Development of a wind gust model to estimate gust speeds and their return periods

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Spatially dense observations of gust speeds are necessary for various applications, but their availability is limited in space and time. This work presents an approach to help to overcome this problem. The main objective is the generation of synthetic wind gust velocities. With this aim, theoretical wind and gust distributions are estimated from ten years of hourly observations collected at 123 synoptic weather stations provided by the German Weather Service. In a first step, an exposure correction is applied on measurements of the mean wind velocity to reduce the influence of local urban and topographic effects. In a second step, a transfer function is built between distribution parameters of wind and gust velocities. The aim of this step is to estimate the parameters of gusts at stations where only wind speed data is available. These parameters can be used in a third step to generate synthetic gusts, which can improve the accuracy of return periods at test sites with a lack of observations. The second objective is to determine return periods much longer than the nominal length of the original time series by considering extreme value statistics. Estimates for both local maximum return periods and average return periods for single historical events are provided. The comparison of maximum and average return periods shows that even storms with short average return periods may lead to local wind gusts with return periods of several decades. Despite uncertainties caused by the short length of the observational records, the method leads to consistent results, enabling a wide range of possible applications.