet event:
 number of months with $SPI > 1$

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



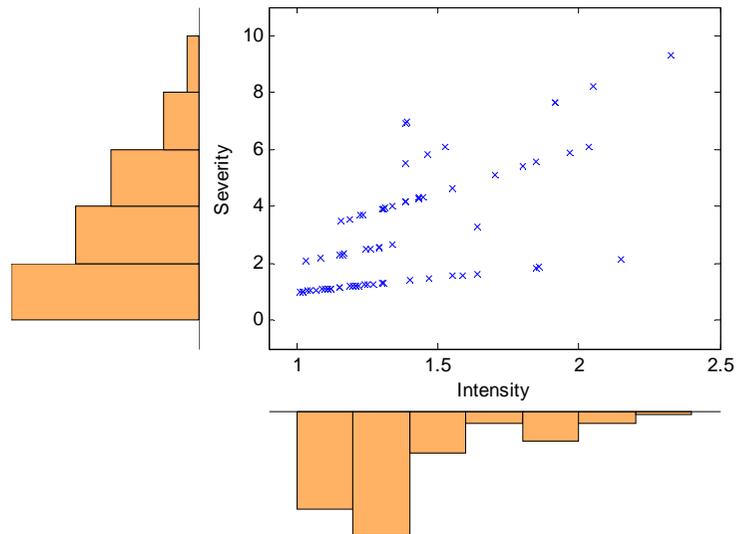
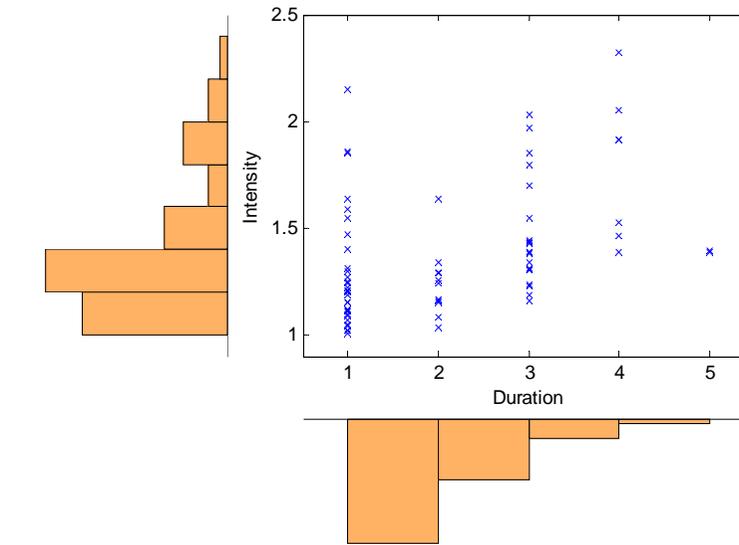
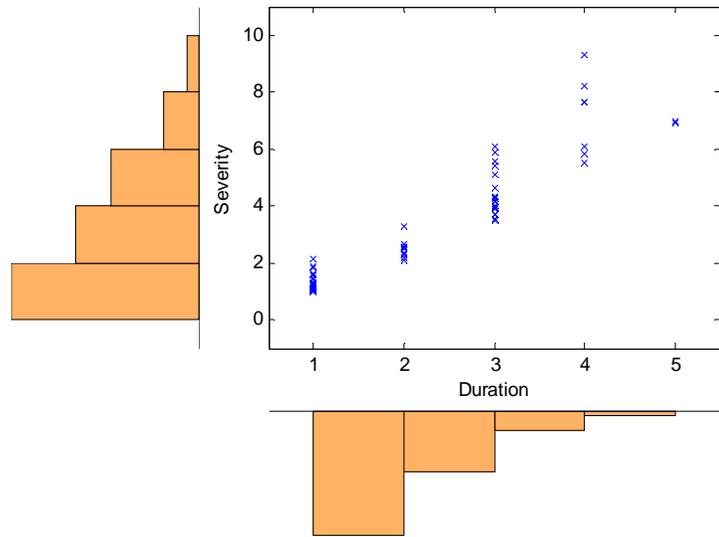


Case study of Jakarta

- 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**



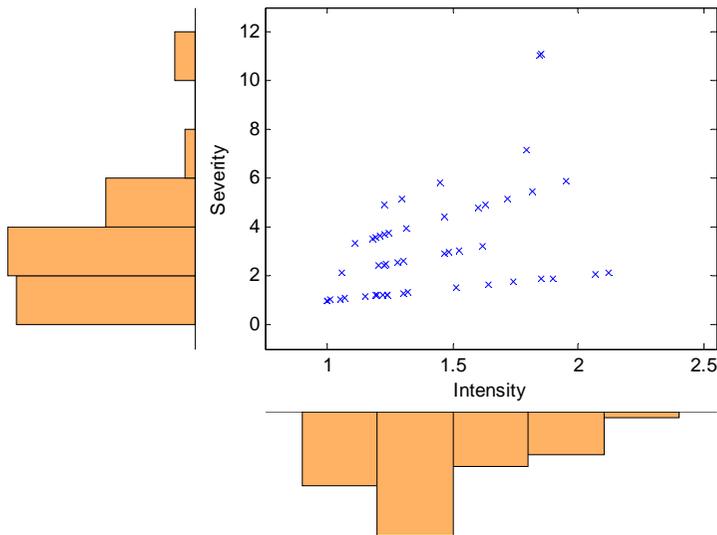
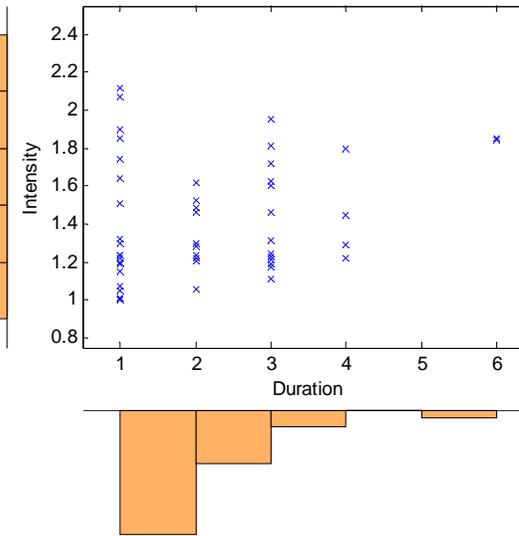
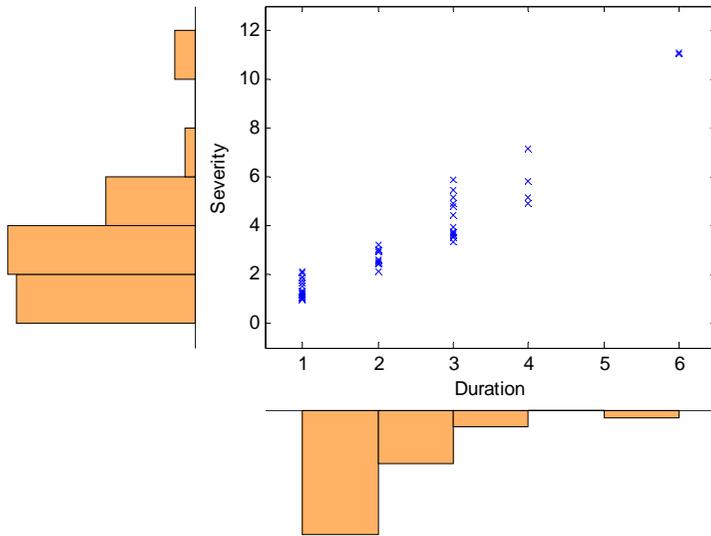
Scatterplot and histogram of duration, severity and intensity



Period: 1864 - 1963



Scatterplot and histogram of duration, severity and intensity



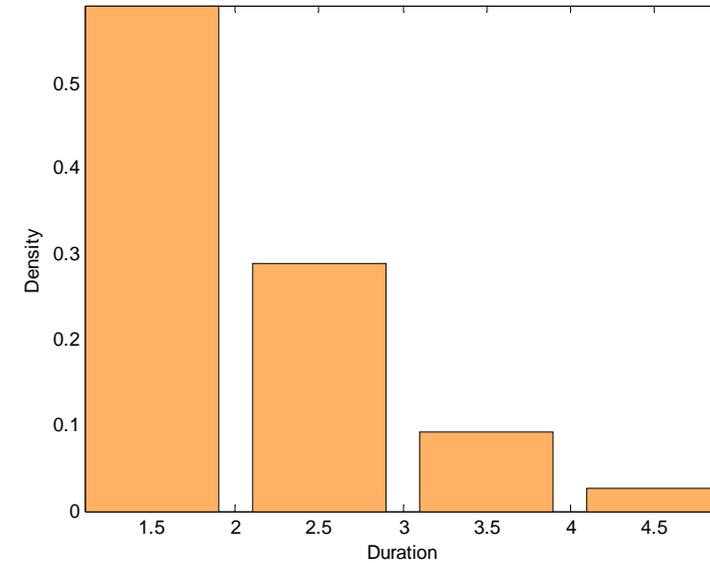
Period: 1964 - 2013



Marginals fitting

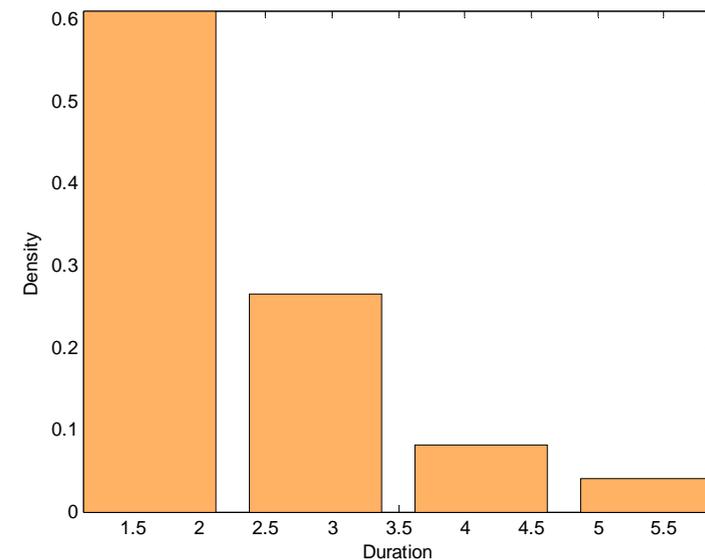
Duration 1864 - 1963

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



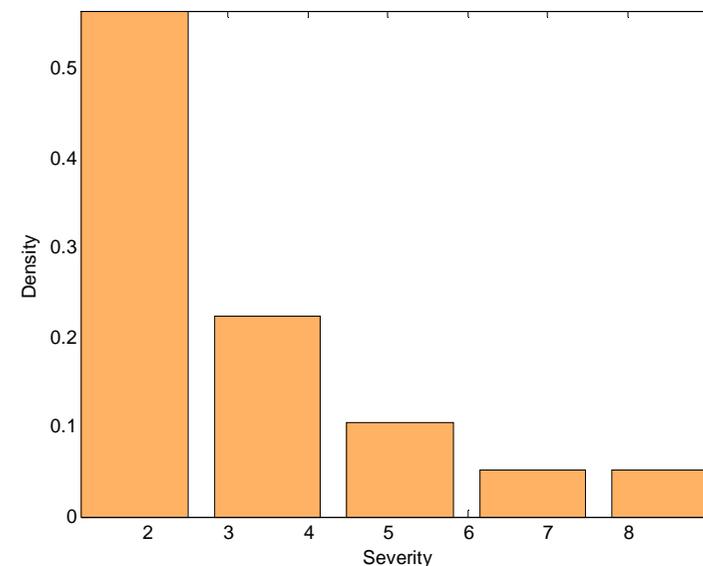
Duration 1964 - 2013

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



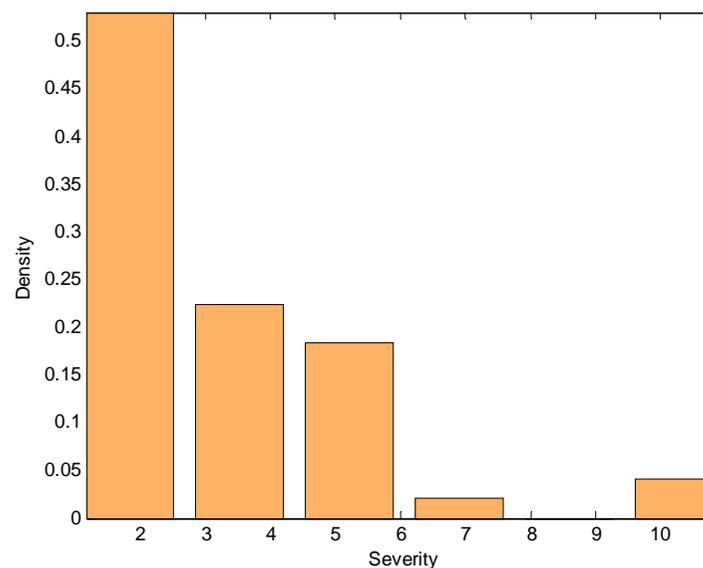
Severity 1864 - 1963

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



Severity 1964 - 2013

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

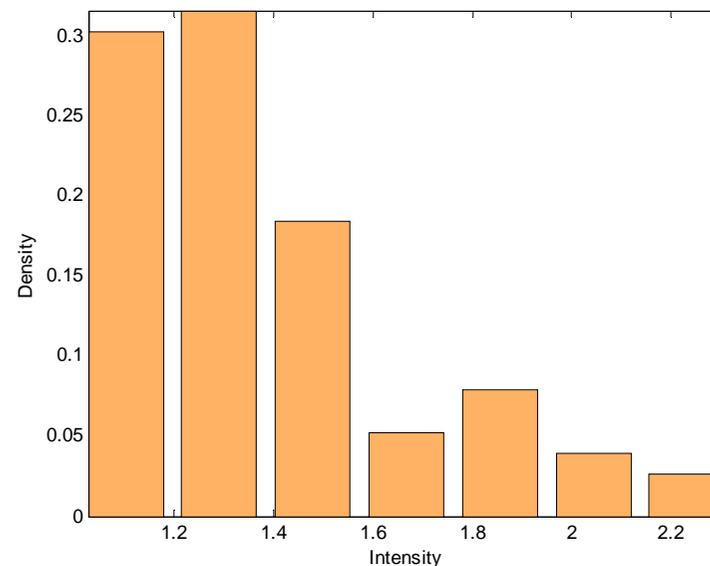




Marginals fitting

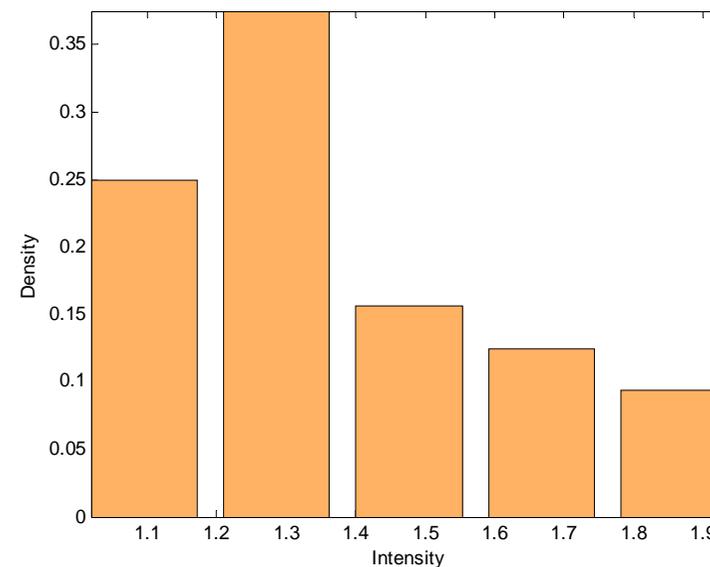
Intensity 1864 - 1963

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



Intensity 1964 - 2013

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



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 $S \geq s$

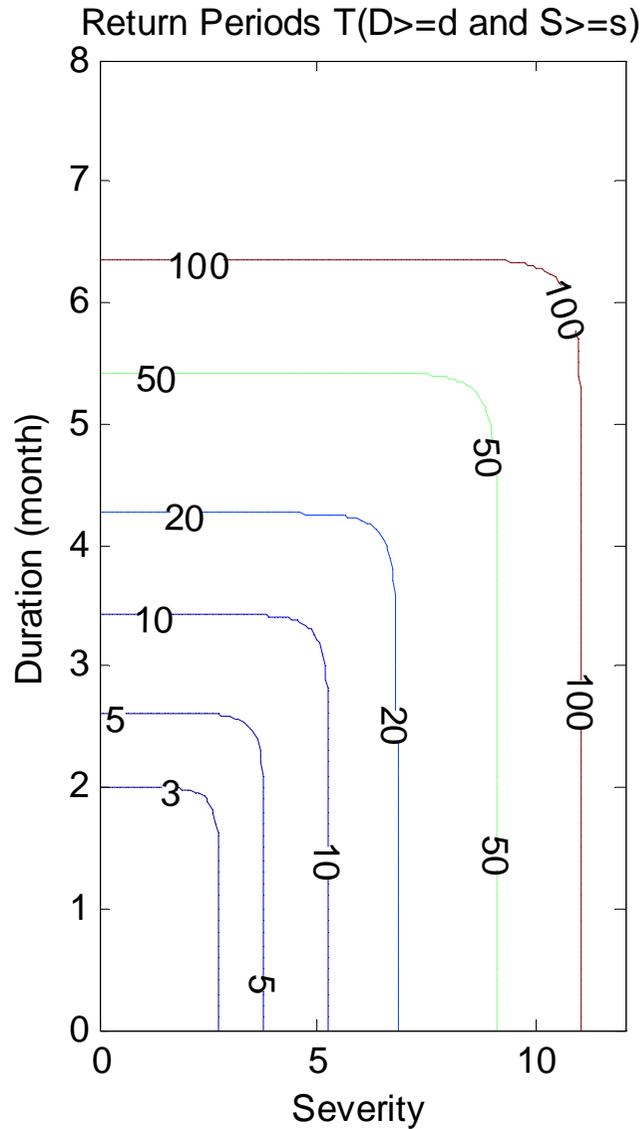
- $$T_{DS} = \frac{E(L)}{P(D \geq d, S \geq s)} = \frac{E(L)}{1 - F_D(d) - F_S(s) + C(F_D(d), F_S(s))}$$

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

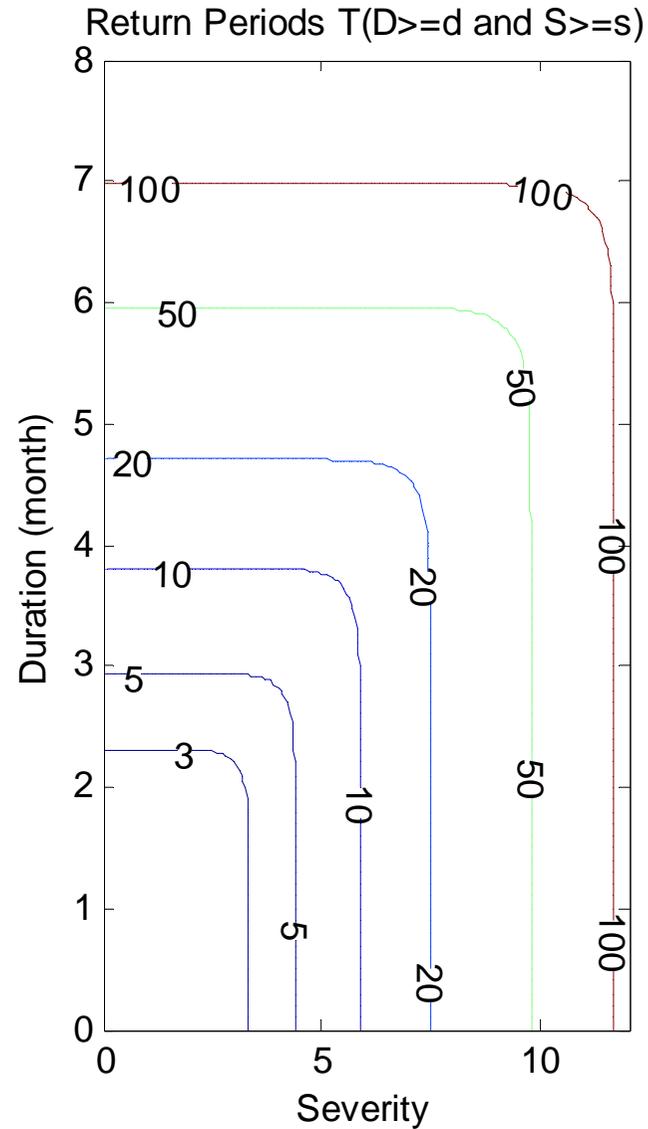
- $$T'_{DS} = \frac{E(L)}{P(D \geq d \text{ OR } S \geq s)} = \frac{E(L)}{1 - C(F_D(d), F_S(s))}$$



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

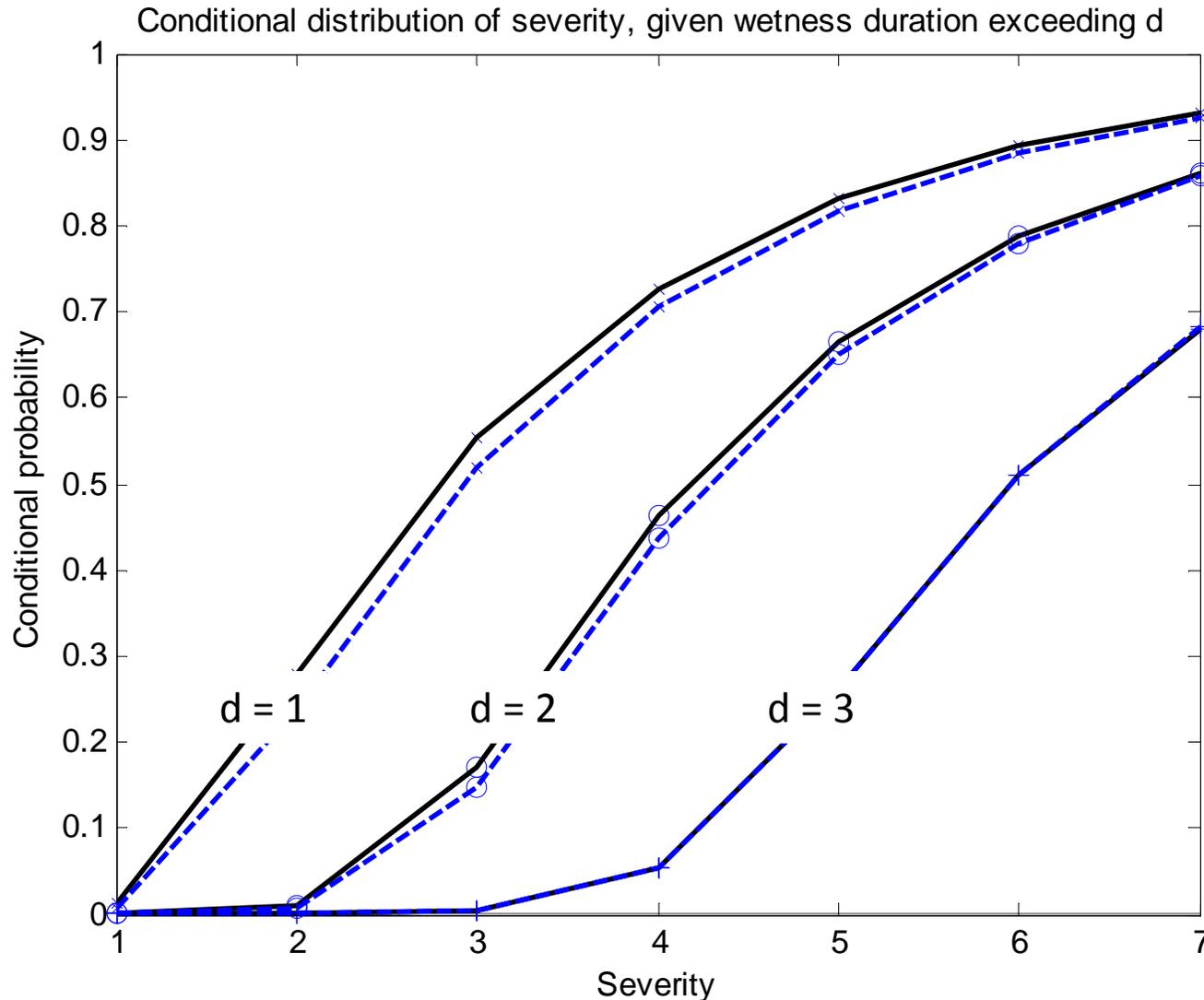


Period: 1864 - 1963



Period: 1964 - 2013

Using Gumbel
copula



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

- 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.



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, ...





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Thank you

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Badan Meteorologi Klimatologi dan Geofisika

