NON-STATIONARY FUTURE RETURN LEVELS FOR EXTREME RAINFALL OVER EXTREMADURA (SW IBERIAN PENINSULA)

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INTRODUCTION

- The statistical Extreme Value Theory (EVT) is commonly used by engineers to evaluate the intensity of meteorological extreme events for water resource design and management.
- These events are evaluated as long return levels (RLs) which correspond to very rare events.

OBJECTIVES

- Describe a new method for the calculation of non-stationary return levels for extreme rainfall.
- Estimate the 20-year Return Level (Z_{20}) in near future.
- Are trends in extremes characterized by trends in mean and variance?

DATA

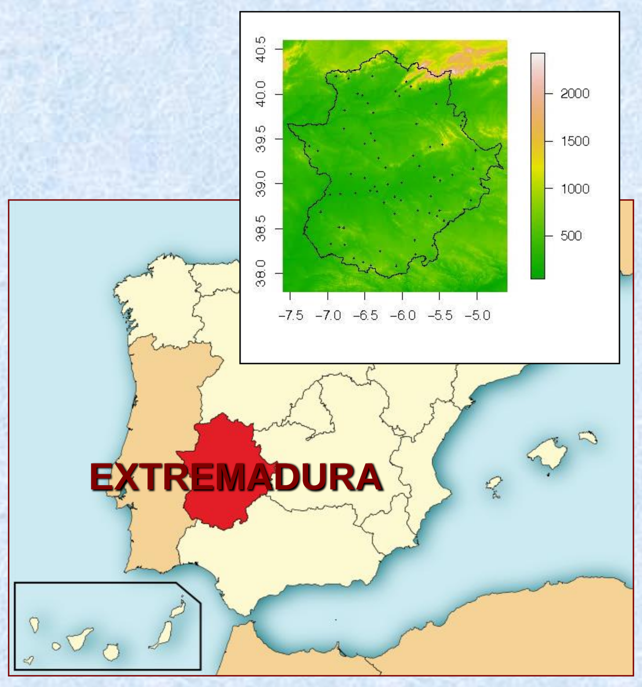
- Observational data: 72 daily rainfall series from AEMET.
- Common period: 1961-2010.
- Data homogeneity is assessed using RHTestV2.
- The study spans for autumn (Sep,Oct,Nov), winter (Dec,Jan.Feb) and spring (Mar,Apr,May).

METHOD

- The N-year return level Z_N is the level expected to be exceeded once every N years in a stationary context.

$$Z_N = u + \sigma \log(N n_y I_u) \quad if\ \xi = 0;\ and\ Z_N = u + \frac{\sigma}{\xi}\left[\left(N n_y I_u\right)^{\xi} - 1\right] \quad if\ \xi \neq 0$$

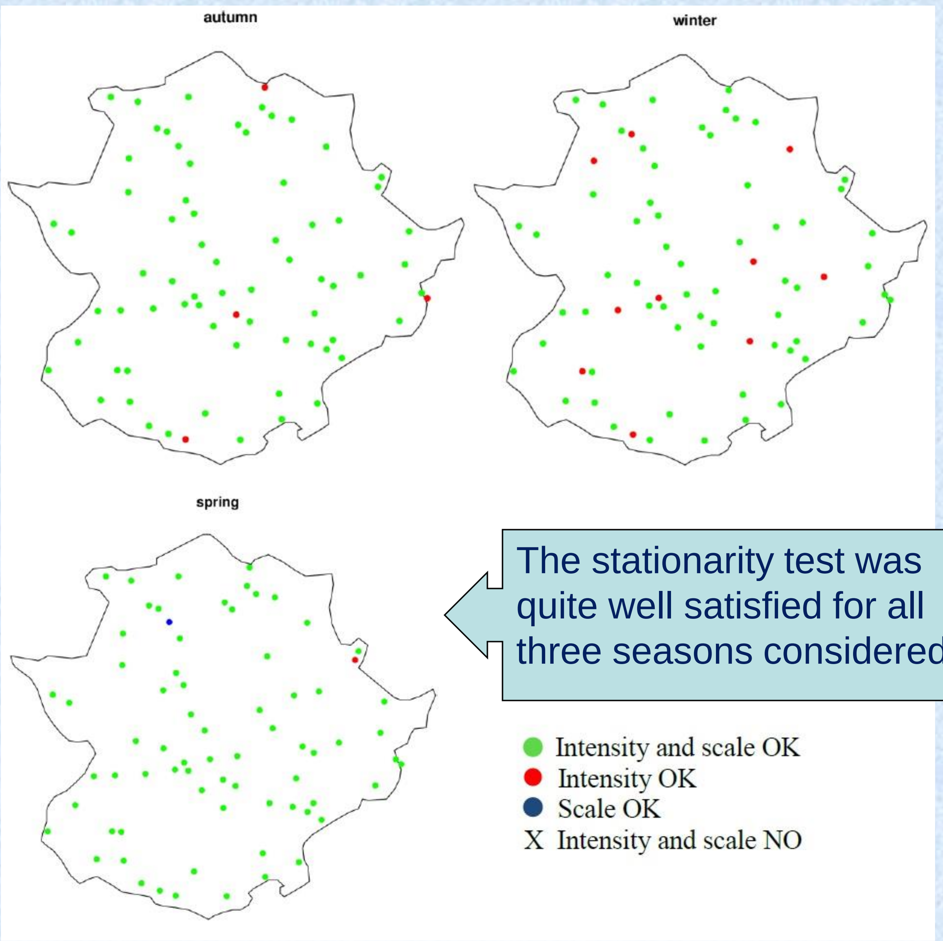
- Two different approaches were taken to calculating near future RLs:
  - M1: A linear threshold is taken, and, as the objective is to study the temporal change in extremes, the GPD parameters are allowed to vary with time according to the following widely accepted trend model: $\xi(t) = \xi$ and $\log \sigma(t) = \sigma_0 + \sigma_1 * t$. Once the trend in $\sigma(t)$ is known (and significant according to a likelihood ratio test at 5%), its linear extrapolation to 2020 is used to calculate the 20-year RLs in that year (Z20-f1).
  - M2: A residual process is constructed whose extremes can be considered as stationary (a test is applied to check for this). Then, to calculate the 20-year RLs in 2020 (Z20-f2), the daily mean and standard deviation in that year are estimated by linear extrapolation of the linear trends estimated from observations.



RESULTS

STATIONARITY TEST

Spatial distribution of the observatories that satisfy the stationarity of the extremes of the residuals computed from the rainy-day time series



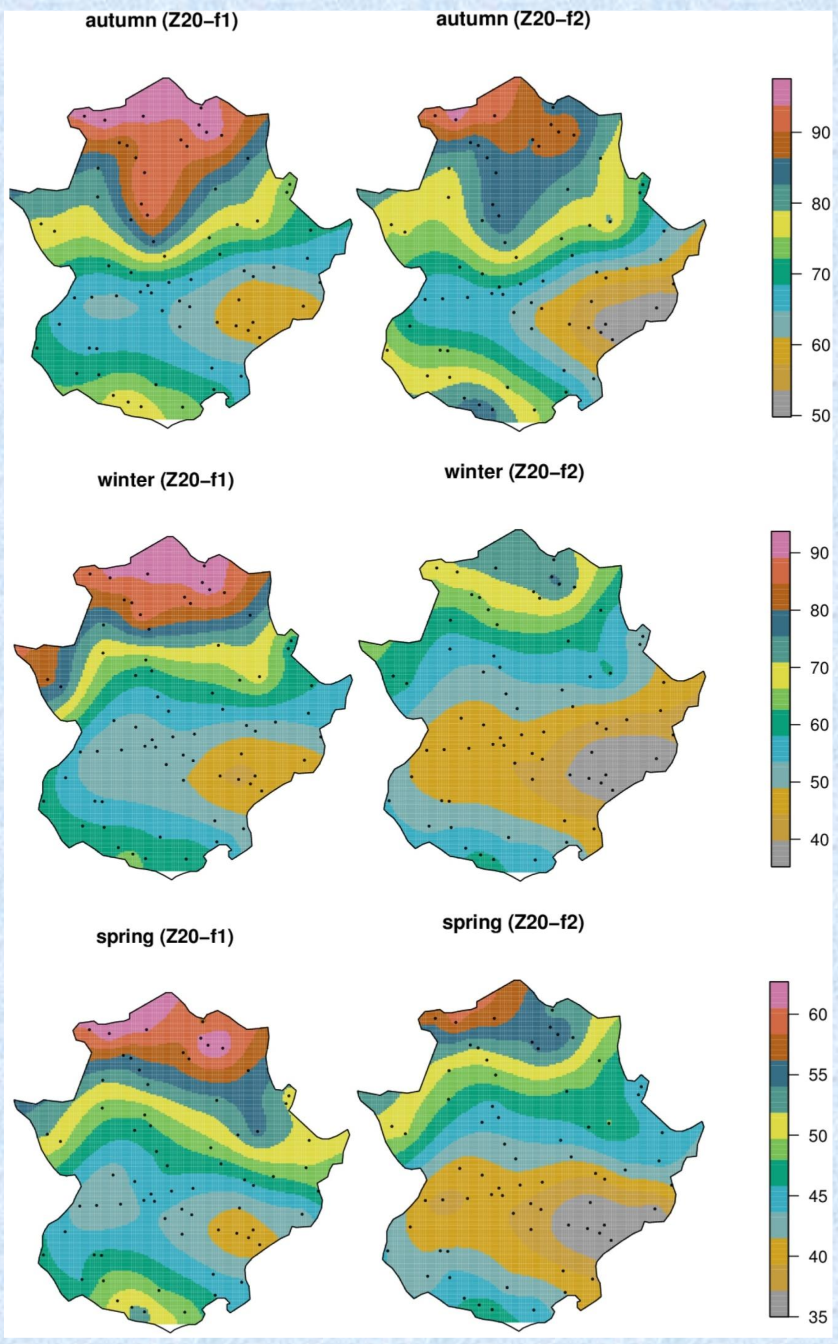
The stationarity test was quite well satisfied for all three seasons considered

	Mean		Variance		Number of Rainy Days	
	+ (signif.)	- (signif.)	+ (signif.)	- (signif.)	+ (signif.)	- (signif.)
Autumn	23 (4)	49 (22)	50 (7)	22 (2)	67 (29)	5 (0)
Winter	4 (0)	68 (48)	12 (0)	60 (37)	46 (41)	26 (7)
Spring	10 (1)	62 (38)	20 (1)	52 (11)	50 (16)	22 (2)

Number of positive or negative trends in the mean, variance, and number of rainy days, with the number of significant trends of each sign in parentheses.

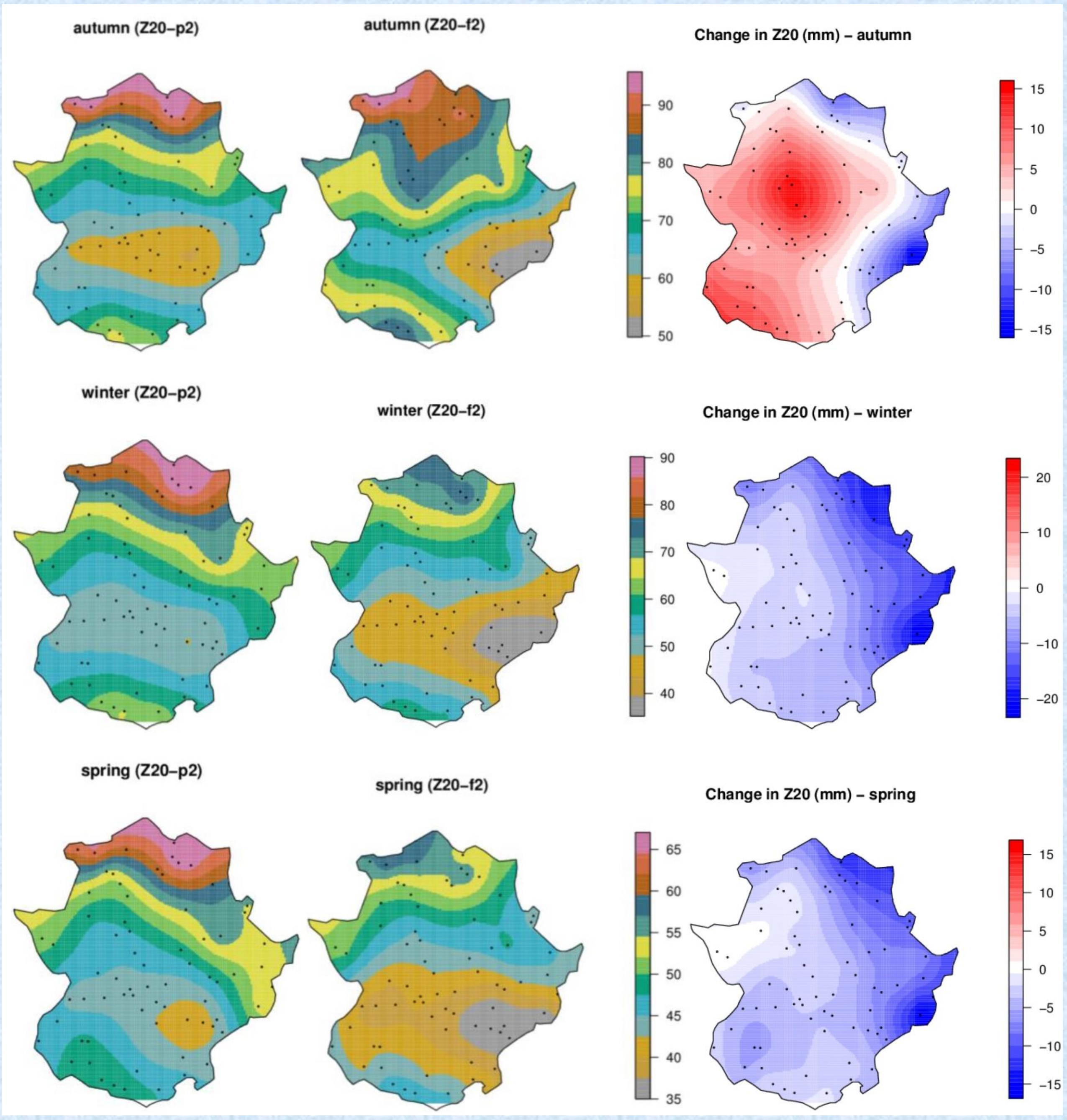
20-YEAR RLs IN FUTURE

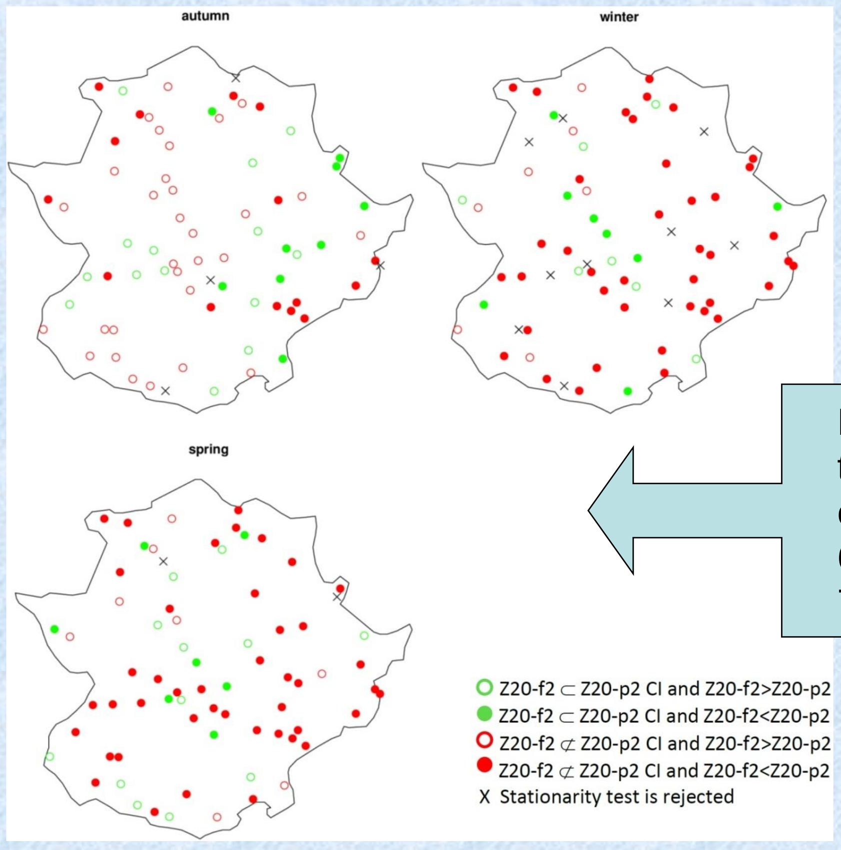
Spatial distribution of the 20-year RLs (Z20) in mm for the future climate in 2020, calculated from the all-day time series (left) using Method M1 and from the rainy-days-only time series (right) using Method M2.)



EXPECTED CHANGES IN RLs

Spatial distribution of the 20-year RLs (mm) for each season considered for the present time (left) and future time (centre), and the differences between the present and the future cases (right)





Spatial distribution of the 20-year RLs in 2020 obtained through the stationarity test (Z20-f2) that lie or do not lie inside the CI of the present 20-year RLs obtained with the same method (Z20-p2).

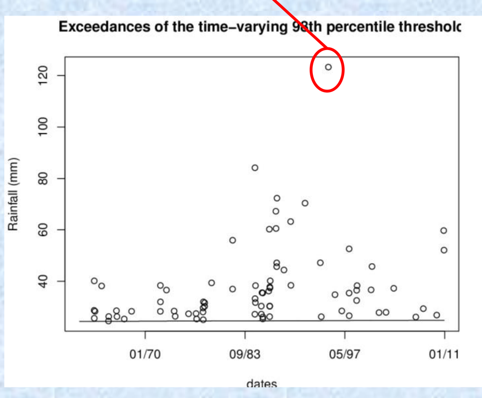
For the three seasons considered, there are more gauges with Z20-f2 outside the Z20-p2 CI – in particular, 67% for autumn, 76% for winter, and 72% for spring

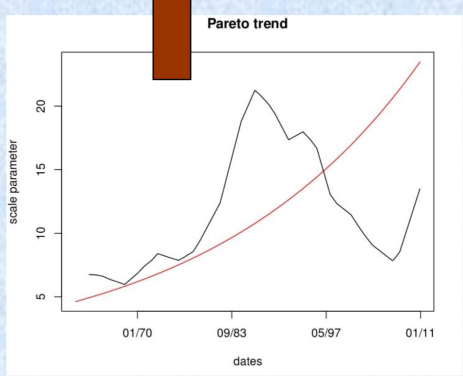
But there are exceptions…

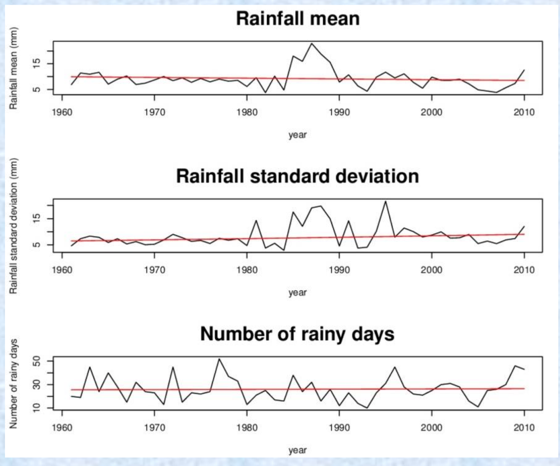
- Trends in mean and variance are identified, but not in the scale parameter.
- A trend is identified in the scale parameter but not in the mean and variance.

This approach is unable to take the isolated maximum of this case into account properly

The great rise in the trend seems to make no sense







CONCLUSIONS

- Generally, the two approaches give comparable results for the future RLs, but there are some exceptions. These are mainly due to the sensitivity to the threshold of the identification of the trend in the scale parameter, and may sometimes lead to unrealistic results. The use of the mean and variance constitutes a more robust approach when the identification of a trend in the GPD scale parameter is difficult and very sensitive to the threshold choice. It also leads to reduced CIs
- There are special cases for which both approaches seem to fail. They give different values for the future RLs, but probably neither of them is reliable.
- The future evolution of the RLs varies from season to season. There are decreases in winter and spring, and increases in autumn. The evolution of the variance was seen to play a major role in the estimation of the extremes since the increases in autumn closely matched the increases in the variance.

REFERENCES: Parey et al. (2010a), *Clim .Dyn. 34*; Parey et al. (2010b), *Environmetrics* 21; Acero *et al.* (2011), *J.Clim 24*

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