Preface

Low carbon has become a global issue, as testified at the recent World Climate Summit 2015, held in Paris. Nowadays, the only viable alternative to this crisis is to develop as much as possible the use of the so-called renewable energy, as the possibility of obtaining clean energy through fusion processes being remote. Several forms of alternative sources of energy are present in nature almost in unlimited quantities, referred to as *renewable*, because they are continuously regenerated. The main source for renewable energies is the Sun. From the Sun are naturally derived accumulations of water to produce hydroelectric power, wind for aeolic turbine generators, and photovoltaics plants to generate electric energy. Also, from the photosynthesis process it is possible to derive energy from biomass.

A challenging problem with integrating renewable energy based plants, such as solar and wind speed ones, into electric grid is that these plants are intermittent. Thus, predicting the weather variables is of great interest for applications. There are essentially two ways to address this issue. One is by using Numerical Weather Forecasting (NWF) models, which are reliable but quite complex and require real-time information, which is usually available from Meteorological Agencies only. Furthermore, it has been pointed out that NWF models have high errors in forecasting meteo variables at local-scale areas and without appropriate postprocessing are often inferior to machine learning approaches. The other kinds of methods are represented by the so-called statistical modeling approaches, which are based on the use of past data recorded at the site of interest. The latter kinds of methods, compared to the former ones, require less computational efforts, but are appropriate for short-time horizons only. This book is devoted to study statistical prediction models for solar radiation and wind speed time series and asses their performance in the range (1, 24) hours. Furthermore, the problem of classifying daily patterns of both solar radiation and wind speed will be addressed as a useful strategy to obtain statistical properties for longer prediction range. The book concisely describes the main techniques of time series analysis, with an emphasis on solar radiation and wind speed, since they are the main kinds of renewable energies involved in the production of electrical energy. The forecasting problem is addressed by using the embedding phase space approach, which is one of the most powerful methods proposed in the literature for modeling complex systems. Further, the book will guide the reader in applying some machine learning techniques to classify the daily patterns; thus allowing to perform statistical analyses that are not possible by using traditional techniques. The concepts will be exposed as much as possible avoiding unnecessary mathematical details, focusing on very concrete examples in order to ensure a better understanding of the proposed techniques. Developing various topics, the readers will be guided on how to find the most appropriate software and data resources with which they could perform their own experiments. The structure of the book is as follows. Methods for analysis of time series are concisely reported in Chap. 1. Application of these methods to solar radiation and wind speed time series are described in Chaps. 2 and 3, respectively. Modeling approaches for solar radiation and wind speed time series, focusing essentially on nonlinear autoregressive (NAR) and Embedded Phase Space (EPS) models, are given in Chap. 4. Identification of solar radiation and wind speed hourly average prediction models is reported in Chaps. 5 and 6, respectively. Classification of daily patterns of solar radiation and wind speed time series are described in Chaps. 7 and 8, respectively. Concluding remarks are given in Chap. 9 and finally, a list of software functions and dataset mentioned in the book is included in Appendix A.

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