



## **Analysis of climate variability in mainland Portugal using a combined Climate Extremes Index**

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Monitoring changes in climate extremes is important because of their potential severe impacts on the environment and the society. Due to its geographical situation, mainland Portugal shows important spatial gradients in precipitation and air temperature and is prone to the occurrence of extreme weather and climate events, such as heat waves, droughts and floods. Thus, there is a need to understand regional specificities in the changes of occurrence of these events in the territory that could require special attention in the prospect of operational climate change adaptation and mitigation measures, to be adopted at the regional scale.

For this purpose, a modified combined Climate Extremes Index (CEI) is proposed here, for mainland Portugal. This index consists of five component indicators of air temperature and precipitation extremes and was developed to measure the percentage of area affected by these extremes. Therefore, we use this index to analyse changes in the fraction of the country experiencing extremes (cold, hot, dry, wet), at the annual and seasonal scales, after 1941.

At the annual scale, results show an increase in the extent of hot and dry extremes and a decrease in the extent of cold and wet extremes over the whole country, although only the results obtained for the air temperature are statistically significant. Since the mid-1970s, the fraction of the area of mainland Portugal experiencing maximum and minimum temperatures much above normal has increased significantly. An increasing trend in the area experiencing drought conditions and with a much greater-than-normal number of dry days is also noted in the last decades.

At the seasonal scale, spring, summer and winter show a significant increase in the extent of hot extremes and a decrease in the extent of cold extremes. For all seasons, the fraction of the area experiencing drought conditions increased, whereas in spring and autumn the fraction of the area experiencing wet conditions decreased. In summer and winter there is an increase (not statistically significant) towards more widespread events in both the dry and wet extremes.

Overall, this study shows the usefulness of the CEI in regional applications, by allowing the increased understanding of the spatial and temporal development of extreme events while combining the air temperature and precipitation extremes. These climate variables are usually inspected separately whereas their combined analysis provides additional important information.