JOINT SCALING ANALYSIS OF ATMOSPHERIC VELOCITY AND WIND POWER PLANT PRODUCTION.

Olmo DURAN MEDINA[1], François G. SCHMITT[1] & Rudy CALIF[2]
[1]*Laboratory of Oceanology and Geosciences UMR 8187, University of Lille 1, 62930 Wimereux, France*
[2]*Laboratory LARGE, University of West Indies, 97157 Pointe-à-Pitre, France*

Abstract In a context of energy transition, wind energy is a source of clean energy with the potential of partially satisfying the growing demand. The main problem of this type of energy, and other types of renewable energy remains the discontinuity of the electric power produced in different scales, inducing large fluctuations also called intermittency. This intermittency of wind energy is inherent to the turbulent nature of wind. Here, we consider the relation between velocity and power output with two wind turbine databases. We focus on joint relations with Fourrier analysis, empirical mode decomposition (EMD), Time-dependent intrinsic correlation (TDIC). We also consider the causality using a new method of analysis of the causality between two time series.

INTRODUCTION

From earlier studies in atmospheric science, we learn that wind speed and the aggregate power output are intermittent and multifractal over a wide range of scales [1]. We employ those results to two new databases in order to study the intermittency and to obtain the scaling properties for this renewable energy (figure 1). The first database is recorded from a wind farm situated in Denmark with a 37.6 Hz sampling frequency, the second wind farm is localized in the Nord of France, and we consider data with a resolution of 10 minutes during a year.

The relation between incident turbulent velocity and output power is a nonlinear one. Fig. 2 shows the wind-power relationship (also called transfer function) by considering the mean curve, and also different percentiles. The wind-power relationship, at smaller scales, is of random nature. It is important to be able to model such relation. Here we use several methods to grasp such relation and to characterize it in a multi-scale way: Fourier analysis (figure 4), cospectral analysis, and also using the recent method called Empirical Mode Decomposition, together with the time-dependent intrinsic correlation analysis.

We finally explore the scale-dependence of the causality between wind-power, by using a newly introduced method to statistically detect causality between two stochastic (or not) time series.

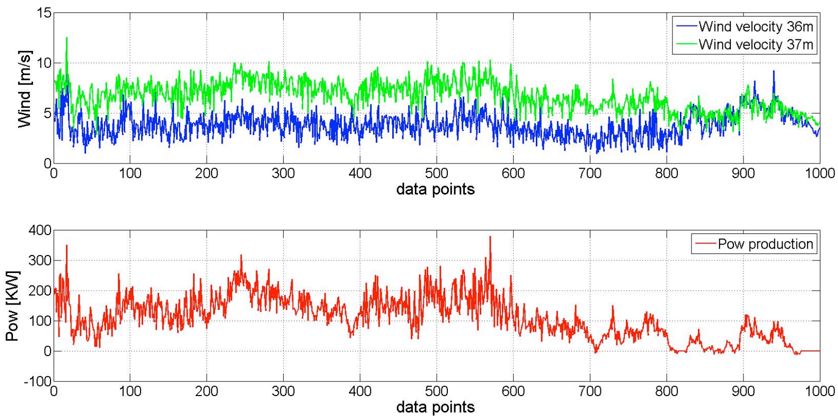

Figure 1. Wind-Power database.

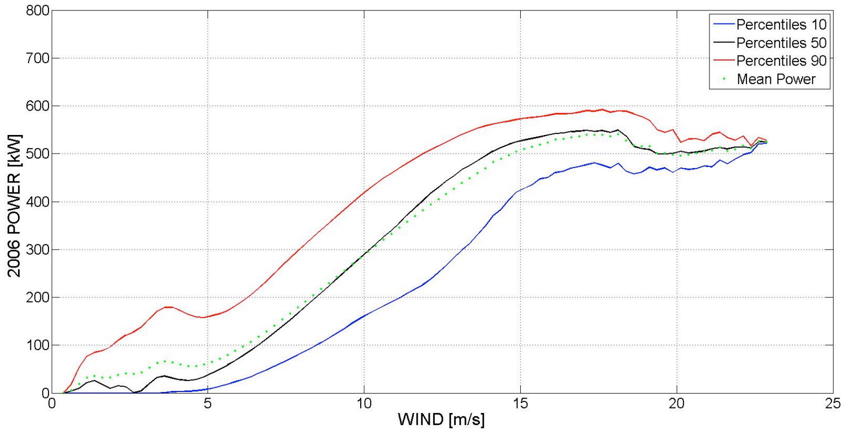

Figure 2. Transfer Function, Nordthank (2006).

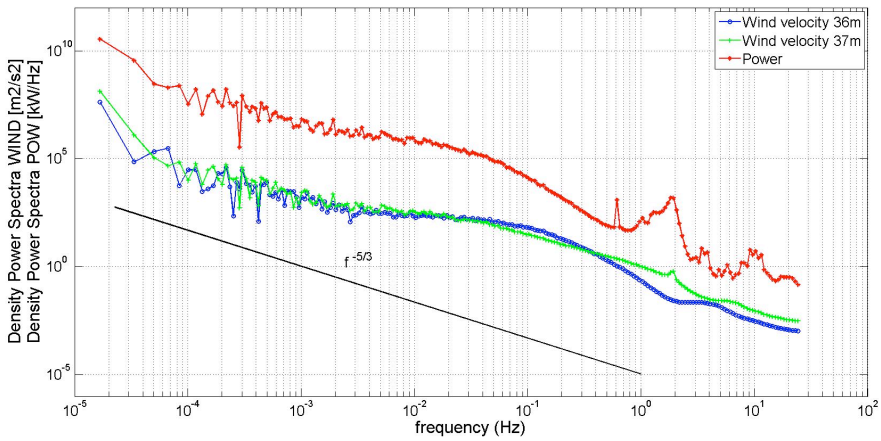

Figure 3. Fourier power spectra.

References

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