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Wind Speed Analysis and Re-Simulation for Long-Term Wind Farm Production Forecast

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We address the task of predicting amount of energy produced during the total duration of a wind-farm project, typically spanning several decades. This is a crucial step to assess the project's return rate and convince potential investors.
To perform such an assessment, onsite mast measures at different heights often provide accurate data over a few years, together with so-called satellite proxies, given by global climate models calibrated using satellite data, less accurrate, but available on a much longer time scale, but. Based on both sources of data, several methods exist to predict the wind speeds at the different turbine locations, together with the energy production.
The aim of this work is to quantify the uncertainties tainting such a forecast, based on a parametric bootstrap approach, which consist in re-simulating the onsite mast measures and satellite proxies, then propagating their uncertainties throughout the whole procedure.
We show that the satellite time-series can be accurately reproduced using a spectral factorisation approach. Then, the onsite measures are simulated thanks to the so-called shear model, which assumes an exponential vertical extrapolation of average wind speeds, together with a Gaussian process model of the residuals.
Our results allowed to detect and correct a bias in the existing calculation method, leading to more accurate predictions, and reduced uncertainties.
We illustrate the benefits of our approach on an actual project, and discuss possible extension, such as optimal wind farm design, and accounting for climate change.

Keywords

Wind farm, spectral factorisation, parametric bootstrap, Gaussian process regression

Classification

Both methodology and application

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