PRECIPITATION TRENDS IN MAINLAND PORTUGAL IN THE PERIOD 1941-2000

M. Isabel P. de Lima (*IMAR/Polytechnic Institute of Coimbra, Portugal*)

Ana C. P. Marques (*IMAR, Coimbra, Portugal*)

João L. M. P. de Lima (*IMAR / University of Coimbra, Portugal*)

M. Fátima E. S. Coelho (*Meteorological Institute, Portugal*)

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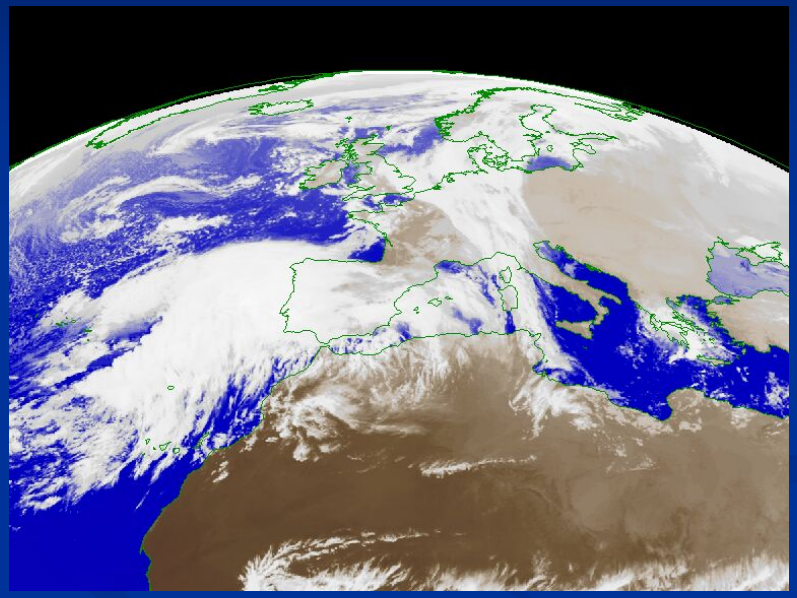
The presence of a trend in hydrologic parameters can result from the highly variable nature of hydrological processes or be related to climate variations.

Precipitation is perhaps the most important component of the complex hydrologic cycle because of its impact on our daily life.

Therefore precipitation is often taken as a starting point towards the understanding of changes of the governing processes of climate.

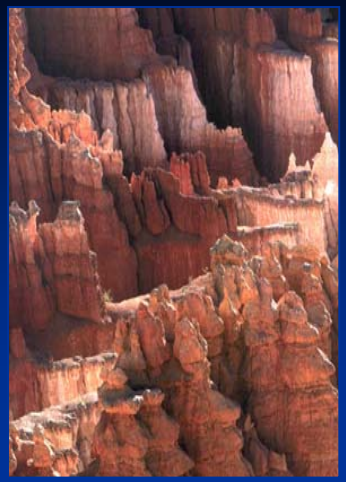
PRECIPITATION

The characterization of the large non-linear variability and intermittency of precipitation, which is present over a wide range of *spatial and temporal scales*, is an important issue in many areas of research as well as in hydrological studies and applications.



Precipitation has impacts on society, economic activities (e.g. agriculture), land use and water resources.

PRECIPITATION



- in certain cases, the large non-linear **variability** of precipitation leads to **catastrophic events**, both related to **drought** and **flood** situations.

Objective:

The purpose of this work is to contribute to a better understanding of the variability of precipitation by investigating recent trends in the temporal structure of this process in Mainland Portugal.

In statistical terms a test for trend is a determination of whether the probability distribution from which the data arise has changed over time.

Precipitation data

Study region:

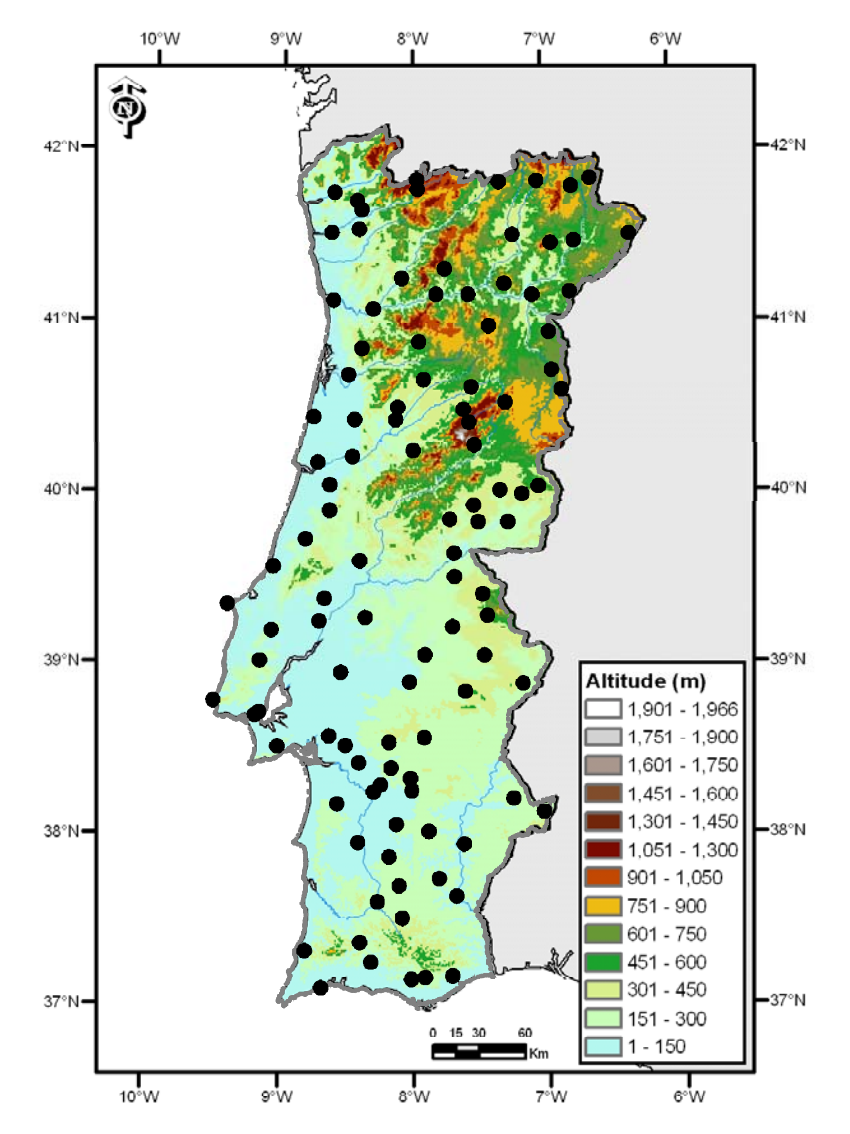
Portugal, 107 locations

Type of data:

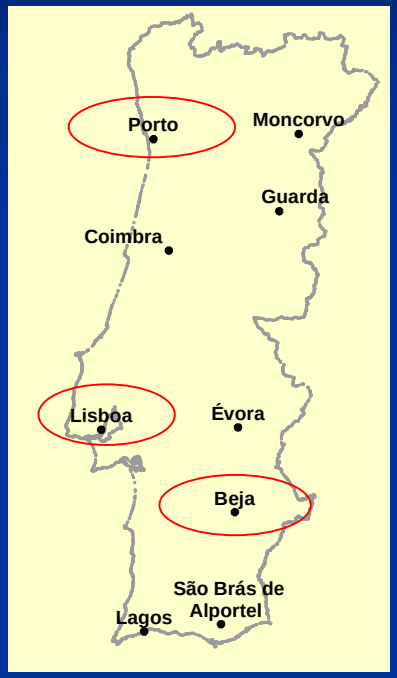
ANNUAL and MONTHLY

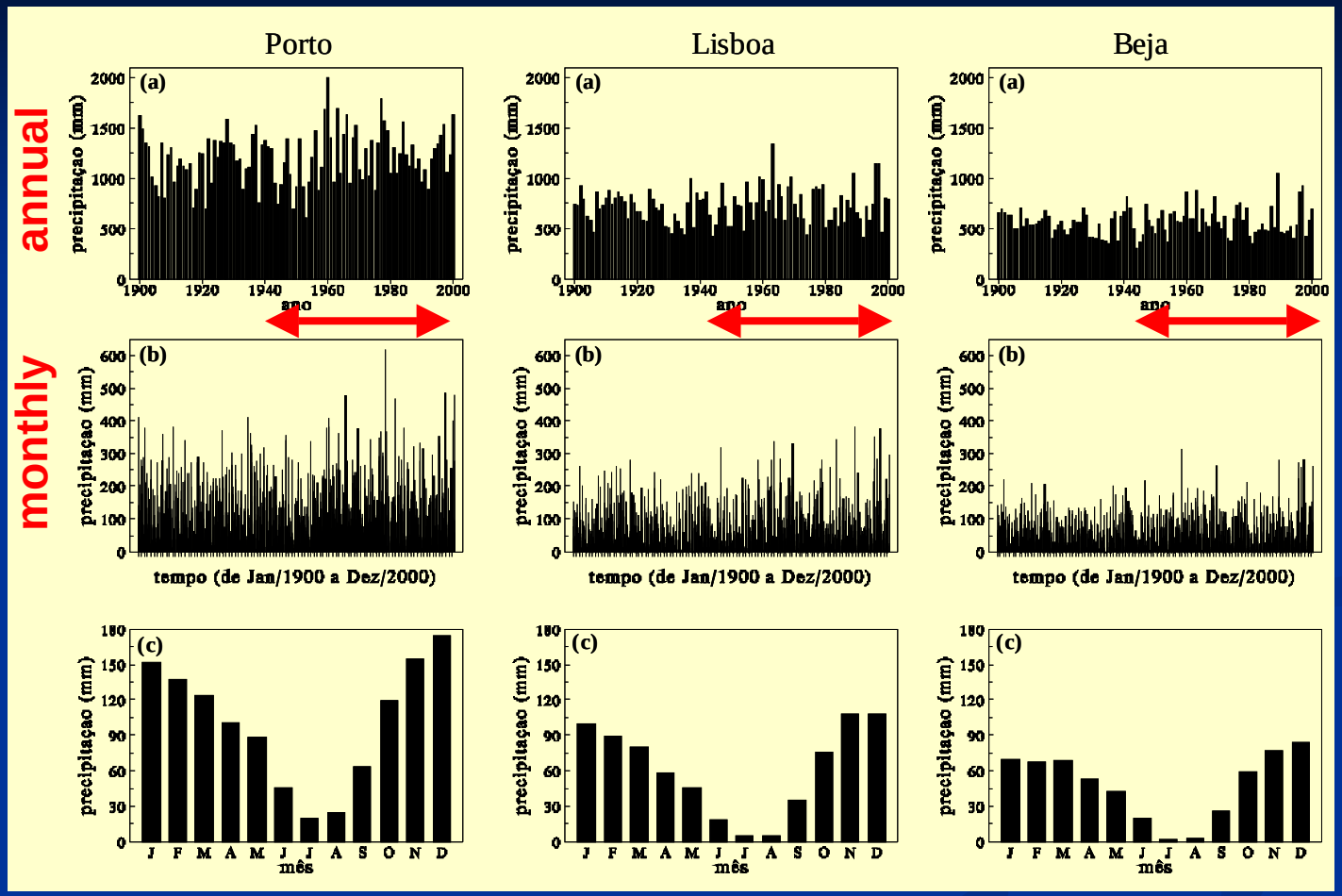
Period:

1941-2000 (60 years)



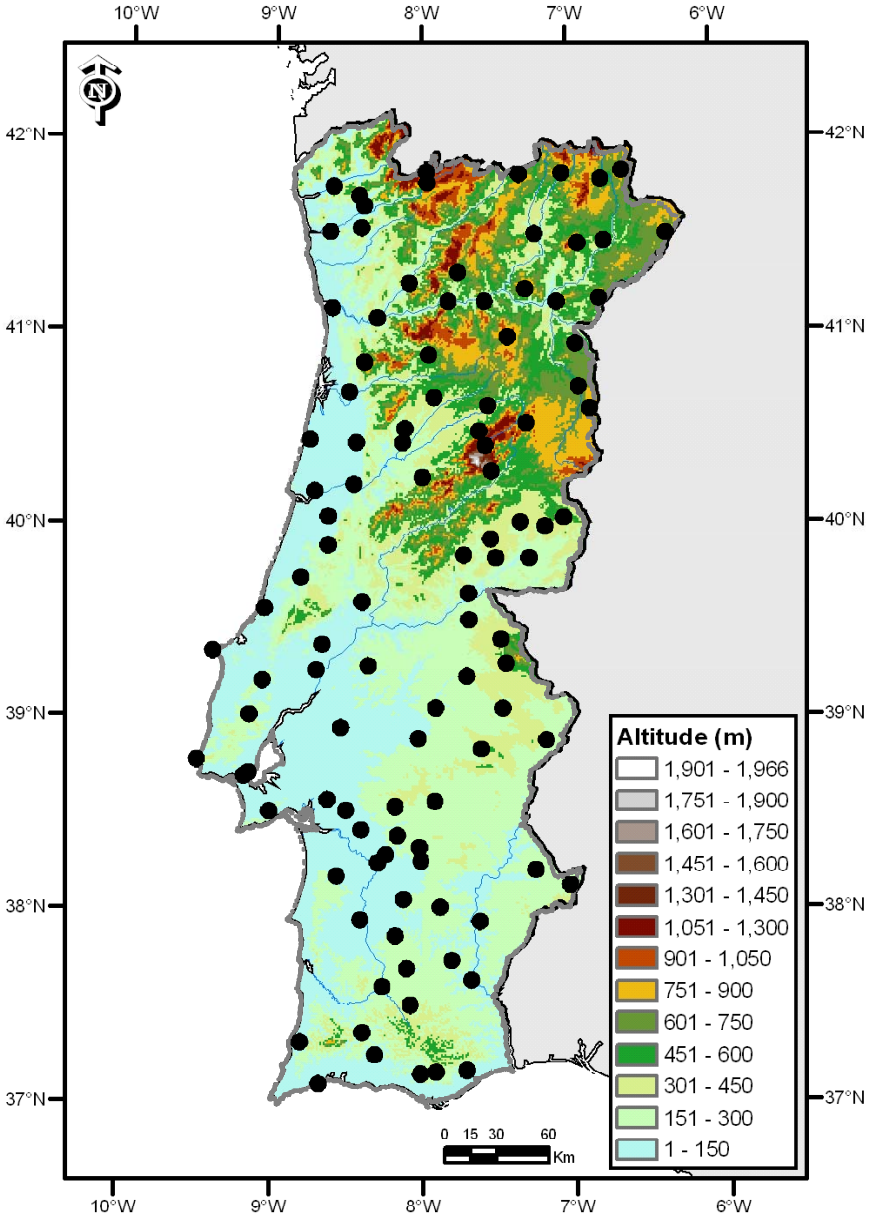
1900-2000

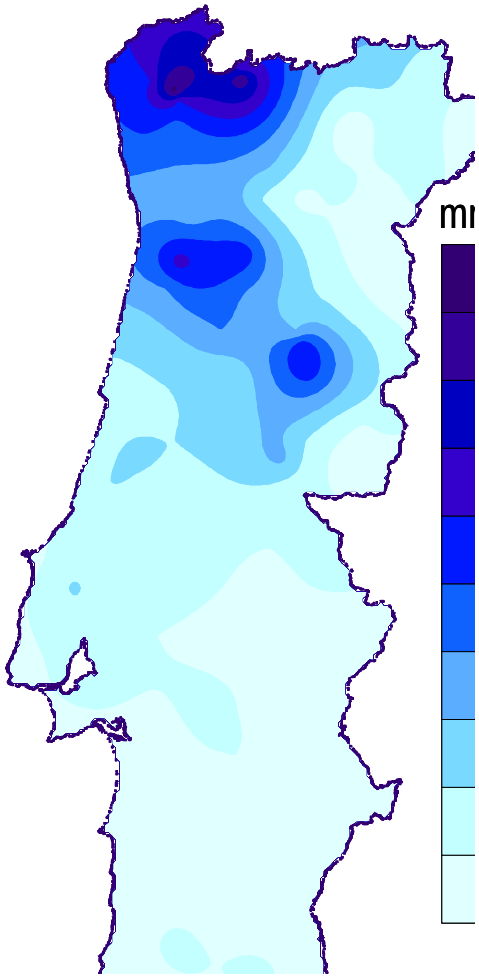




The spatial distribution of precipitation and its seasonal variability are the result of the characteristics of the global circulation (specifically the Atlantic origin of many synoptic disturbances) in the context of the regional factors (e.g. latitude, orography, oceanic and continental influences).

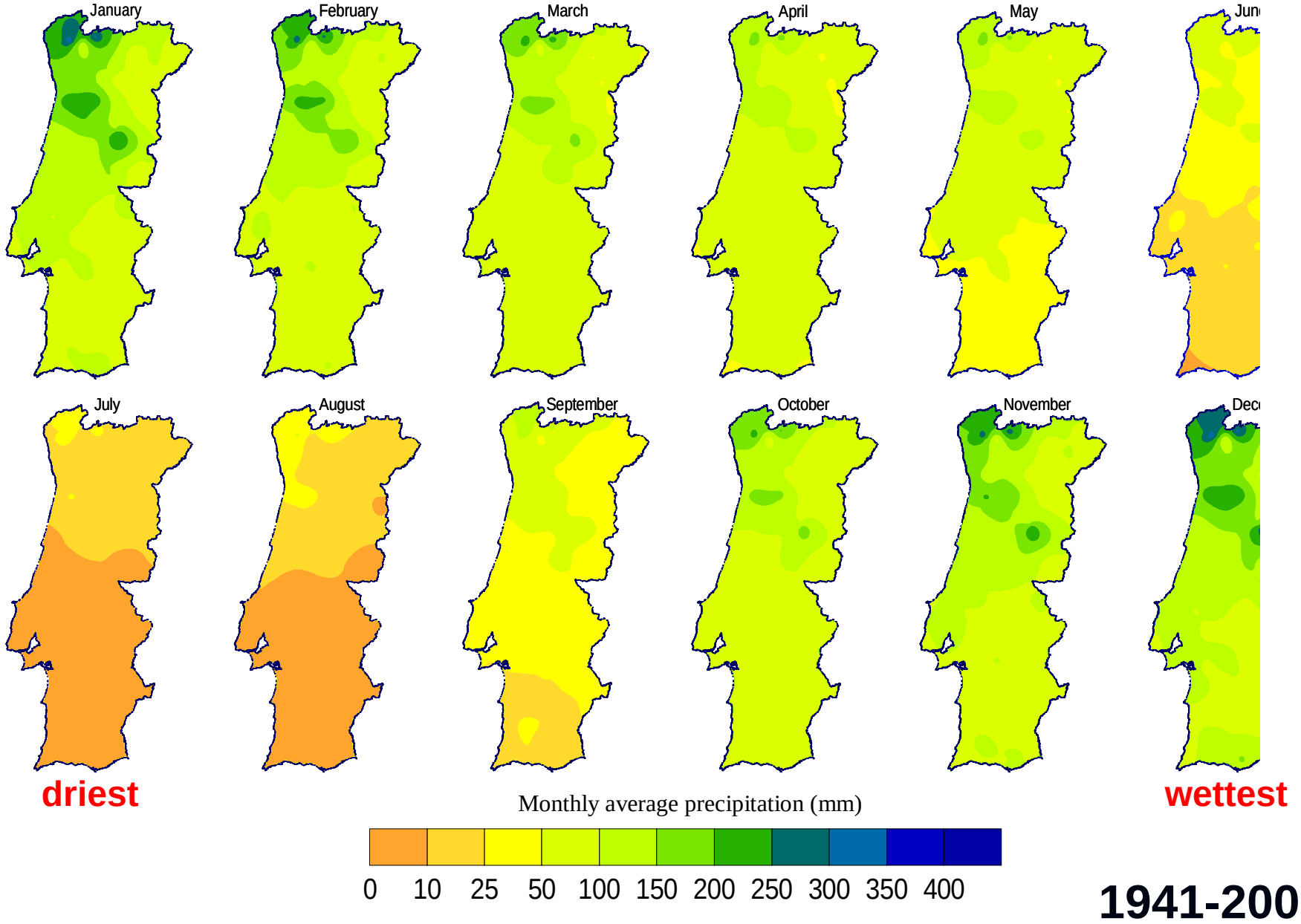
Mean annual precipitation





1941-2000

MONTHLY AVERAGE PRECIPITATION



Methods

<u>Relative consistency and homogeneity</u> test

analyses of deviations from the mean

<u>Serial Correlation</u> test

non-parametric Wald-Wolfowitz test

<u>Trend</u> tests

non-parametric Mann-Kendall test

Sen-slope estimator

Wald-Wolfowitz test (Wald & Wolfowitz, 1943)

A non-parametric test used for detecting serial correlation in the precipitation data

Let $x_1, x_2, \ldots, x_n$ be a time series with mean equal to zero.

The statistic U of the test is defined by

$$U = \frac{1 + (n-1)\left[\dfrac{\sum_{i=1}^{n} x_i x_{i+1}}{\sum_{i=1}^{n} x_i^2}\right]}{\sqrt{n-1}}$$

where x_i is the observation i, $x_{i+1} = x_1$, and n is the sample dimension.

Under the null hypothesis of no persistence, the statistic U follows a standard normal distribution (mean equal to zero and variance equal to one).

Mann-Kendall test (Gilbert, 1987)

A non-parametric test, used to verify the possible existence of monotonic increasing or decreasing **trends** in precipitation.

For each element x_i from the time series, the number n_i of elements x_j preceding x_i ($I < j$) is counted. The test statistic ***R*** is then given by

$$R = \sum_{i=1}^{n} p_i$$

where p_i is the number of elements exceeding x_i.

Under the null hypothesis, ***R*** is asymptotically normal, with mean and variance:

$$E(R) = \frac{n(n-1)}{4}$$

$$Var(R) = \frac{n(n-1)(2n+5)}{72}$$

The null hypothesis must therefore be rejected for high values of $|Z|$ with:

$$Z = \frac{r - E(r)}{\sqrt{Var(r)}} \cap N(0,1)$$

$$\Phi(|z|) > 0.95$$

$Q_i = \frac{x_j - x_k}{j - k}$

Sen's non-parametric method (Sen, 1968; Gilbert, 1987)

To estimate the **slope** of an existing trend (assumed to be linear), which allows for the quantification of the amount or rate of change over time.

The precipitation time series ***P*(*t*)** can be described as ***P(t)* =*Qt* + *B***, where ***Q*** is the slope (trend), ***t*** is time and ***B*** is a constant.

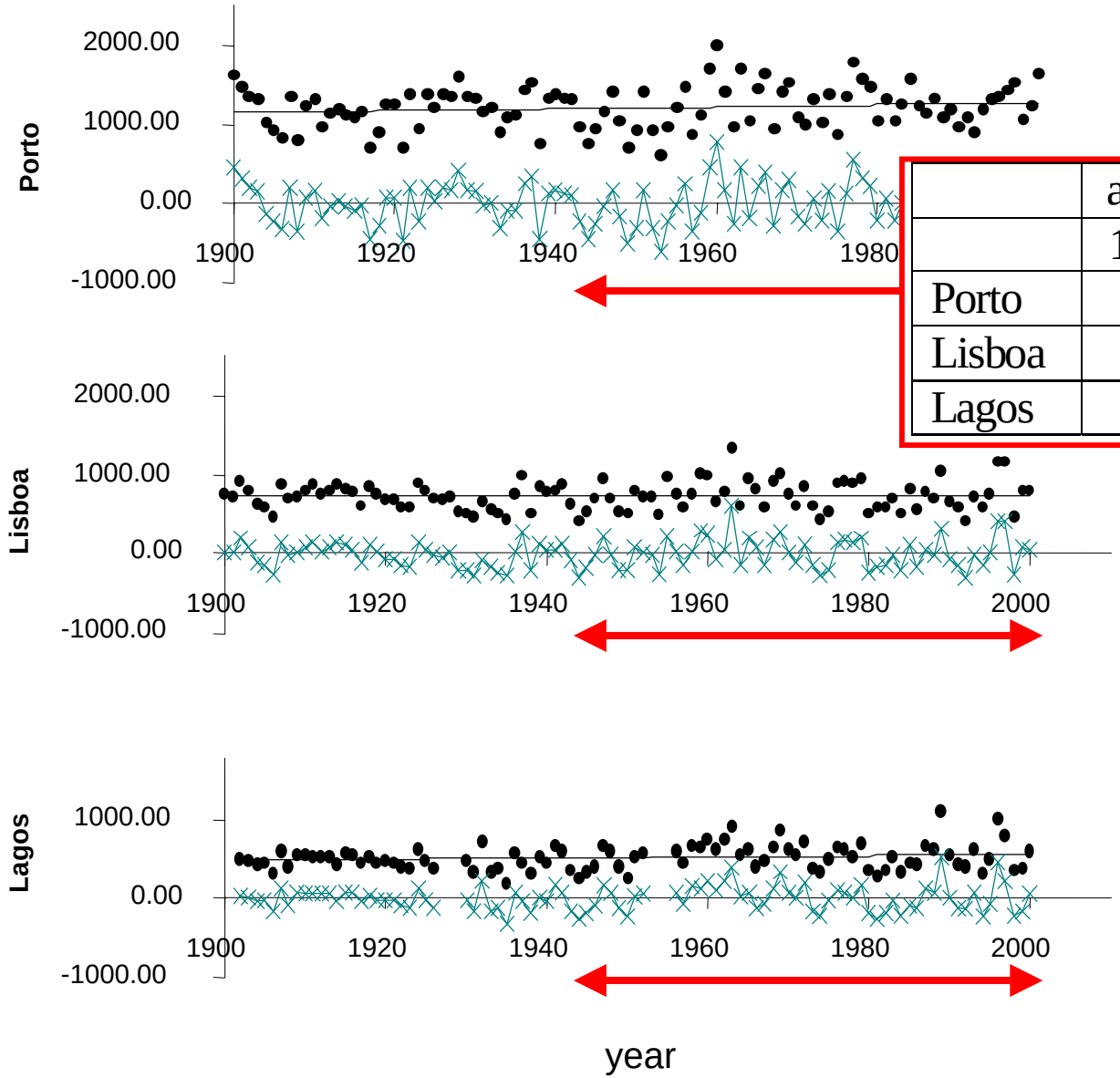
To get the slope ***Q***, we first calculate the slopes $\boldsymbol{Q_i}$ for all *i* pairs of data (*j* and *k*):

$$Q_i = \frac{x_j - x_k}{j - k}$$

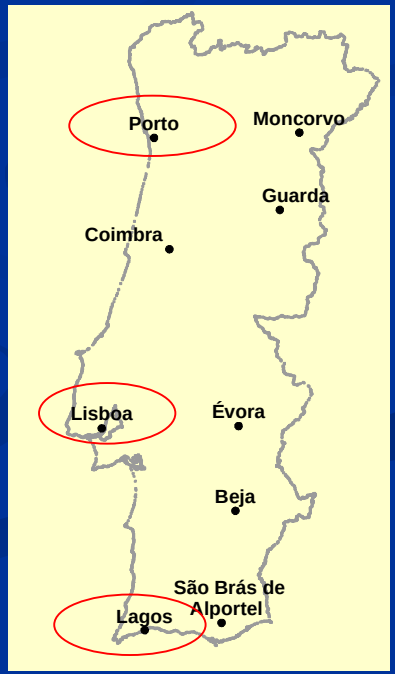
with $j > k$

For *n* values x_j in the time series we get slope estimates Q_i.

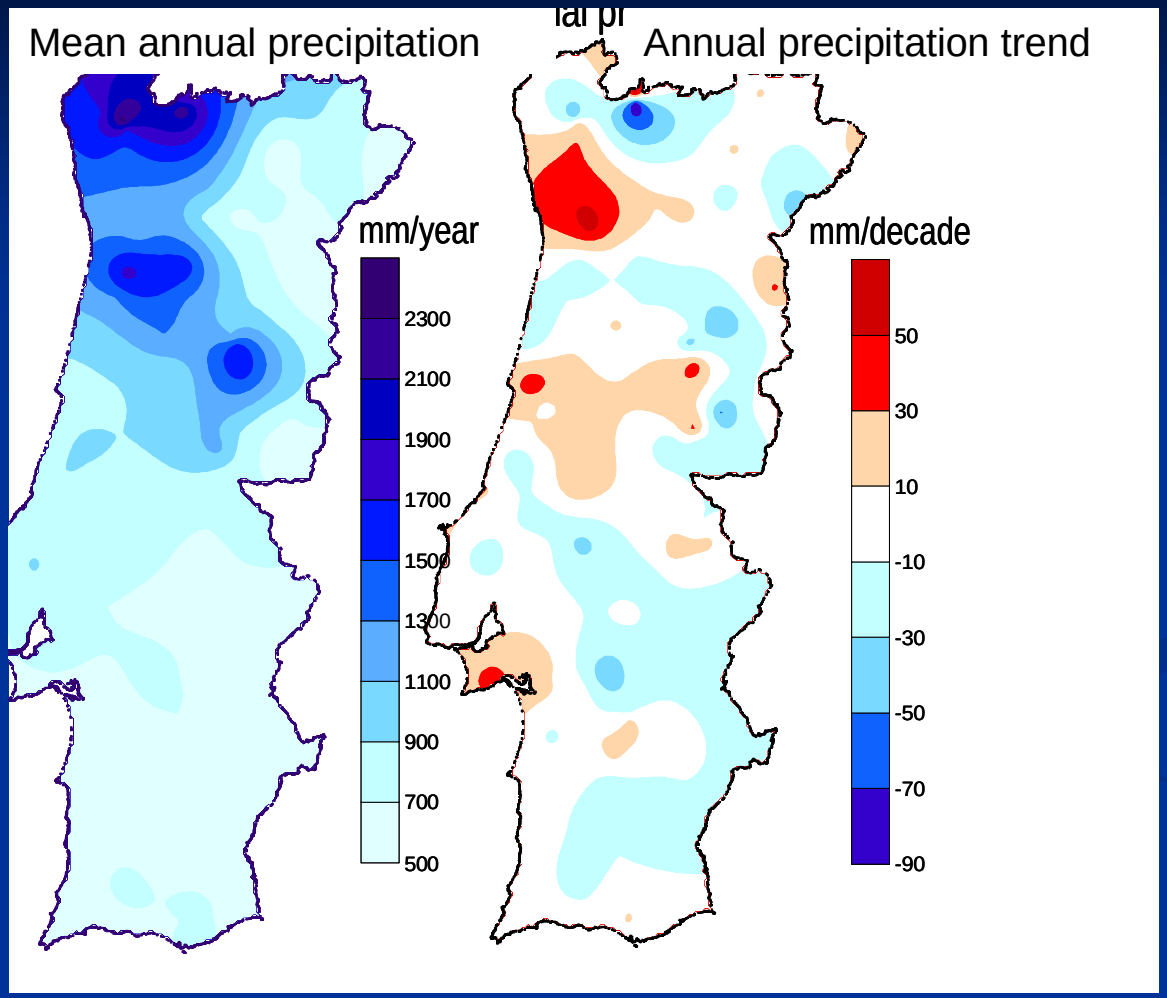
The Sen´s estimator slope *Q* is the median of these *N* values of Q_i.

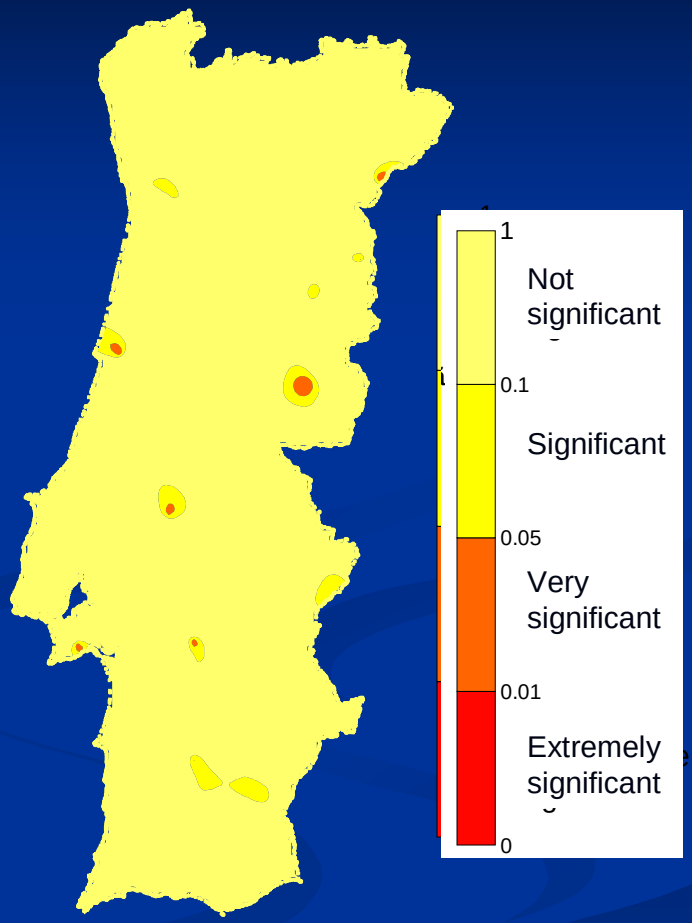


	annual trend (mm/decade)	
	1900-2000	**1941-2000**
Porto	11.5	36.8
Lisboa	0.8	1.7
Lagos	8.5	-0.3



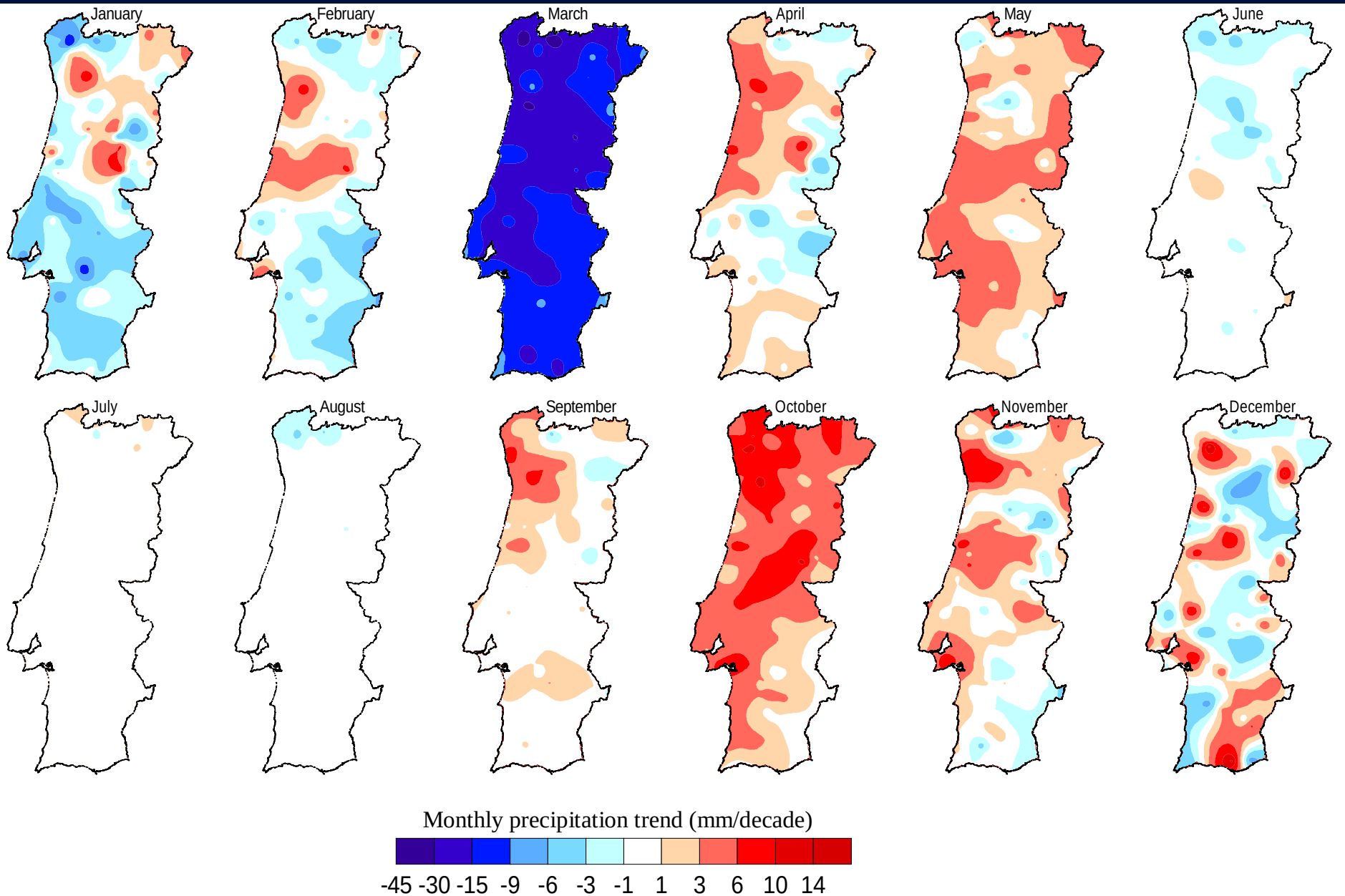
1941-2000

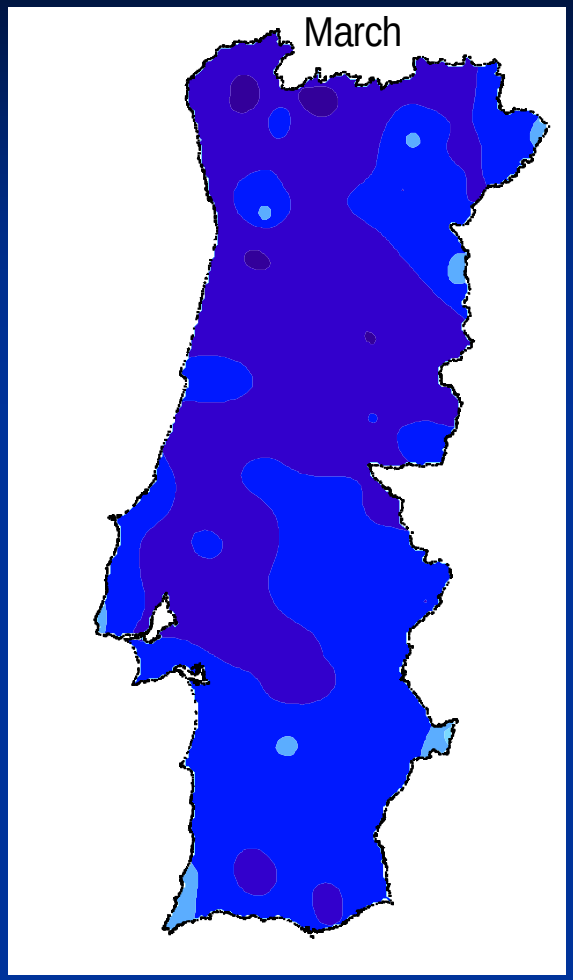




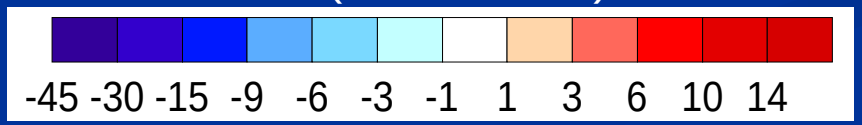
Statistical significance level

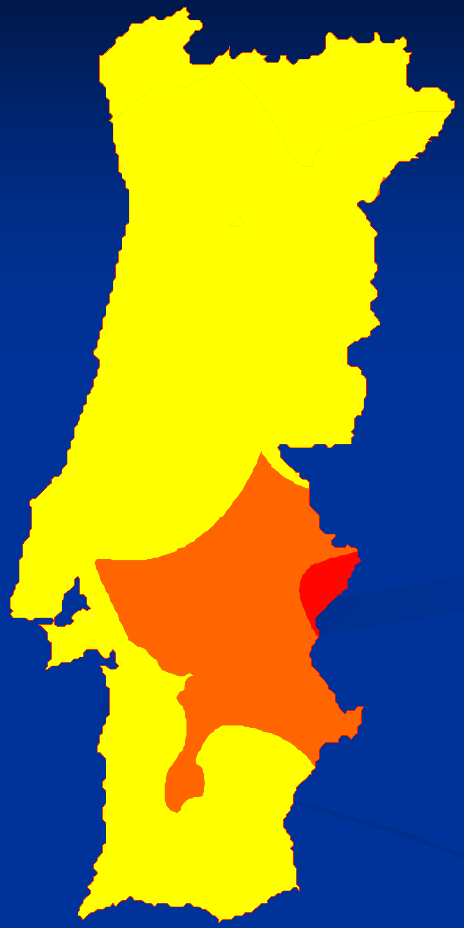
Monthly precipitation trend: 1941-2000

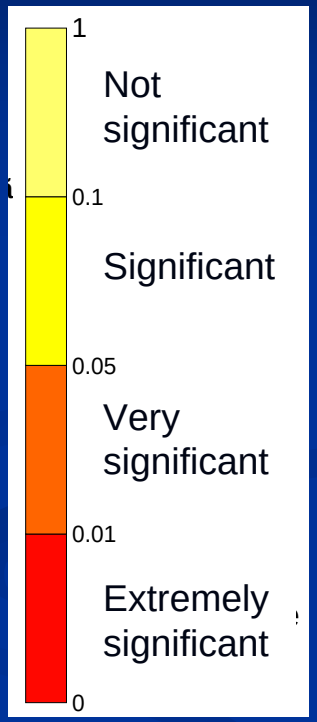




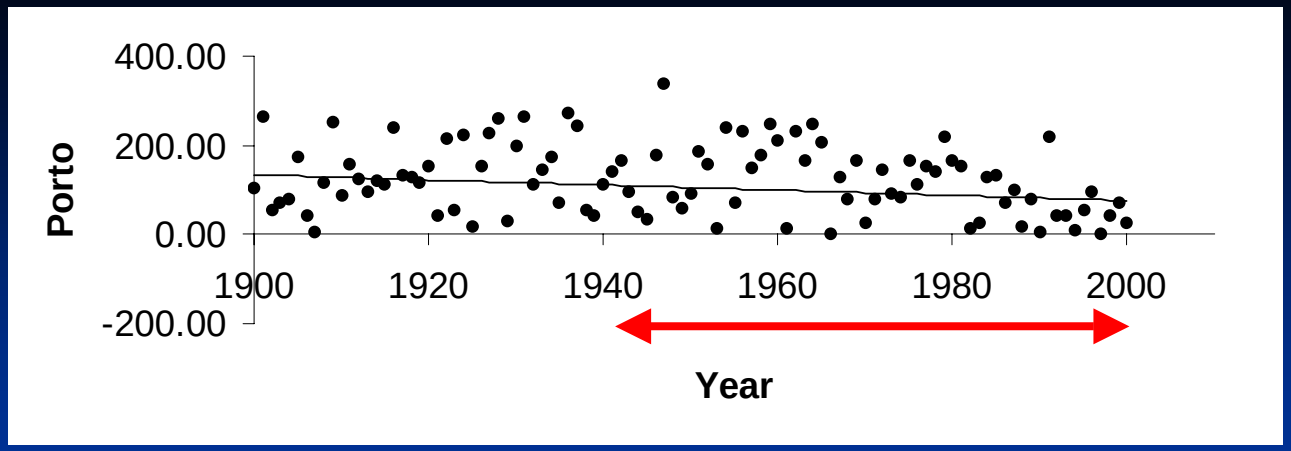
Precipitation trend
(mm/decade)

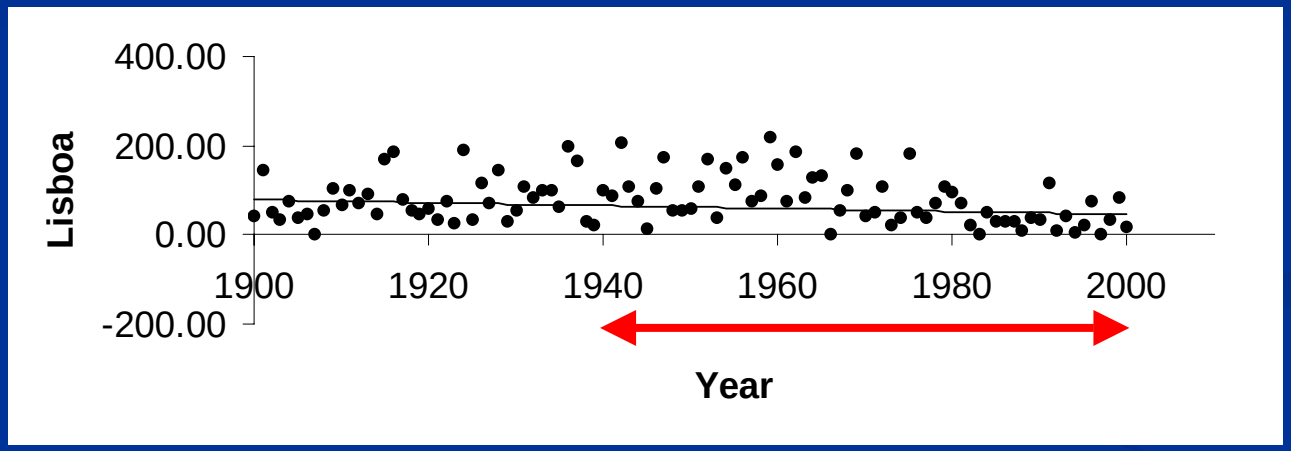


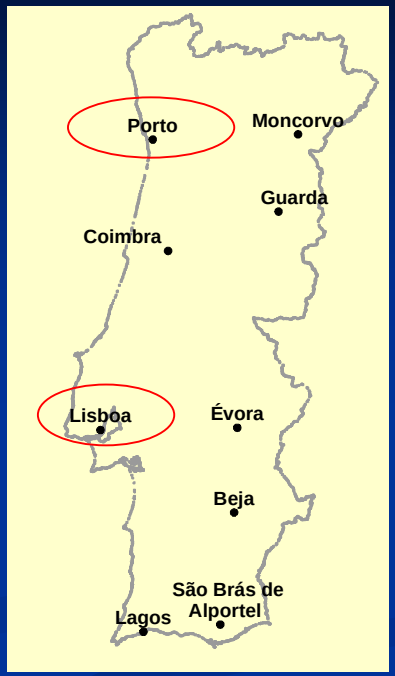




Statistical
significance level







MARCH	Monthly trend (mm/decade)	
	1900-2000	**1941-2000**
Porto	-5.8	-17.1
Lisboa	-3.3	-15.6

Concluding remarks

Overall, the annual precipitation in Mainland Portugal shows no signs of statistically significant trends (i.e. at least at the 90 % confidence level) during the period from 1941 to 2000.

These trends in annual precipitation are limited to a few locations.

There is however consistency in the behaviour (increase or decrease of annual precipitation over time) observed in the various regions of Mainland Portugal.

Concluding remarks

- With respect to the seasonal distribution of precipitation during the year over Mainland Portugal, results show that there is a trend, from 1941 to 2000, towards the following:

  middle autumn and beginning of spring has become wetter;

  winter and late spring has become drier;

  This trend is not always statistically significant.

- Although the analyses of both annual and monthly data led to a characterization of changes in the distribution of precipitation over Mainland Portugal and within the year, the period analysed and the selection of stations may have influenced the regional pattern.