An overview of statistical methods for studying the extreme rainfalls in Mediterranean

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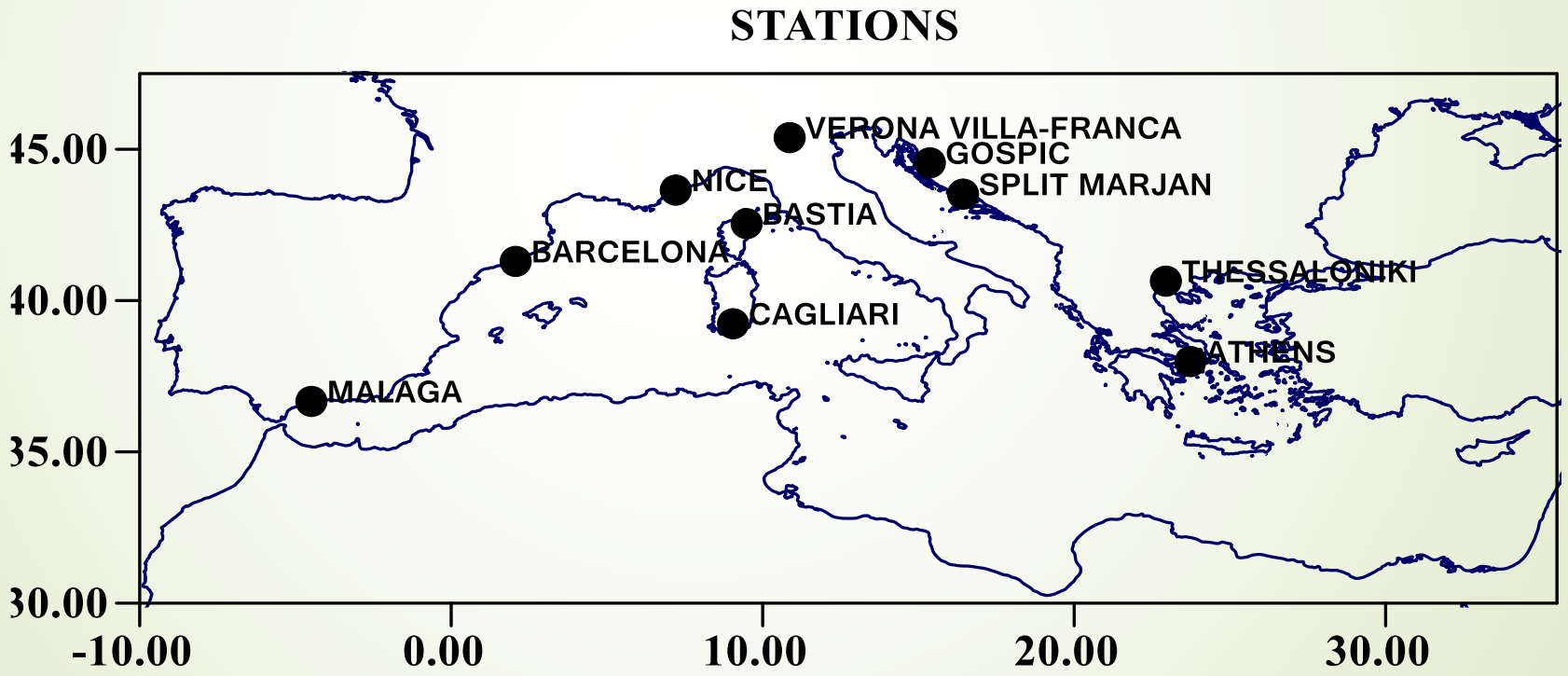
Introduction

- The last decades the frequency and the intensity of the extreme rainfall events in the Mediterranean region has been increased.
- This change has serious impacts in many fields such as agriculture, economy etc.
- The science tries to investigate the extremes behavior with some statistical tools. The most common is the Extreme Value Theory (EVT).

*The **main purpose** of this study is to evaluate some of the most commonly used statistical methods and techniques that are used for the analysis of the extreme precipitation events in the Mediterranean region. Moreover it offers a measurement of the rainfall risk for the Mediterranean stations through the return levels.*

Data

- This study uses daily values of precipitation from 10 Mediterranean stations.
- The values cover the period from 1951 to 2010.



Methodology

- The extreme precipitations were chosen for each station, using the **Block Maxima** and the **Peaks Over Threshold** (POT) techniques.
- The Block Maxima was applied on annual sub-periods. For POT, the precipitation events with amounts higher than 99% were chosen as extremes.
- The GEV and the Pareto distributions were fitted on the new data sets with the extreme values.
- For finding the shape, scale and the location of the distributions, three estimation methods were used and evaluated: the Maximum Likelihood estimation method (MLE), the L-moments method and the Bayesian method.

** Each method is named with the combination of the distribution and the estimation method. For example the GEV-B describes the GEV distribution with the Bayesian estimation method.*

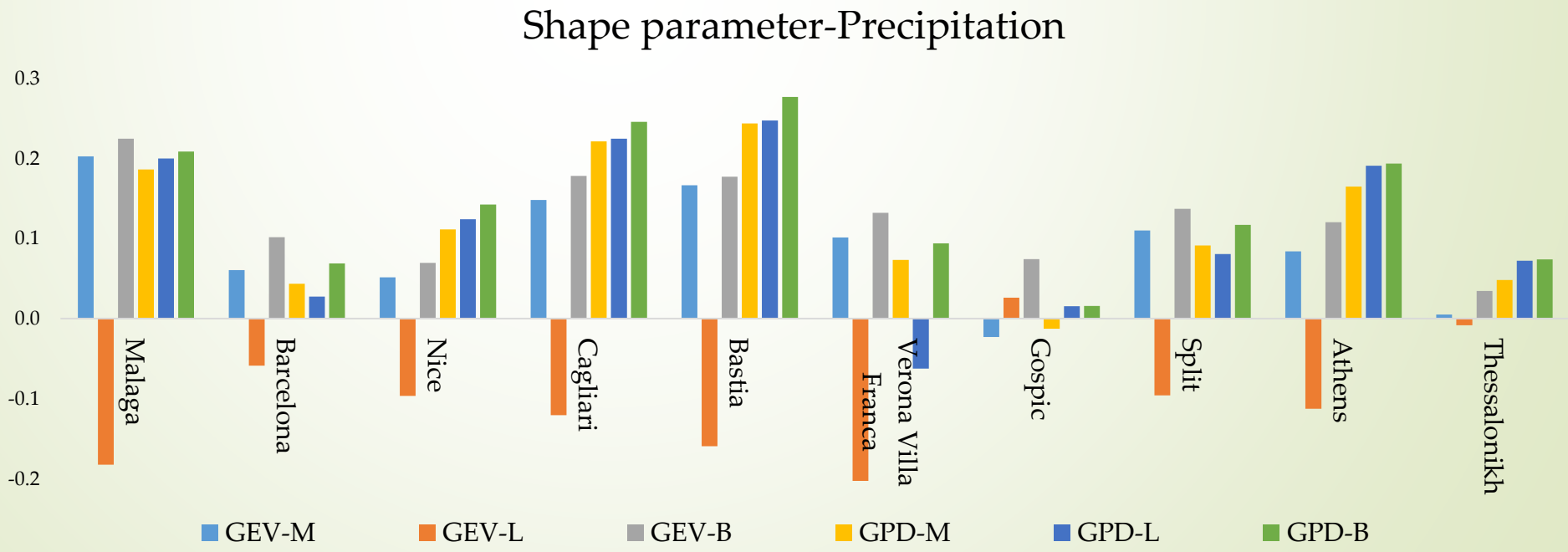
Results (Station's Climatology)

STATIONS		PRECIPITATION	
Name	**Country**	**Mean daily (mm)**	**Absolute maximum (mm)**
Malaga	Spain	1.55	313
Barcelona	Spain	1.72	194.8
Nice	France	2.2	191.4
Bastia	France	2.12	232.4
Cagliari	Italy	1.14	109.6
Verona Villa Franca	Italy	2.17	198
Gospic	Croatia	3.79	141
Split Marjan	Croatia	2.23	131.6
Athens	Greece	1.09	116
Thessaloniki	Greece	1.24	98

- **Gospic** is the station with the highest mean daily precipitation, while **Malaga** has the highest absolute maximum amount.
- The absolute maximum rainfall amount was record in **Malaga**, whereas the minimum in **Thessaloniki**.
- The mean daily precipitation is not related with the absolute maximum amount.

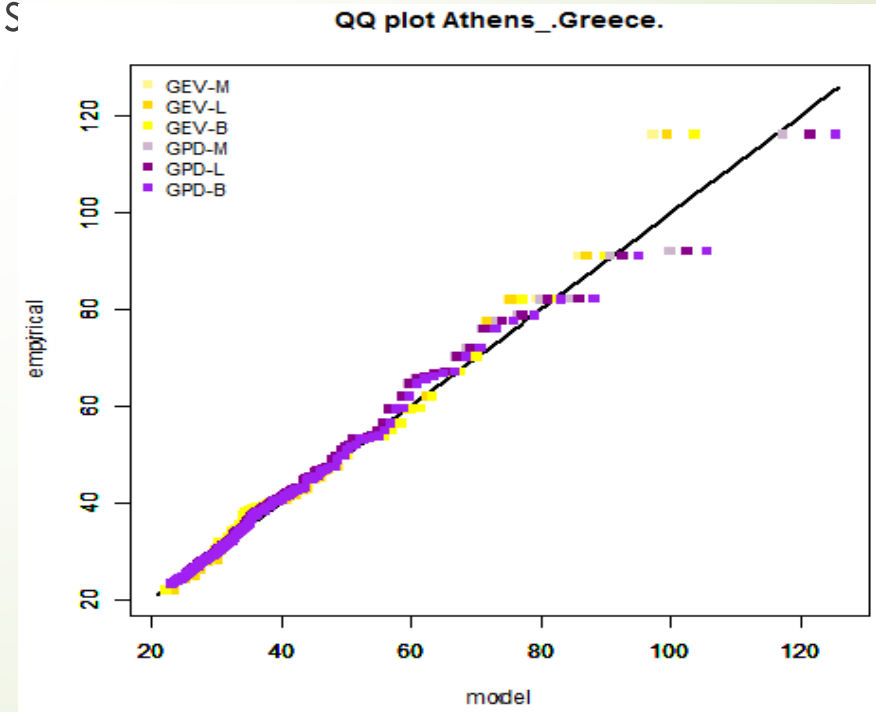
Results (Shape Diagram)

- Shape parameter can be considered as one of the most appropriate method for checking the distribution fit. For precipitation a distribution with an upper threshold is not appropriate.
- **Weibull** distribution (positive shape), is inappropriate for the parameter of precipitation, while **Frechet** (negative shape), can describe rainfalls.
- GEV-L does **not** fit accurately the extreme rainfalls in the majority of stations.



Results (QQ plots)

- QQ plots is another test for the evaluation of the assumed distributions.
- Both GEV and GPD can characterize satisfactorily the extreme rainfalls in the majority of the stations.
- GPD-M, GPD-L and GPD-B methods are more appropriate for small and medium rainfall value.
- For more extreme values both GEV-B and GPD-B distributions are appropriate in almost all stations
- The QQ plot of only one station (Athens) is presented.



Results (Return Levels)

The return levels were estimated for three return periods (50,100,150 years), using all the estimation methods and studied distributions.

	Malaga	Barcelona	Nice	Gagliari	Bastia	Verona Villa-Franca	Gospic	Split	Athens	Thessaloni kh
50										
GEV-M	194.9	140.1	153.6	110.8	**222.2**	106.4	128.3	115.9	93.9	**81.2**
GEV-L	192.9	139.7	158.7	109	**221.8**	113.1	129.7	115.7	95.8	**81.9**
GEV-B	216.4	150.4	162.6	117.3	**231.8**	111.9	134.5	122.9	99.3	**85.5**
GPD-M	191.6	138	156	115.1	**240.1**	109.3	129	111.9	112.4	**83**
GPD-L	195.7	135.3	158.6	115.1	**239.3**	94.1	131.9	110.4	116.2	**85.6**
GPD-B	203.2	143.8	163.9	120.7	**255.7**	113.1	132.4	116.3	117.9	**86.7**
150										
GEV-M	258	167.9	183.4	142.4	**287.1**	128.4	145.3	140.9	113	**94**
GEV-L	252.4	167.3	194	137.9	**285.6**	146	146.9	139.8	117.1	**95**
GEV-B	297.7	185.2	195.6	150.4	**309.3**	138.8	155.5	154.2	122.3	**102.8**
GPD-M	248.9	163.6	190.3	153.7	**325.7**	130.2	147	134.4	143.2	**98.1**
GPD-L	256.8	159	194.9	154.1	**325.4**	105.1	151.3	131.8	150.7	**102.4**
GPD-B	270	172.8	203.6	163.9	**354.8**	136.3	152	141.6	152.7	**104.1**
300										
GEV-M	305.5	186.4	203.1	165	**334.4**	143.6	155.7	158.2	126	**102.1**
GEV-L	296.4	185.5	218.2	158.1	**331.8**	171.3	157.5	156.4	131.9	**103.3**
GEV-B	361.6	209.2	217.5	174	**368**	158	168.9	176.8	138.4	**114.3**
GPD-M	291.6	180.3	214.1	183.4	**392.8**	144.2	158.3	149.8	165.6	**108**
GPD-L	302.9	174.4	220.5	184.1	**393.1**	111.6	163.8	146.4	176.4	**113.8**
GPD-B	321	192.3	232	197.7	**434.3**	152.1	164.5	159.3	178.6	**115.8**

- For the three return periods, Bastia presents the highest return levels while Thessaloniki the lowest.
- Bayesian method with both GPD and GEV distributions gives the highest return levels.
- In the western Mediterranean and in the stations with the highest altitude, the greatest precipitation return levels are recorded with the GEV-B while for the eastern stations with the GPD-B.
- The GPD-M or GPD-L methods present the lowest return values for the western stations, while the GEV-M for the eastern ones.

Conclusions

The choice of the most appropriate distribution for a data set is difficult and can affect the final results.

Based on statistical and graphical tests (goodness of fit tests, shape diagram, QQ plots), GEV,GPD distributions and three estimation methods were evaluated.

- The GPD method (with MLE, L-moments and Bayesian) could characterize sufficiently the minimum and medium extreme values.
- The Bayesian estimated method with both GEV and GPD distribution is the most suitable method for fitting the maximum extreme rainfalls.
- The less suitable estimated method for the extreme rainfalls in Mediterranean is GEV-L.

Conclusions

- The Bayesian method gives the highest return levels in Mediterranean, GEV-B method for the western Mediterranean stations (Malaga and Barcelona) and GPD-B for the eastern Mediterranean stations (Athens and Thessaloniki).