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Extreme wind speed climatology over Greece

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Extreme wind speeds are a multifaceted environmental risk. They may cause considerable damage to infrastructure (e.g., bridges, private property), they can jeopardize maritime and aviation activities, and sometimes even human safety. Furthermore, the design of wind turbines for on and off-shore wind farms requires a study of the return periods of extreme wind speeds in combination with the lifespan of the wind turbines. Windstorms also result in major economic losses and cause up to 80 % of the natural hazards' long term insurance loss in Europe. The scope of this work is to identify location-specific extreme wind speed thresholds and obtain accurate estimates of exceedances for multiple future horizons. In this context, the Extreme Value Analysis framework is used for providing the return periods and the respective return levels of extreme wind speeds. The Peaks Over Threshold method is utilized for the 10 m wind speed for a domain centered over Greece, in Southeastern Mediterranean. Wind speed data at 10 m are extracted from the ERA5 reanalysis dataset that provides hourly estimates of surface wind speed with a horizontal resolution of 0.25°x0.25°, from 1979/01/01 up to 2019/12/31 (i.e., 41 years). The thresholds are selected using the Mean Residual Life plots, which is the most reliable method for identifying accurate threshold values. The seasonal analysis of the exceedances is discussed in terms of the physical mechanisms in the region. The exceedances are modelled using the Generalized Pareto Distribution, whose shape and scale parameters (ξ and σ, respectively) are estimated using the Maximum Likelihood Estimation method. The return levels and their confidence intervals are estimated for return periods up to 100 years. Geographic Information Systems are used for mapping future projections of extreme wind speeds and the corresponding confidence intervals. The results are discussed in terms of identifying high-risk areas and the findings could assist in informed decision-making in the wind energy industry. The proposed methodological framework could be extended to other areas characterized by particularly high wind speeds and the results can contribute towards sustainable investments and support adaptation mechanisms.