



Smart control of the climate resilience in European coastal cities

Grid-Point Rainfall Trends, Teleconnection Patterns, and Regionalised Droughts in Portugal (1919–2019)

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ABSTRACT

The research addresses long-term **grid-point rainfall trends** in the context of **climate change**, recent regionalised rainfall decline and drought events in mainland **Portugal** teleconnected to the trends of mathematical descriptions of the North Atlantic Oscillation (NAO) during the century from October 1919 to September 2019.

- The gridded rainfall dataset (126 centroids in a regular mesh over the country, Figure 1) have been constructed from high-quality ground-based data and as such, it provides a reliable source for the analysis of rainfall trends at the following timescales: October-December (OND), January-March (JFM), December-March (DJFM), and hydrological year, from October to September (ANN).
- The **Mann-Kendall (MK)** coupled with **Sen's slope** estimator tests were applied to quantify the trends. The **Sequential Mann-Kendall (SQMK)** analysis is implemented to obtain the fluctuation of the progressive trends along the studied 100-year period (Figure 2).
- Because of their pivotal role in linking and synchronising climate variability, teleconnections to the fluctuation of atmospheric pressure over the **North Atlantic Ocean** were also explored to explain the rainfall trends over the Portuguese continuum.
- Results provide a solid basis to explain the climate change effects on the Portuguese rainfall based on significant associations with strong negative correlations between changes in rainfall and in NAO indices (NAOI, i.e., nOND, nJFM, nDJFM, and nANN; Figure 3). **After late 1960's a generalised rainfall decrease in Portugal emerges against a background of significant upward trends of the North Atlantic Oscillation, which has persisted for decades.**
- Regionalised droughts at three identified **climatic regions** (Figure 4), based on factor analysis and Standardised Precipitation Index (SPI), are also discussed concluding that the frequency of severe droughts may increase again accompanied by a stronger influence of recently more positive and unusual winter season and annual NAOI.

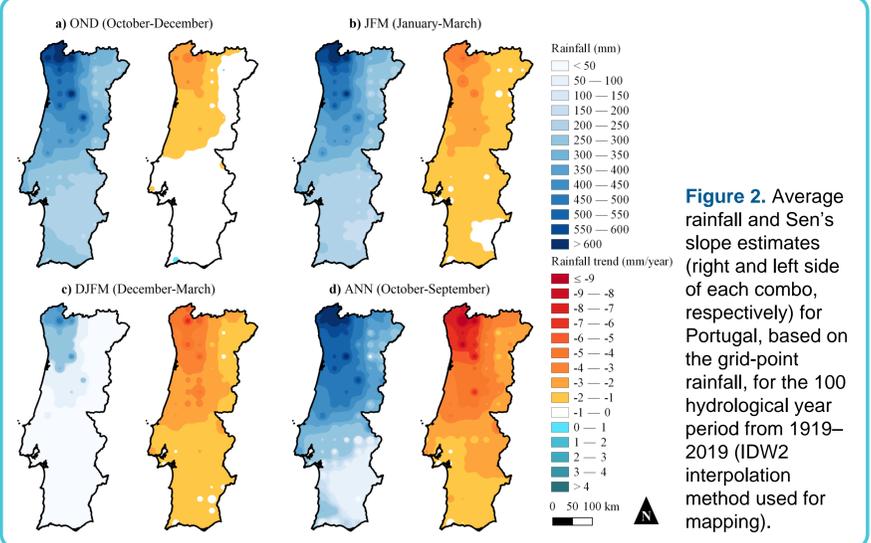


Figure 2. Average rainfall and Sen's slope estimates (right and left side of each combo, respectively) for Portugal, based on the grid-point rainfall, for the 100 hydrological year period from 1919–2019 (IDW2 interpolation method used for mapping).

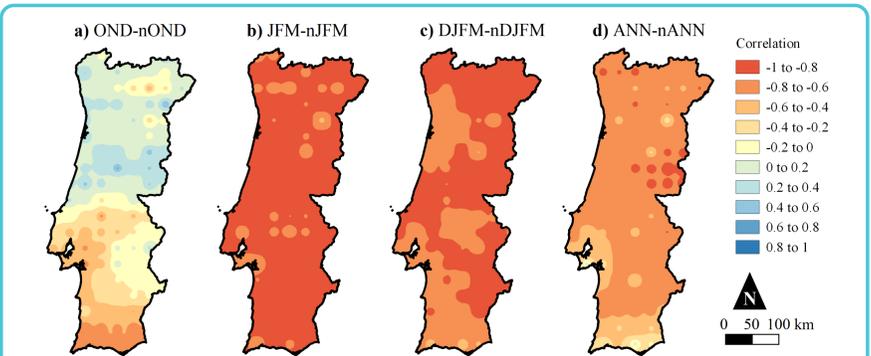


Figure 3. Teleconnection between the gridded rainfall trends and NAOI trends from 1919 to 2019. Spatial distribution of the Pearson correlation coefficient between the progressive-trend series of OND, JFM, DJFM, and ANN rainfall; and nOND, nJFM, nDJFM, and nANN NAOI, respectively (IDW2 interpolation method used for mapping).

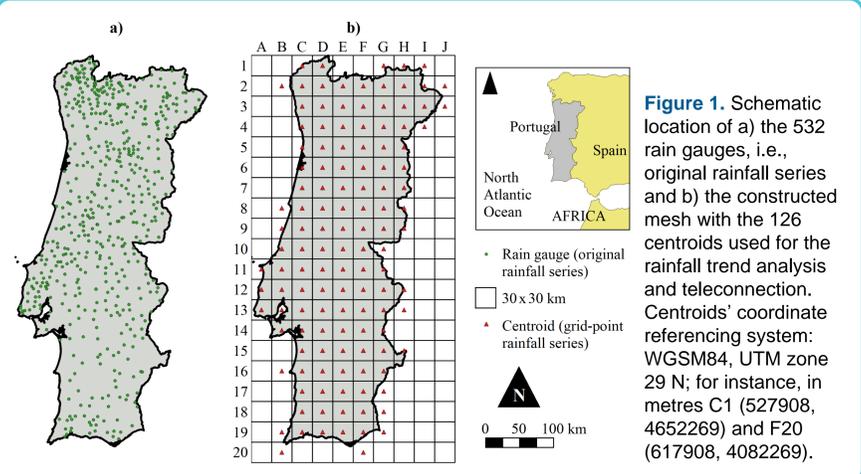


Figure 1. Schematic location of a) the 532 rain gauges, i.e., original rainfall series and b) the constructed mesh with the 126 centroids used for the rainfall trend analysis and teleconnection. Centroids' coordinate referencing system: WGS84, UTM zone 29 N; for instance, in metres C1 (527908, 4652269) and F20 (617908, 4082269).

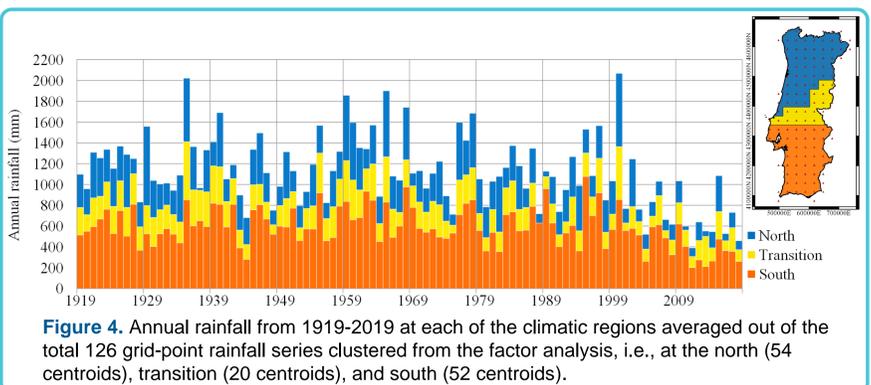


Figure 4. Annual rainfall from 1919-2019 at each of the climatic regions averaged out of the total 126 grid-point rainfall series clustered from the factor analysis, i.e., at the north (54 centroids), transition (20 centroids), and south (52 centroids).

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