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In situ measurements of wind and current speed and relationship between output power and turbulence

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In a context of energy transition, wind and tidal energy are sources 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 and tidal energy is inherent to the turbulent nature of wind and marine currents. We consider this intermittent power production in strong relation with the turbulent intermittency of the resource. The turbulence theory is multifractal energy cascades models, a classic in physics of turbulence.

From earlier studies in atmospheric sciences, we learn that wind speed and the aggregate power output are intermittent and multifractal over a wide range of scales [Calif and Schmitt 2014]. We want to extend this study to a marine current turbine and compare the scaling properties for those renewable energy sources.

We consider here coupling between simultaneous velocity time series and output power from a wind turbine and a marine current turbine. Wind turbine data were obtained from Denmark and marine current data from Western Scheldt, Belgium where a prototype of a vertical and horizontal marine current turbines are tested. After an estimation of their Fourier density power spectra, we study their scaling properties in Kolmogorov's theory and the framework of fully developed turbulence.

Hence, we employ a Hilbert-based methodology, namely arbitrary-order Hilbert spectral analysis [Calif et al. 2013a, 2013b] to characterize the intermittent property of the wind and marine current velocity in order to characterize the intermittent nature of the fluid. This method is used in order to obtain the spectrum and the corresponding power law for non-linear and non-stationary time series. The goal is to study the non-linear transfer characteristics in a multi-scale and multi-intensity framework.