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Multi-decadal Variability of the Wind Power Output

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The knowledge of the long-term wind power variability is essential to provide a realistic outlook on the power output during the lifetime of a planned wind power project. In this work, the Power Output (P_o) of a market wind turbine is simulated with a daily resolution for the period 1871-2009 at two different locations in Spain, one at the Central Iberian Plateau and another at the Gibraltar Strait Area.

This is attained through a statistical downscaling of the daily wind conditions. It implements a Greedy Algorithm as classificator of a geostrophic-based wind predictor, which is derived by considering the SLP daily field from the 56 ensemble members of the longest homogeneous reanalysis available (20CR, 1871-2009). For calibration and validation purposes we use 10 years of wind observations (the predictand) at both sites. As a result, a series of 139 annual wind speed Probability Density Functions (PDF) are obtained, with a good performance in terms of wind speed uncertainty reduction (average daily wind speed MAE=1.48 m/s).

The obtained centennial series allow to investigate the multi-decadal variability of wind power from different points of view. Significant periodicities around the 25-yr frequency band, as well as long-term linear trends are detected at both locations. In addition, a negative correlation is found between annual P_o at both locations, evidencing the differences in the dynamical mechanisms ruling them (and possible complementary behavior). Furthermore, the impact that the three leading large-scale circulation patterns over Iberia (NAO, EA and SCAND) exert over wind power output is evaluated. Results show distinct (and non-stationary) couplings to these forcings depending on the geographical position and season or month. Moreover, significant non-stationary correlations are observed with the slow varying Atlantic Multidecadal Oscillation (AMO) index for both case studies. Finally, an empirical relationship is explored between the annual P_o and the parameters of the Weibull PDF. This allowed us to derive a linear model to estimate the annual power output from those parameters, which results especially useful when no wind power data is available.