A spatial extremes characterization of the annual maxima precipitation in Madeira Island

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Abstract
A variety of statistical tools such as copulas and spatial max-stable processes have been used in the most recent decades for modelling spatial extreme data. Our aim is to give a spatial extremes characterization of Madeira Island’s annual maxima precipitation using annual maximum daily precipitation data from 17 rain gauge stations throughout the island.

Key Words: Statistics of extremes, spatial extremes, copula function, extreme precipitation.

Introduction
Extreme spatial rainfall events triggered a significant number of flood hazards, landslides and debris flows in Madeira Island, a volcanic island located in the north-east Atlantic Ocean between latitudes 32°35’N and 32°57’N, and longitudes 16°19’W and 16°41’W. Among the most significant events was the one that happened in the 30th of May 2000, which caused 179 fatalities, as well as material and economic damage to properties and infrastructure [1].

The spatial distribution of precipitation in Madeira Island is generally affected by its high geographical topography and sea coasts. It is aimed to give a spatial extremes characterization of Madeira Island’s annual maxima precipitation through copula function [2]. Using annual maximum daily precipitation data from 17 rain gauge stations spread throughout the island for the study the Department of Water Resources and Energy Technologies of the Madeira Regional Laboratory of Civil Engineering.

A variety of spatial extremes methods based on a neural tree, copula and spatial max-stable processes is presented by Bastos et al. [2], which show that the approach chosen copula or max-stable models seems to be essential for the spatial modelling of extremes. The importance of copulas and a copula approach for modelling spatial dependences is also emphasized by other authors such as Coles et al. [5]. Although the present work and result of the studies on spatial extremes are in the spatial context of focus on modelling block maxima data, it is important to mention here that there are other studies (e.g., [7]) where these same methods are also applied to continuous time series of extreme values.

Statistical Analysis

Data
The data used in this study concern the highest values of annual daily precipitation on the island of Madeira, in the period of 1961-1985. The data come from 17 rain gauge stations maintained in the past by the General Council of the Autonomous Region of Madeira, which approximate location is indicated in Figure 1. Gouveia-Reis et al. [5], according to the proximity of the station to each other. Table 1 provides information about each of the rain gauge stations, namely their identification, geographical location and altitude.

The station altitude is of interest in the analysis of the annual maxima precipitation on the island of Madeira. In this study, a station is considered for analysis the one that is found to be the most suitable for the analysis of the spatial extremes characterization of the annual maxima precipitation on the island of Madeira.

The latest and highest annual return periods were obtained for the stations of Group 4 and 3, respectively. The only rain gauge stations common to both groups is Santo da Serra (N). The other two stations in Group 4 have higher altitude than Santo da Serra (N), but not in the same group as Group 4. Some of the stations have an altitude of block maxima data.

Table 6: Return periods in years, , and for the extreme precipitation in the southern and northern groups.

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Table 7: Spatial groups and corresponding parameters, , , and .

The location and altitude range of the rain gauge stations are showed in Figure 2. All the corresponding groups treated by pairs of stations are described in Table 5. The values for the parameters , in (2) and (4), for the rain gauge stations are also presented in Table 7.

Key Words: Statistics of extremes, spatial extremes, copula function, extreme precipitation.

References

Table 1: Total rainfall distribution in Madeira Island.

Table 2: Annual maxima daily precipitation values at the rain gauge stations.

Table 3: Rainfall groups and corresponding parameters, , , and .

Table 4: Rainfall groups and corresponding parameters, , , and .

Table 5: Return periods in years, , and for the extreme precipitation in the southern and northern groups.

Table 6: Return periods in years, , and for the extreme precipitation in the southern and northern groups.

Table 7: Station and corresponding parameters, , , and .