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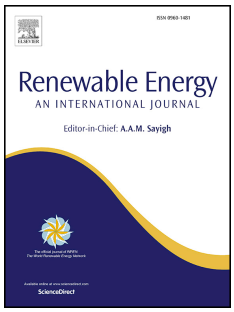

Diverse dynamical characteristics across the frequency spectrum of wind speed fluctuations

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Diverse dynamical characteristics across the frequency spectrum of wind speed fluctuations

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Abstract

Wind speed oscillations are known to exhibit varying characteristics at different time scales. Our recent analysis has shown that a collection of autoregressive models fitted separately on the frequency components of wind speed data can significantly increase the prediction accuracy. In this paper, we report the results of the investigation of dynamical behaviour across a broad frequency spectrum of wind speed measurements. The results show the existence of diverse characteristics such as stochastic, deterministic and chaotic behaviour apart from the variation of the dimensionality of underlying dynamics as well as the degree of fluctuations. It is also demonstrated that a cluster of deterministic models built upon separate frequency components of a wind speed time series can enhance the prediction accuracy by as much as 80%, on the average, consistently for predictions up to 12 hours. The comparison shows the definite advantage of deterministic prediction models over autoregressive models. The f-index introduced in this paper to measure the fluctuations of wind speed over a period indicates that the observed seasonal variations of prediction errors can be correlated with changes in the f-index of the component series contributed mostly by the lower scales of decomposition.

Keywords: Wind speed, wavelet decomposition, chaos, linear first order method

1. Introduction

The use of the wind as a feasible, eco-friendly source of alternate energy has increased steadily over the past several years. There are many factors that make wind energy attractive over thermal or nuclear energy; it is available in abundance, pollution-free, sustainable in the long term and comparably cheaper to produce with minimum recurring costs. It is estimated that if the growth rate of wind power production continues at the present pace, it would account for about 12% of the total energy demands in the next five years [1]. A major impediment to harnessing wind energy to its full potential, or deploying windmills on large scale, is the indeterminate nature of wind. Wind speed exhibits fluctuations at all time-scales due to numerous meteorological factors, and wind

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