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Modelling Afghanistan's Average Monthly Temperature from 1901 to 2015

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Peer-review under responsibility of 4th Asia International Conference 2018 editorial board (http://www.utm.my/asia/our-team/)

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Research Highlights

The historical dataset of the monthly average temperature from 1901 to 2015 were analyzed. The relationship between temperature and time during the four time intervals, i.e (1901 - 1930), (1931-1960), (1961-1990) and (1991-2015) is presented using a new analytical model based on the last –square method of estimation. We accurately fit a polynomial regression trend of degree 4 to the time series to describe the temperature variation. This approach of modeling temperature using regression form significantly simplifies the data analysis. The information from data, namely the variation of the temperature, maybe be obtained from the extracted parameters such as slope, y-intercept, and the coefficients of polynomial function that are a function of time.

Graphical Abstract

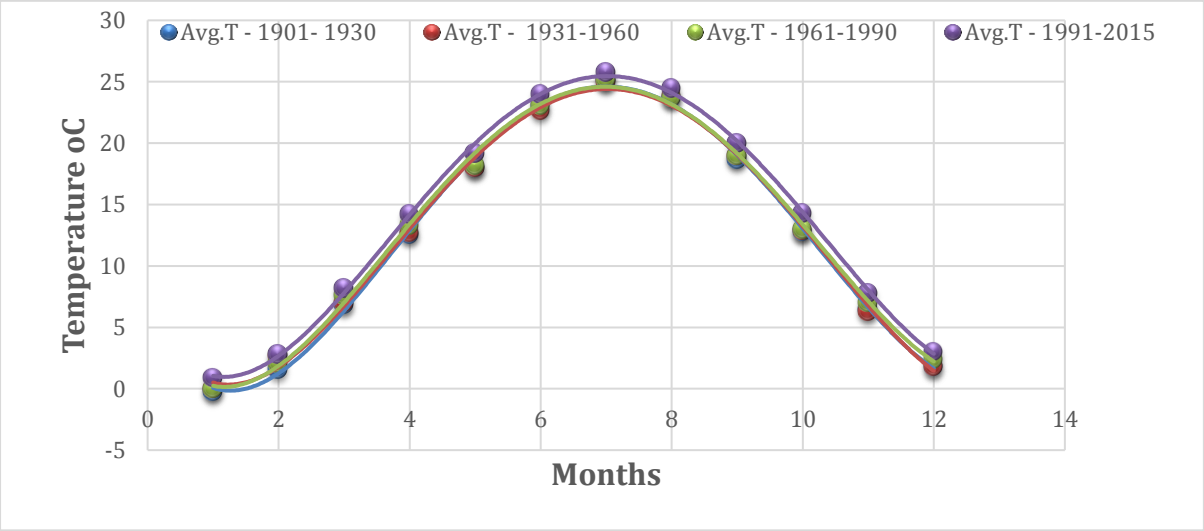

Figure 1 the average monthly temperature for four intervals time from 1901 to 2015.

The mathematical relationship between the average temperature and time during the above period (Figure 1) are given in the following polynomial regression equations 1, 2, 3 and 4. Table 1 indicates the coefficient a1, a2 , a3 , a4 and constant b of these polynomial equations that are displayed in Figure 2 versus the time series.

$$T_{(1901-1930)} = 0.0229t^4 - 0.6416t^3 + 5.2286t^2 - 10.347t + 5.8078 \quad (1)$$

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$$T_{(1931-1960)} = 0.0213t^4 - 0.6003t^3 + 4.9004t^2 - 9.5214t + 5.7 \quad (2)$$

$$T_{(1961-1990)} = 0.0215t^4 - 0.598t^3 + 4.8126t^2 - 8.9367t + 4.9359 \quad (3)$$

$$T_{(1991-2015)} = 0.0209t^4 - 0.5868t^3 + 4.7426t^2 - 8.7917t + 5.6591 \quad (4)$$

Table2: Coefficients a1, a2, a3, a4, constant b and R^2 are obtained from the equations 1, 2, 3, and 4.

Year	a_1	a_2	a_3	a_4	b	
1901-1930	0.0229	-0.6416	5.2286	-10.347	5.8078	0.9975
1931-1960	0.0213	-0.6003	4.9004	-9.5214	5.7	0.9962
1961-1990	0.0215	-0.598	4.8126	-8.9367	4.9359	0.9973
1991-2015	0.0209	-0.5868	4.7426	-8.7917	5.6591	0.9987

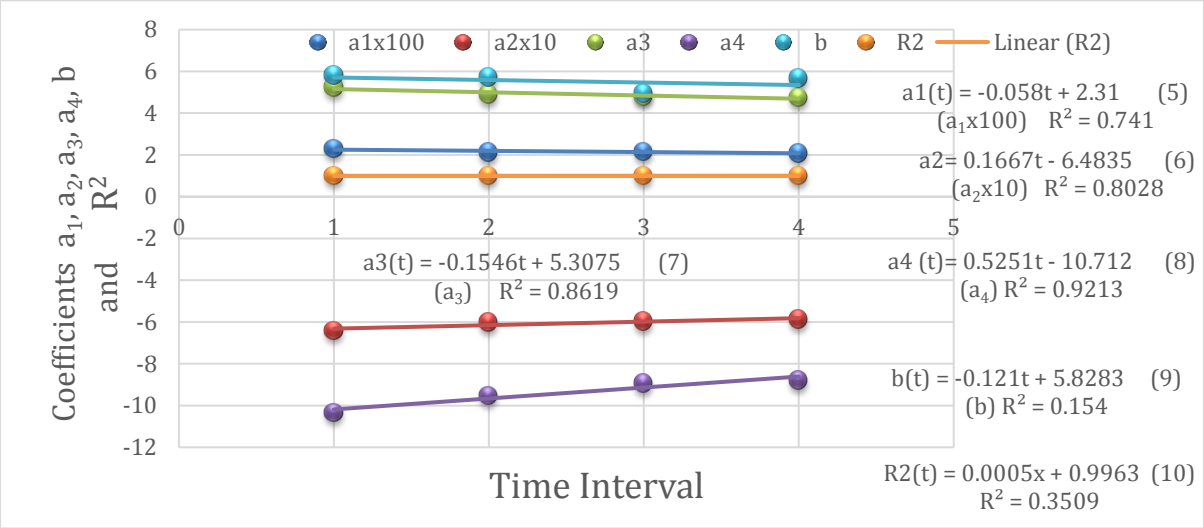

Figure 2 Coefficients a_1, a_2 , a_3 , a_4, b and R^2 versus time interval obtained from the equations 1, 2, , 3 and 4. The *x-axis*, 1, 2,3 and 4 indicate the time intervals (Δ_{t_1}=1901-1930), (Δ_{t_2}=1931-1960), (Δ_{t_3}=1961-1990), and (Δ_{t_4}=1991-2015), respectively.

Research Objectives

The purpose of this investigation is to examine the variation of temperature in Afghanistan over the past 114 years. The relationship between temperature and time during from 1901 to 2015 is presented using a new analytical model based on the last –square method of estimation. We accurately fit a polynomial regression trends of degree 4 to the time series to describe the temperature variation. The evaluation of Afghanistan's past climate data can be extremely important for better understanding how climate has varied along with their possible

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predictable outcomes that come with increasing drought risk due to gradual increase of temperature. These results may be useful for environmental policy makers in comprehension of climate change in Afghanistan, and can help to develop appropriate strategies for the environment, and regulate resource use or pollution reduction to promote human welfare and/or nature protection.

Methodology

The historical temperature dataset of Afghanistan was collected by the Climate Research Unit (CRU) of the University of East Anglia (UEA) and has been downloaded from the website of Climate Change Knowledge World Bank Group [4] (Climate Change Knowledge Portal, 2018). Microsoft Excel was used to carry out comparison between the average temperature data versus time (years and months). For the analysis, the obtained data has been broken down into specific smaller datasets and represented graphically. For comparison of the time variation temperature, slopes, y-intercepts and the polynomial regresion coefficients that decribe the data are extracted from each graphs .These polynomial coefficients with their corresponding R2 are shown graphically. Data are represented using x-y scatter diagram plot. During analysis we try to find the equation of polynomial and line that fit with the data. The pair points (x=month and y=T temperature) with their corresponding coefficients can be plotted on the Cartesian coordinate system. Correlation is used to give information about the relationship between x and y and the variation of these coefficients versus time. The strength of these relationships is given by the correlation coefficient R2. The values of R2 range from -1 to +1. A correlation coefficient of 0 means that there is no relationship. A value of -1 is a perfect negative coefficient and a correlation value of +1 indicates a perfect positive correlation. Another value of use in correlation analysis is the coefficient of determination which is represented asR2, and varies between 0 and 1.

Results

The monthly temperature data has been mapped from 1915 to 2015 to examine the variation of temperature in Afghanistan for specific time periods of year. We fit a linear and polynomial trend to the temperature series time to show how these functions can be used to describe and analyses the information of the variation of temperature maybe considered as an indicator of climate change not only in Afghanistan but over the earth. The results show the average difference of temperature between 2015 and 1901 increases about 1.03 oC. The average monthly difference between the maximum and minimum temperature was

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approximately 3.66 oC and the average monthly difference between the maximum and minimum temperature during these periods is approximately about 1.31 oC. More importantly, the relationship between temperature and time over 115 years can be described by quadratic function of degree 4 with very strong correlation R2. The magnitude of the extracted parameters, namely the slopes, y intercepts and the coefficients of the polynomial regression remains approximately constant over 115 years. The evaluation of Afghanistan's past climate data can be extremely important for better understanding how climate has varied along with their possible predictable outcomes that come with increasing drought risk due to gradual increase of temperature. These results may be useful for environmental policy makers in comprehension of climate change not only in Afghanistan 's climate but in the global environment. The results can help develop appropriate strategies for the environment, and regulate resource use or pollution reduction to promote human welfare and/or nature protection. The extracted parameters can be used as guideline or an indicator to asses and evaluate the temperature variation, may be useful for environmental policy makers in comprehension of climate change in Afghanistan. More importantly, the parameters that describe the time variation temperature trends over 115 years obtained with a high R-squared do not vary significantly. This is in agreement with the Earth's average temperature that has climbed to more 1 oC [5] (Union of Concer Scientists, 2016).

Findings

In this investigation, polynomial regression analysis is used to examine the value of the variable temperature versus the time series based on the extracted parameters. The temperature for each year versus time series (months) fit accurately with a polynomial function of degree 4. The results shows that the extracted parameters, namely the coefficient of the polynomial regression and slopes and y intercepts do not vary significantly in good agreement with the local and Earth's average temperature variation that have climbed less than 2 oC . Using the whole datasets is more complicate to interpret and retrieve the information needed to assess the effect of the physical parameters, such as temperature on the Earth's climate that has changed throughout history.Based on the extracted parameters, database can be created to analyze and make comparison for the future variation of temperature in order to speculate on the climate change or global warming. This investigation is expected to help readers such as policy makers and researchers to obtain better understanding of the latest status of the climate and further to take measures against the global warming and for protection of the global environment.

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