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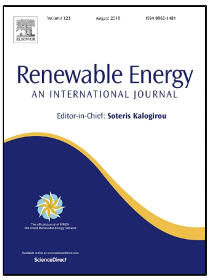

A spatiotemporal universal model for the prediction of the global solar radiation based on Fourier series and the site altitude

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ACCEPTED MANUSCRIPT

A spatiotemporal universal model for the prediction of the global solar radiation based on Fourier series and the site altitude

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Abstract

This paper presents the development, testing and validation of a novel generic type universal model consisting of a set of sine and cosine harmonics in the temporal and spatial domain suitably parameterized for the prediction of the mean expected global solar radiation H(n,φ) on the horizontal for a day, n, at any latitude φ. Its prediction power is further enhanced with the introduction of a correction term for the site altitude taking into account the φ dependent atmospheric height. Solar radiation data from 53 stations around the earth were obtained from GEBA database to train the model. H(n,φ) is expressed by a Fourier series of compact form with the zero frequency component dependent on φ providing the main spatial dependence and two n dependent harmonics in the form of cosine functions giving the time dependence. The φ dependent model parameters follow symmetry rules and are expressed by Fourier series up to the 3rd order harmonic. The 3D spatiotemporal profile of the model is in agreement to the extraterrestrial one. The model was validated using GEBA data from additional 28 sites and compared with NASA, PVGIS and SoDa data, showing the robustness, reliability and prediction accuracy of the proposed model.

Keywords: solar radiation prediction; universal model; Fourier series; site altitude; atmospheric height

1. Introduction

For the sizing of Renewable Energy Systems (RES) configurations it is necessary to provide as input the values of the daily global solar radiation H(n,φ) kWh/m^2/day on the horizontal in any place with latitude φ, for any day n, while in more detailed dynamic simulation models the values of the intensity of the global solar radiation, I(h;n), at a site in any hour h of a day n, are required, [1-4]. Solar radiation is monitored in many stations around the world and data are processed and stored in international databases as in [5-8]. A large number of research studies outline models which provide for H(n) and/or I(h;n) estimates for various sites. Those models are categorized as semi-empirical, ASHRAE [9] and Iqbal [10] models, providing elaborated expressions based on theoretical approaches with regard to the solar light optics such as transmission, reflection and scattering, as well as the atmospheric pressure versus altitude and the ambient temperature for the site and the time period concerned. Both models predict the beam, incident and diffuse components of the global solar radiation in a site

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