Towards a better characterization of extreme precipitation in the Mediterranean using instrumental time series and the 20th century reanalysis

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Introduction

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The Greater Mediterranean Region

Source: ESA, 2010

It is influenced by subtropical processes, mid-latitude dynamics[1] …

High population density (especially along rivers and the coast), vulnerability, exposure to climate change….**HOT SPOT**[2]

1 Xoplaki, 2002

2 Giorgi, 2006

Introduction

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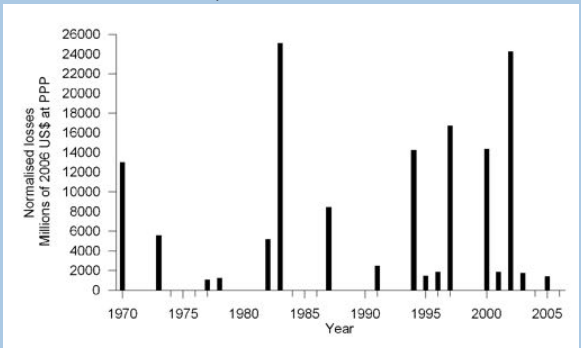
Source: Barredo, 2009



Extreme precipitations have a profound impact on societies and economies.
Total losses estimated in the Euro-Med region (1970-2006):

140 billion US dollars

Source: Department of National Civil Protection. Rome 2008

Data

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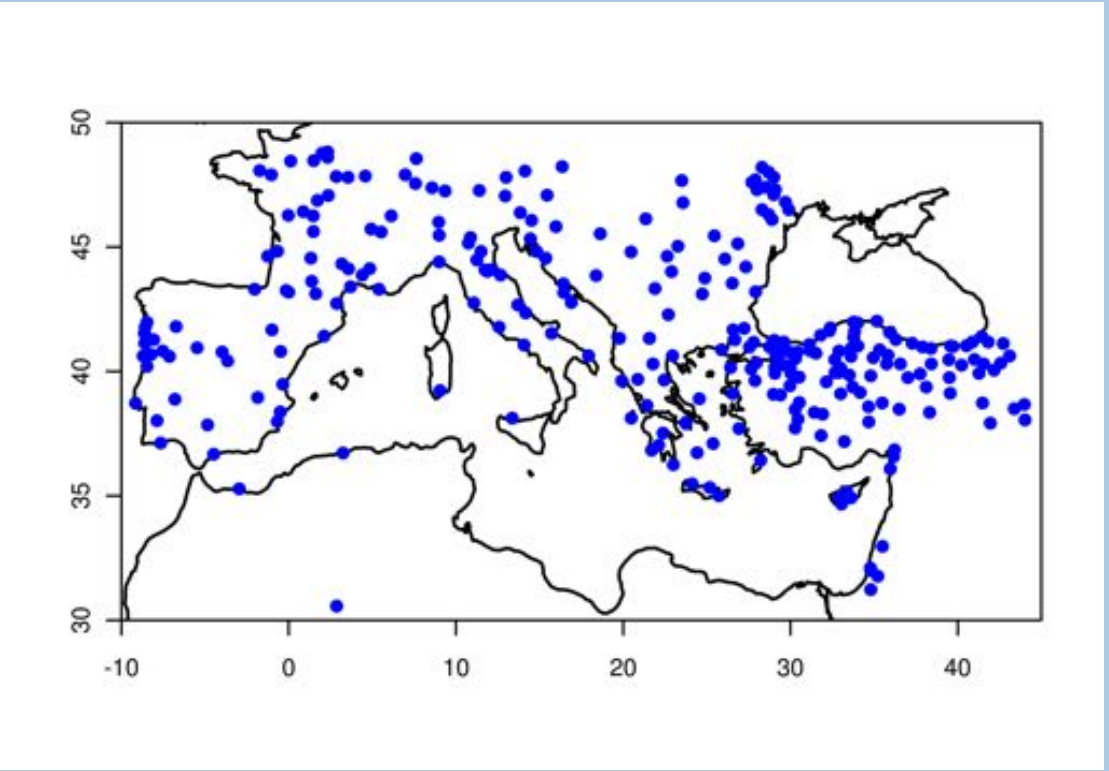
In the framework of the EU-FP6 **CIRCE** project more than 400 daily precipitation series have been collected.

CLIMATE CHANGE AND IMPACT RESEARCH: THE MEDITERRANEAN ENVIRONMENT
Circe



Quality control + break point identification[1]

286 series

Oct-March, 1950-2006

Source: Toreti, 2010 and references therein

Data

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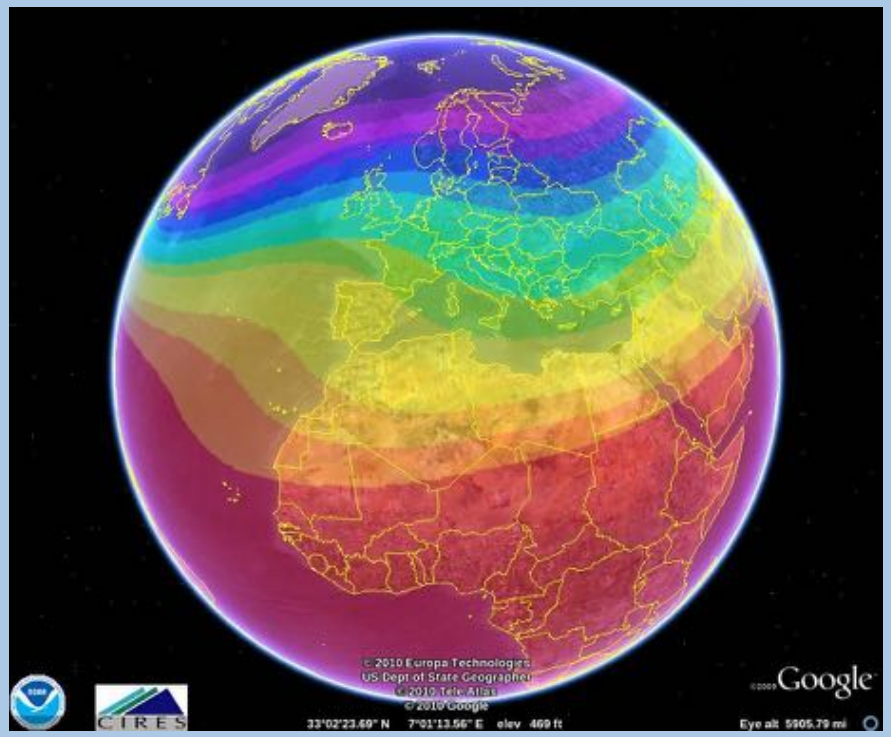
Reanalysis: Z500, SLP, wind, precipitable water, precipitation



Winter Z500, 1999-2008.

NCEP-NCAR Reanalysis: www.esrl.noaa.gov/psd. Kalnay et al., 1996; Kistler et al., 2001

20th century Reanalysis v2: www.esrl.noaa.gov/psd. Compo et al., 2010

Period: 1950 - 2006

Methods – characterization of extremes

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Climate extremes can be characterized by using an index approach and/or **Extreme Value Theory** tools

X_t daily time series → *X-u* conditional on $X > u$

Generalized Pareto Distribution[1,2]

$$H(y) = 1 - \left(1 + \frac{\xi y}{\sigma}\right)^{-1/\xi}$$

1 Davison and Smith, 1990
2 Pickands, 1975

Methods – characterization of extremes

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Estimation of the GP parameters + return levels and uncertainties[1]

1st choice of u ⇨

- Declustering
- Minimum Density Power Divergence Estimator
- Goodness-of-fit

⇨ $$z_{\mathrm{R}} = u + \hat{\sigma}\hat{\xi}^{-1}\left[\left(\mathrm{R}\zeta_u\hat{\theta}\right)^{\hat{\xi}} - 1\right]$$ and associated uncertainties (delta method)

1 Toreti et al., 2010 and references therein

Methods – atmospheric circulation

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All the anomalies (penalized spline) of Z500 & SLP during the identified extreme events were collected and classified[1]

Self **O**rganized **M**aps

Genetic K-means

Singular Value Decomposition - similarity measure

Significance: Comparison with clusters associated with dry (non-extreme wet) days

1 Toreti et al., 2010 and references therein

Results – extreme precipitation

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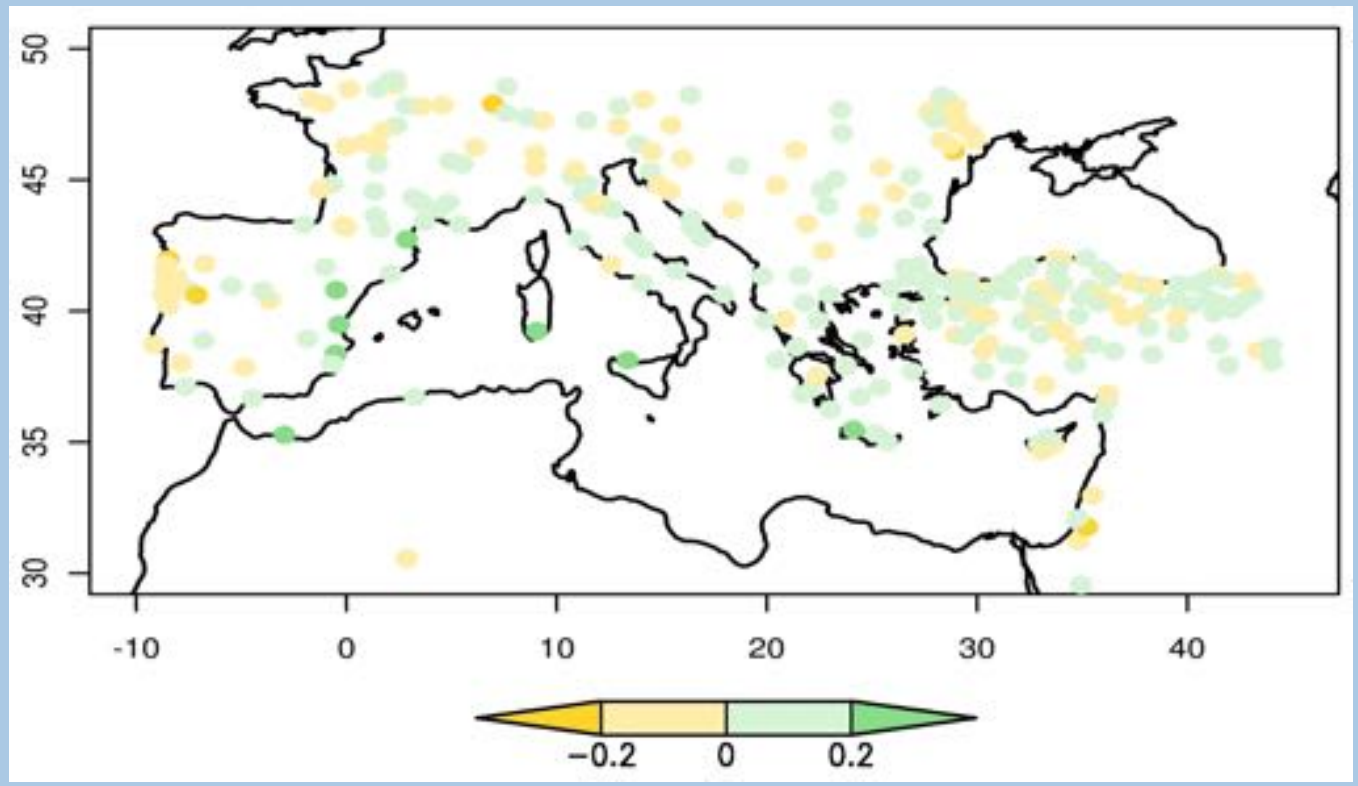
Estimated shape (ξ) parameters



ξ > 0 heavy tail; ***ξ < 0*** finite right end point; ***ξ = 0*** exponential

Results – extreme precipitation

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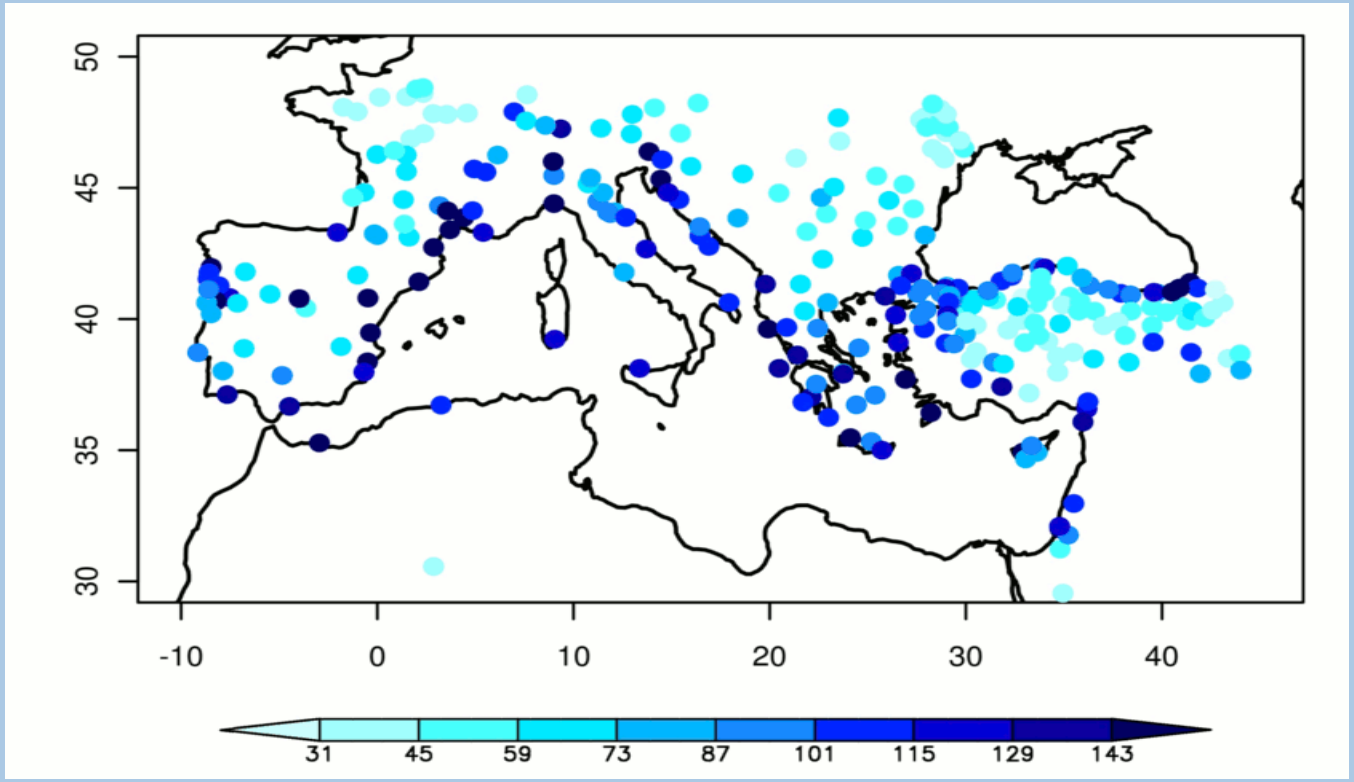

Estimated **50**-year return levels (mm)

Results - extreme precipitation

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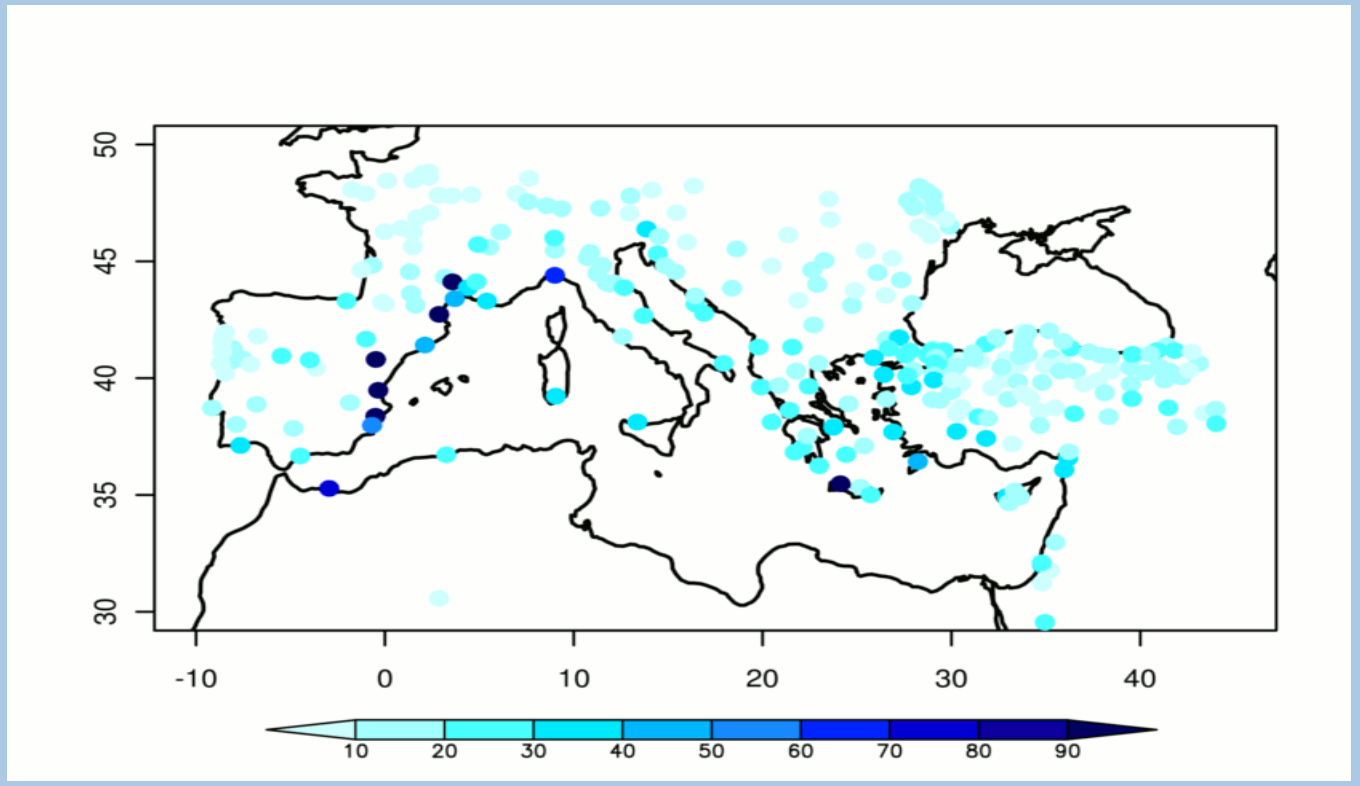
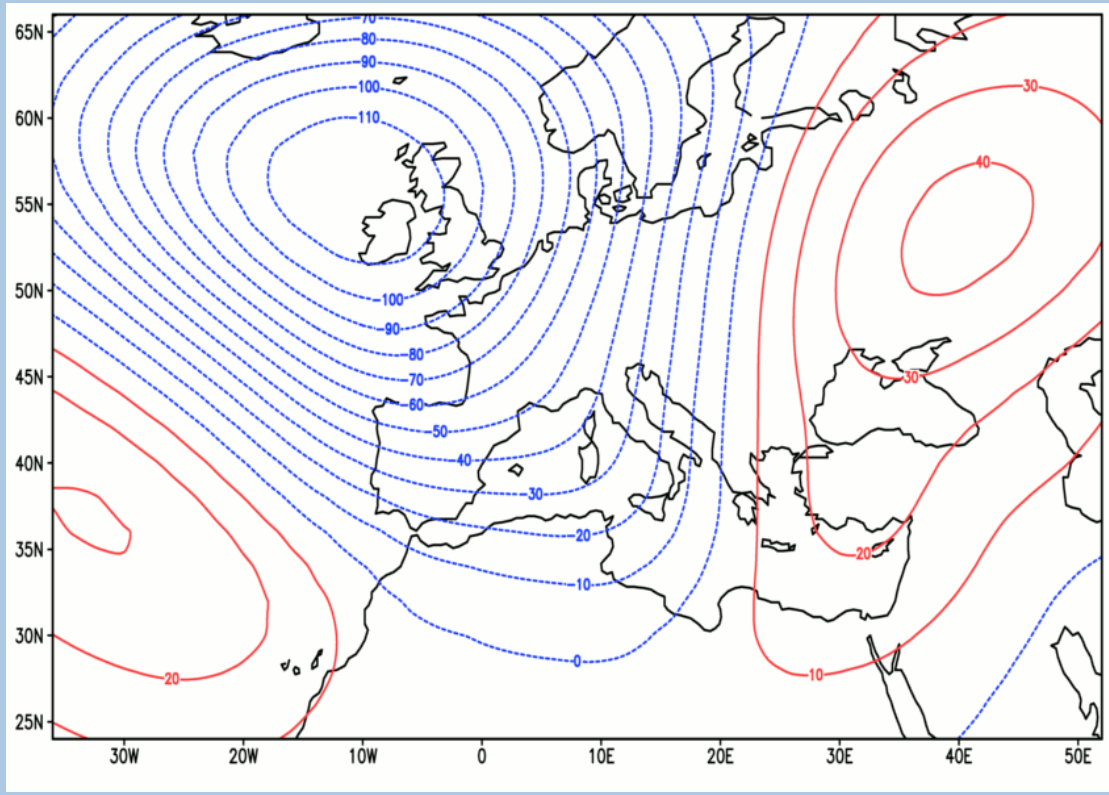


Uncertainties (mm) associated with the estimated **50**-year return levels

Results – 20CRv2



Z500 anomalies: 1st centroid associated with extreme events in the Western-Central Mediterranean

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Results - 20CRv2

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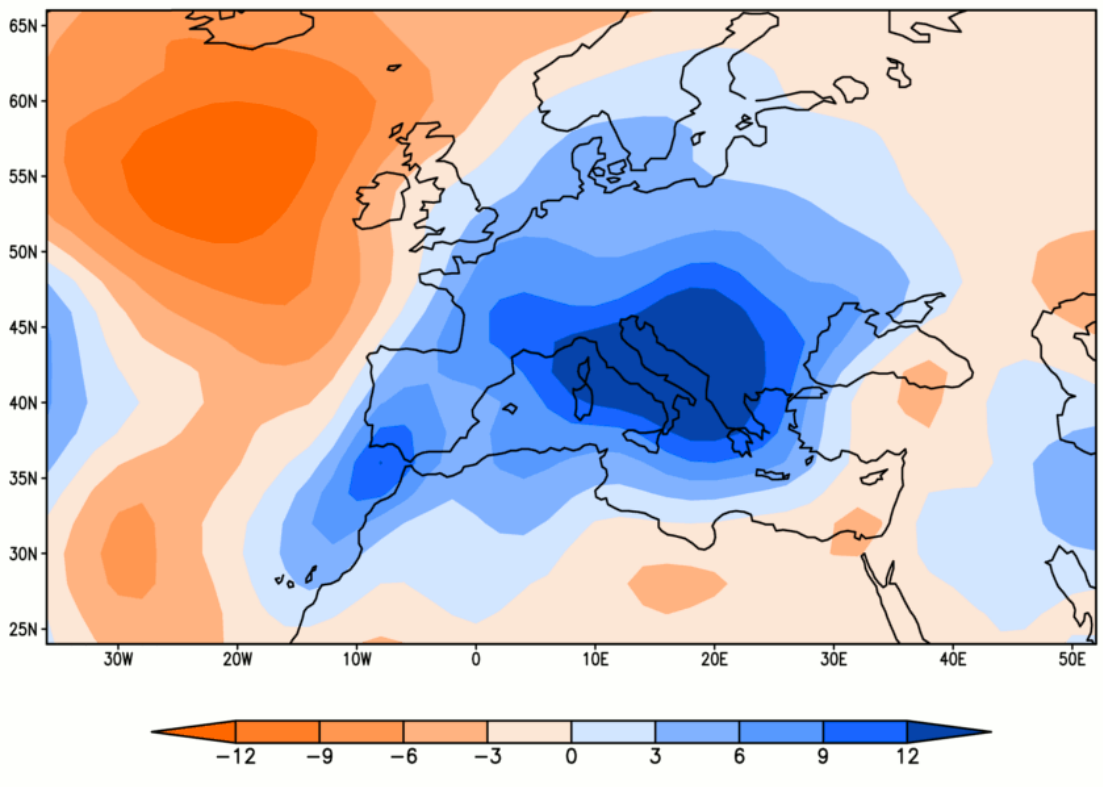

Precipitable water associated with the first cluster of Z500 in the Western-Central Mediterranean

Results - 20CRv2

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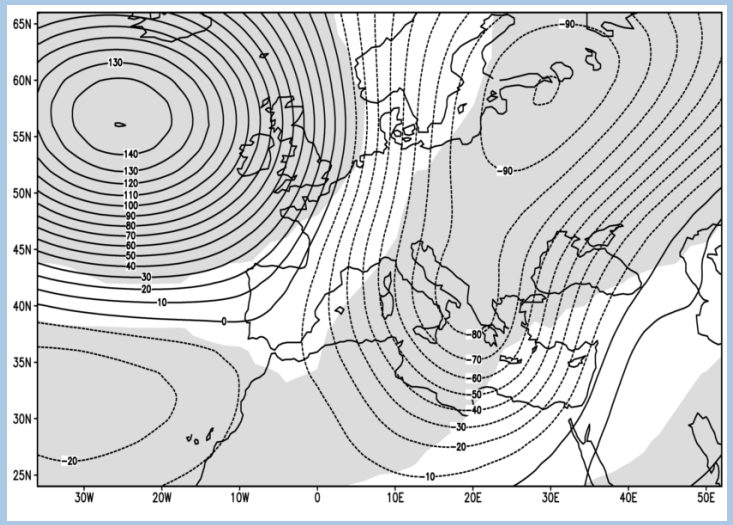

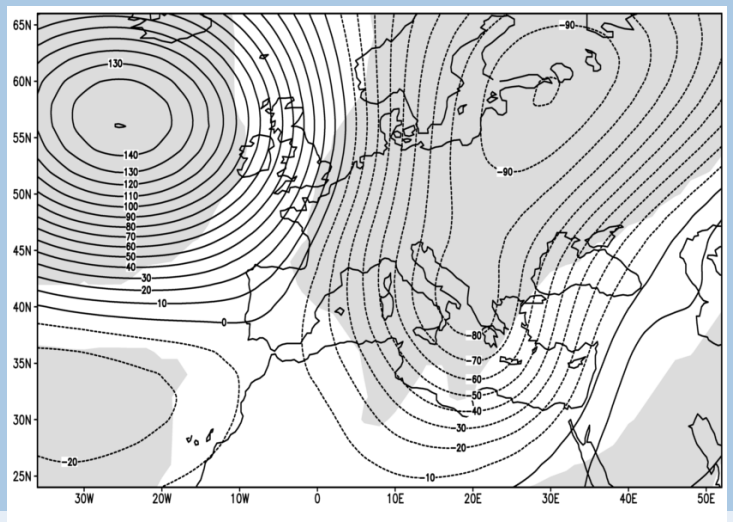

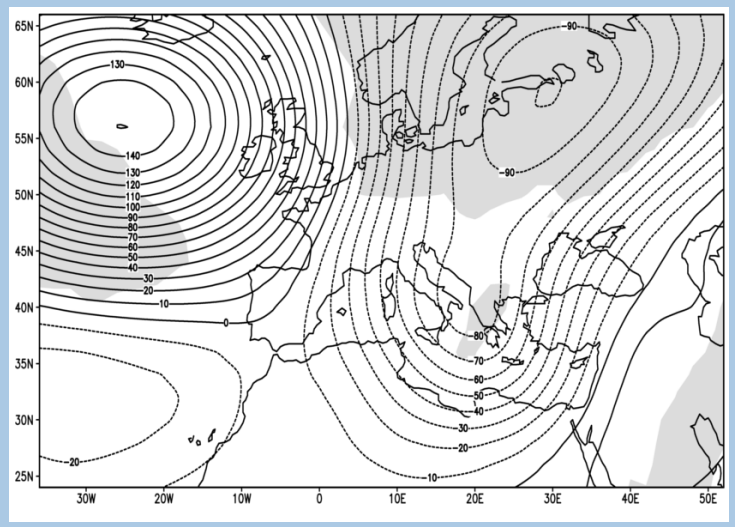

Z500 anomalies: 1st centroid associated with extreme precipitation in the Eastern Mediterranean. Comparison with non-extreme wet days.

Case study I – Western Mediterranean

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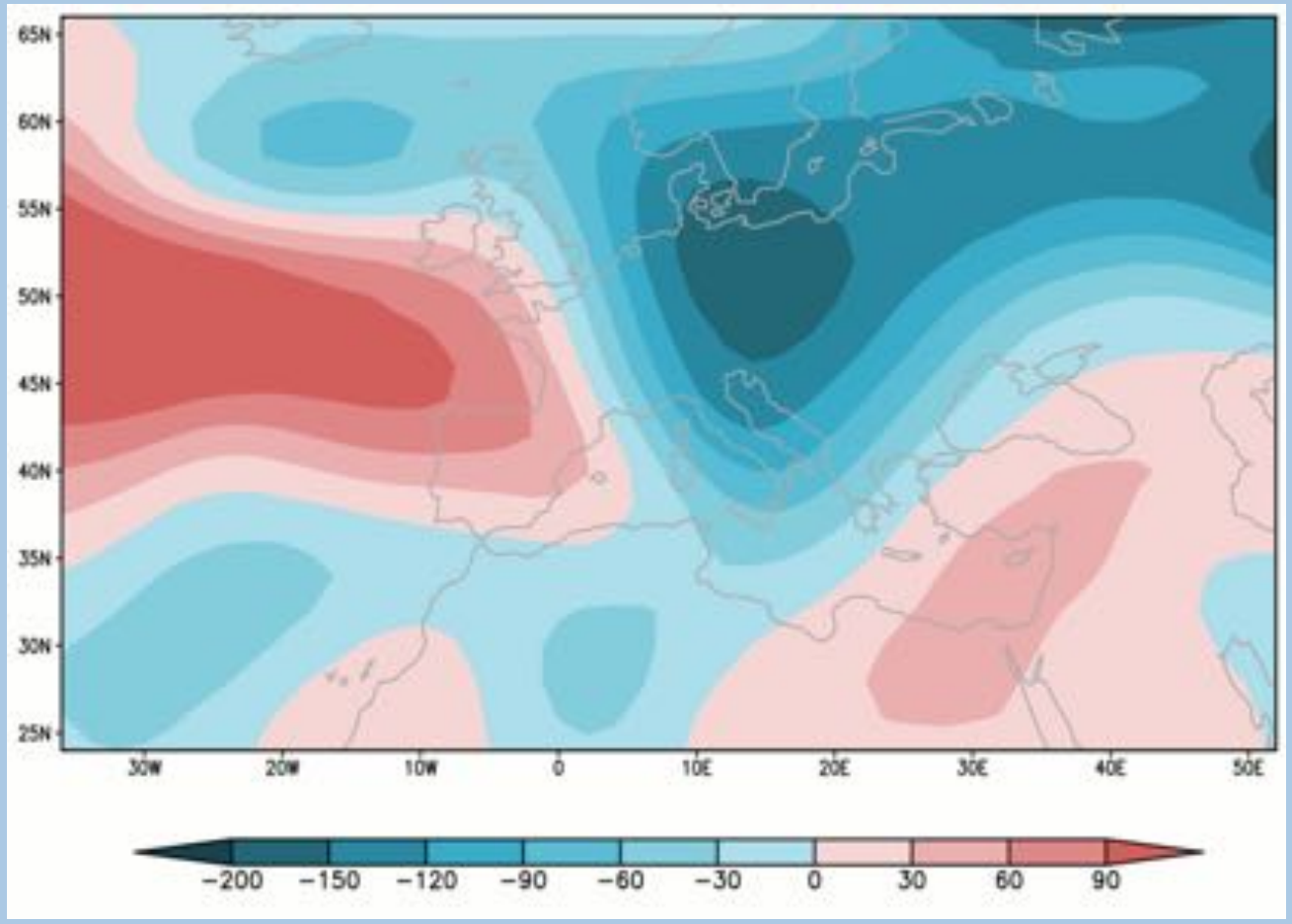

Extreme precipitation event in Rome (2-3 October 1978): Z500 anomalies from the 28th of September to the 3rd of October 1978

Case study I – Western Mediterranean

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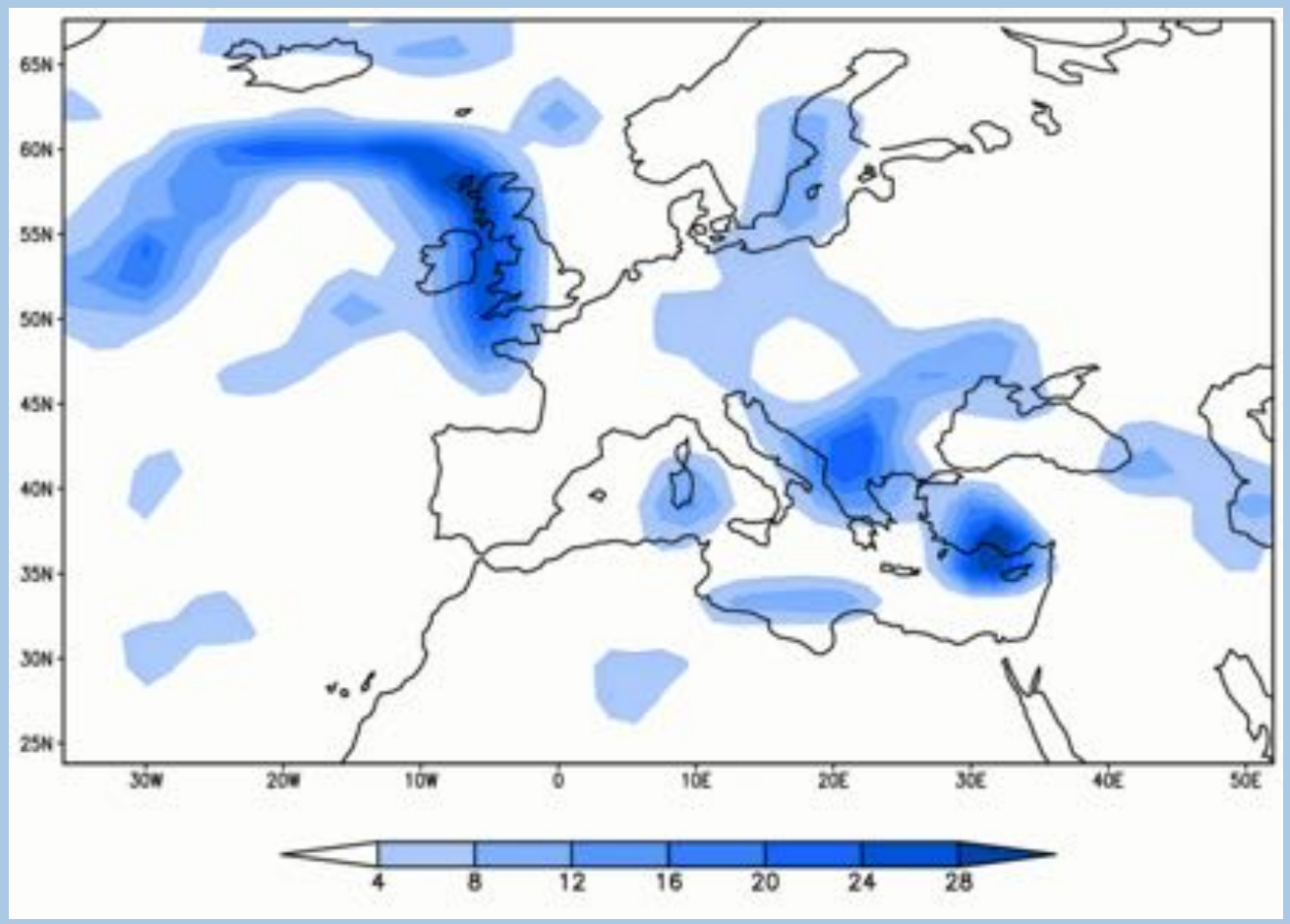

Precipitation from the 28th of September to the 3rd of October 1978

Case study II - Eastern Mediterranean

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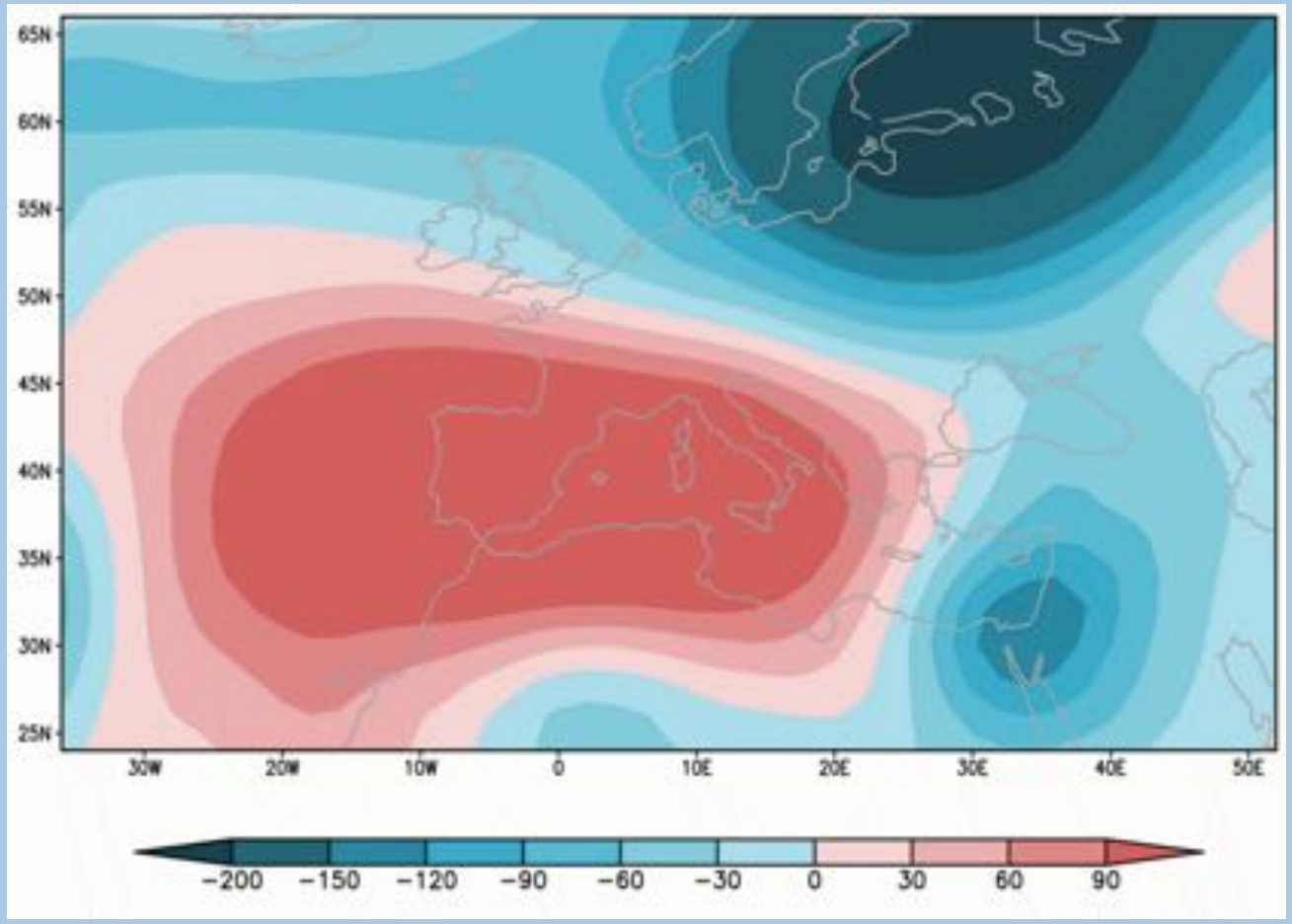

Extreme precipitation event in Rhodes (20 November 1994): Z500 anomalies from the 16th to the 20th of November 1994

Case study II - Eastern Mediterranean

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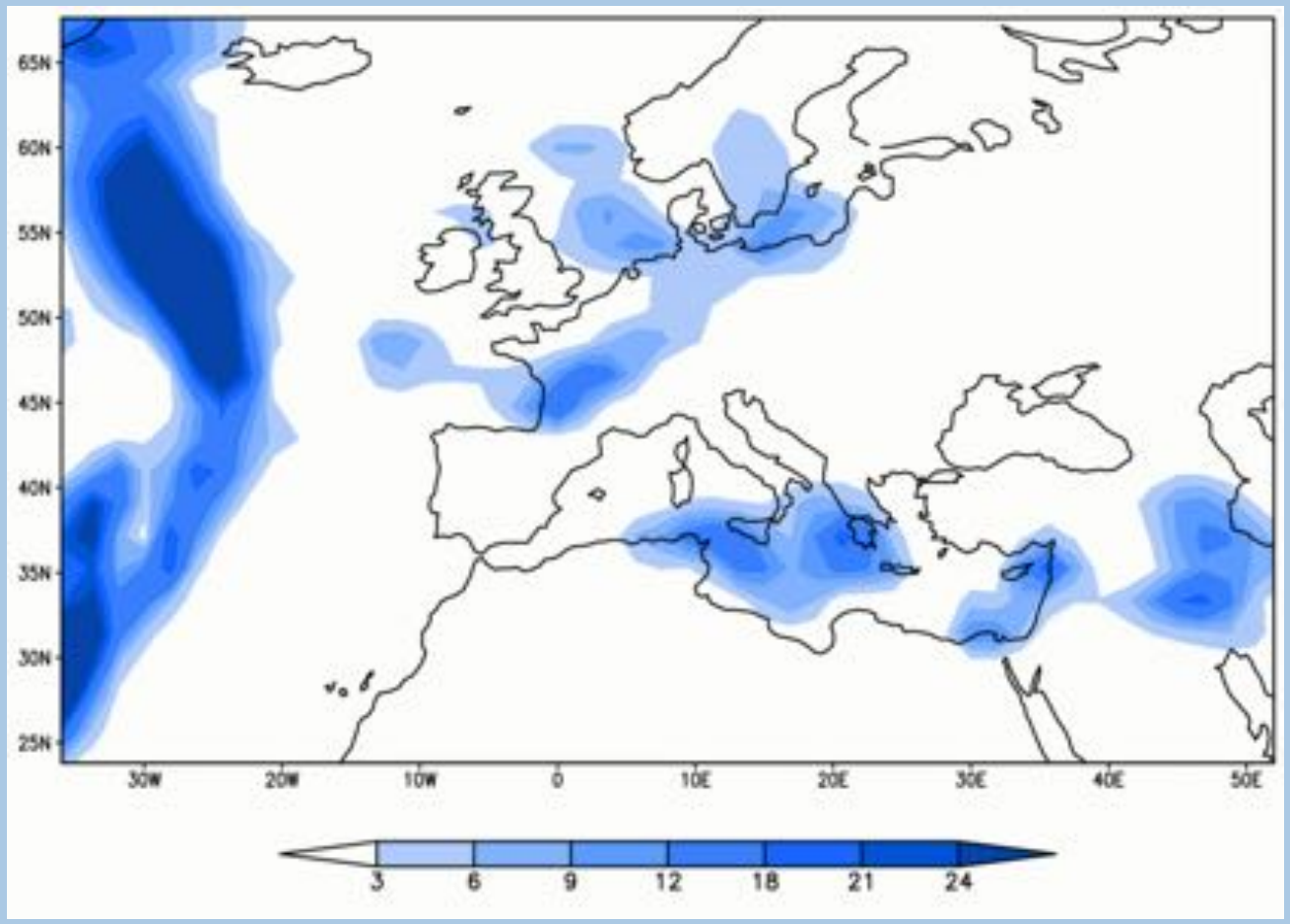

Precipitation from the 16th to the 20th of November 1994.

Conclusions

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- EVT tools are very useful for a better characterization of extreme precipitations
- Despite low seasonal totals, some coastal sites show very high extremes
- There are remarkable spatial differences in the statistical features of extreme precipitations
- Atmospheric patterns associated with extremes help in the understanding of the dynamics and the genesis of extreme events. They are significantly different from patterns associated with dry and non-extreme wet days.
- Extreme precipitation in the Mediterranean are not driven by a single factor, but their development is due to the combination/interaction of several elements
- Reanalyses (e.g. 20CRv2) are essential tools for improving the dynamical characterization and understanding of extremes

Outlook

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- Collection of other daily (and subdaily) series in the Mediterranean region
- Improvement of the break point identification (and correction)
- Improvement of the statistical extreme model, e.g. full non-stationary approach
- Understanding of the identified spatial patterns in the statistical properties of extreme precipitation
- Role of the different factors leading to extreme precipitation events in the Mediterranean, e.g. interaction between the local and the large scales, moisture fluxes, etc.
- Analysis of exteme precipitation in the dry season