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Empirical correlations for the climate data in the Kingdom of Bahrain

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Abstract

The Average yearly recorded weather data in the Kingdom of Bahrain over an extended period ranging from 1902 to 2002 for the temperature and from 1962 to 2002 for the atmospheric pressure, the relative humidity, the wind speed and the sunshine duration (i.e. long-term data), is statistically analyzed and empirically modeled. Regression methods, including polynomial and sinusoidal models, are used to fit the data. Polynomial fits are used in modeling the average yearly variations. The obtained coefficients of determination (R^2) of these fits are tabulated. In addition, we empirically modeled the monthly variations of the climate parameters using both polynomial as well as sinusoidal regression models. Our results were compared with similar studies for nearby countries, i.e. Oman and Kuwait. The values of R^2 for both fits are also tabulated.

1. Introduction

Modeling the long-term recorded meteorological parameters provides mathematical and statistical tools that are useful in meteorological studies. It helps in forecasting climate patterns and the climate changes. Several studies in various parts of the world were carried out to model meteorological parameters. Dorvlo and Ampratwvm [1] obtained models for nine weather parameters for the Sultanate of Oman for the period 1987–1992. Alaruri and Amer [2] performed regression analyses of eight weather parameters for Kuwait. Canada et al. [3] developed correlation models for global, diffused and tilted irradiation, ambient temperature, sunshine duration and specific humidity. Coppolino [4] developed a polynomial relationship between the clearness index and relative sunshine hours.

Also, parameters such as pressure, humidity, sunshine duration, rain level, etc. are very important when one is involved in the mathematical simulation of climate, ocean-atmosphere heat engine

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and exchange processes between the earth's surface and the atmosphere energetic [5]. In addition, these variables allow the estimation and determination of many environmental parameters such as the emissivity [6], turbidity [7], Angstrom coefficient [8], albedo [9], optical depth [10], transmittance factor [11], horizontal optical density [12] and the clear-sky monochromatic extinction coefficient [13]. These parameters are good indicators of the quality of the sky and hence the sky environment. Also, such atmospheric and meteorological parameters are useful for estimating the potential of renewable energy resources in a location [14], since these sources of energy are environmentally friendly and are important for sustainable development.

The variations in the ambient temperature follow a periodical pattern, which is a known phenomenon worldwide [15]. These natural changes of climate are caused by several factors, such as:

(i) The orientation of the earth (Milanko-Vitch effect), where the eccentricity of the elliptical orbit of the earth changes in time between the values of 0.002 and 0.055 with a period of 100,000 years.
(ii) The tilt of the earth's axis between 22.5 and 24.5° (at present 23.5°) with a period of about 41,000 years.
(iii) Precession of the axis of the earth around the normal to the orbital plane with a period of about 23,000 years.

The above factors cause long-term climate changes. They affect the climate pattern over thousands of years.

However, there are short-term periodical changes, which are mainly due to the changing sun. The luminosity of the sun is connected with the fluctuation in the number of sunspots. These spots are the darker parts of the sun with a temperature range 4000–5000 K, as compared with 5800 K for the rest of the solar surface. In fact, in association with the sunspots, there are brighter areas of the surface, called faculae, with a temperature of perhaps 6800 K. Because of the dependence of the emitted energy on the fourth power of the temperature T ($E=\sigma T^4$), the emission of the hot faculae per unit area is more than compensates for the lower emission of the sunspots. As the total area of the faculae is bigger than that of the sunspot, a higher number of sunspots results in more faculae, hence results in a higher total emission from the sun. This, in turn, leads to a higher earth temperature [15]. The number of sunspots varies irregularly with an average period of around 11 years. This means that the sun changes 1% of its insolation, i.e. 1.5 W m^{-2} during this cycle. According to Reid [16] and Alnaser and Merzaa [17], there are indications of a strong correlation between the temperature and the sunspot cycle.

Modeling the monthly and yearly average temperature variations is of significance for many reasons. For example, the air temperature, T, is an important factor to estimate the added energy ($E_{\text{greenhouse}}$) to our globe from the greenhouse gases; including water vapor, CO_2, CH_4 and N_2O_2. This can be understood using the following equation [18]

$$E_{\text{out}} = E_{\text{in}} - E_{\text{greenhouse}}, \tag{1}$$

where E_{in} is energy flux coming to earth; E_{out}, the energy emitted from the earth; $E_{\text{greenhouse}}$ is the energy added to earth from the re-emission of heat (Infrared radiations) of the greenhouse gases. Eq. (1) can be written as follows

$$0.7S\pi R_e^2 = 4\pi R_e^2\sigma T^4 - E_{\text{greenhouse}}, \tag{2}$$