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Studying the Effect of Changing One of the Climatic Phenomena on Human Life and Reducing its Risks with A Statistical Eye

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Abstract

Due to the climatic changes that directly affected the nature of life on the globe, so most recent statistical studies tended to study these changes, which would provide climate scientists and researchers with information as they answer many complex inquiries related to climate forecasts, and also help them to find solutions to problems Which are caused by these changes and reduce their risks, either by avoiding them or reducing those risks, in addition to the important role of these studies in developing future plans that would protect humanity from the consequences of climate changes, which affected various areas of life, including agriculture, industry, etc. And because the statistical parametric methods need conditions and criterions that may be difficult to meet, so the direction in this research was towards the use of non-parametric methods, in particular (spline) in order to study one of the phenomena of climate change because it is characterized by flexibility and the possibility of its application at various sides of life.

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Introduction

We all know that nature has its conditions and factors that are interrelated with each other, and that any imbalance in one of these factors directly affects the other factors, which causes damage to the environmental balance equation and thus negatively affects human life, especially in the continuous increase in population numbers and the human possession of advanced technological means. And because these changes began to have negative consequences on different aspects of life and in all of the world, so the researchers went to study these natural changes and the extent of their negative effects and repercussions on life by defining the problem and then finding possible solutions that can be implemented by humans.

Therefore, the researcher went in this paper to study the phenomenon of predicting the amounts of rainfall by creating predictive chart for rainfall, depending on the climatic data of temperature and humidity for Iraq, being one of the countries affected by these changes, which negatively affected on the nature of the life on its land, which generated high rates of desertification which could be exacerbated year after year.

Theoretical side

We going to use bivariate quantile regression to construction the predictive chart for rainfall, where we estimate two quantile functions by using nonparametric method (B-Splines (BS) with nodes (0.5, 1, 1.5, 2 and 2.5)) to estimate those functions depending on the concept of the (time-varying coefficient with depth) (see: [4], [9], [10]).

Below are the steps for constructing the predictive chart:

- ✓ **First stage:** assume we have two models of the quantile functions g_1 and g_2 , the two equations of the models that have been adopted here, written respectively is as the following:

$$\mathcal{Q}_q\big(Y_{i,j,1}\big) = g_1\big(q; t_{i,j}, \mathbf{X}_{i,j}\big) \tag{1}$$

$$\mathcal{Q}_q\big(Y_{i,j,2}\big) = g_2\big(q; t_{i,j}, \mathbf{X}_{i,j}, Y_{i,j,1}\big) \tag{2}$$

To combine the two models above of the quantile functions (bivariate response models), first we will writing the quantile functions to the bivariate response in (1) and (2) depending on the concept of (time varying coefficient), (see: [8], [11], [15]), as the following:

$$\mathcal{Q}_q\big(Y_{i,j,1}\big) = \alpha_1\big(q; t_{i,j}\big) + \sum_{k=1}^{d} \gamma_{1k}\big(q; t_{i,j}\big)\,\mathbf{X}_{i,j,k} \tag{3}$$

$$\mathcal{Q}_q\big(Y_{i,j,2}\big) = \alpha_2\big(q; t_{i,j}\big) + \beta_2\big(q; t_{i,j}\big)Y_{i,j,1} \quad + \sum_{k=1}^{d} \gamma_{2k}\big(q; t_{i,j}\big)\,\mathbf{X}_{i,j,k} \tag{4}$$

Where: α_1 and α_2 are the intercepts of $\mathcal{Q}_{Y_1}(q)$ and $\mathcal{Q}_{Y_2}(q)$

β_2 is the slope of $\mathcal{Q}_{Y_2|Y_1}(q)$

γ_{1k} and γ_{2k} are the coefficients associated with $\mathbf{X}_k$ in both of models (3) and (4) respectively.

And second**,** converted the models of the first stage by rewrite the models in equations (3) and (4)) to the concept of depth where this concept is the second definition of (Koenker-Bassett methods) when the linear regression is an extension for covariates in dimension $d \geq 1$, therefore, the directional q −quantile hyperplane $\mathbf{\Pi}_{qu}$ under the nonparametric case, where $(a, \mathbf{b}^\intercal, \boldsymbol{\beta}^\intercal)^\intercal \in \mathbb{R}^{d+p}$, (see: [14], [16]), and can be written as the following:

$$\mathcal{Q}_q\big(Y_p\big) = q_p = u^\intercal y = \mathrm{b}_{qu}^\intercal \Gamma_u^\intercal y + \beta_{qu}^\intercal \mathrm{x} + a_{qu} \tag{5}$$

Where :

$$\boldsymbol{u}^\intercal \boldsymbol{y} = \mathbf{b}_{qu}^\intercal \boldsymbol{\Gamma}_u^\intercal \boldsymbol{y} + \boldsymbol{\beta}_{qu}^\intercal \mathbf{x} + a_{qu} \tag{6}$$

$\boldsymbol{X} := (\boldsymbol{X}_1, \dots, \boldsymbol{X}_d)^\intercal$ is a random vector of covariates.

$\boldsymbol{Y} := \big(Y_1, \dots, Y_p\big)^\intercal$ is p −dimensional of response, and for empirical distribution for n as $\boldsymbol{Y}_1, \dots, \boldsymbol{Y}_n$ $(\boldsymbol{X}_1^\intercal, \boldsymbol{Y}_1^\intercal)^\intercal, \dots, (\boldsymbol{X}_n^\intercal, \boldsymbol{Y}_n^\intercal)^\intercal$ are the pairs which will be dealt with which is denoted as $(\boldsymbol{X}^\intercal, \boldsymbol{Y}^\intercal)$ where $(\boldsymbol{X}, \boldsymbol{Y}) \in \mathbb{R}^d \times \mathbb{R}^p$.

- ✓ **Second stage:** we will going towards the nonparametric methods to estimate two quantile functions g_1 and g_2 by using the nonparametric method (B-splines (BS), (see: [6], [7]), with knots (0.5, 1, 1.5, 2 and 2.5)) as the models by minimizing the quantile regression objective functions:

$$\hat{g}_{n1}(q) = \text{argmin} \sum_{i,j} \rho_q \left(Y_{i,j,1} - g_1(t_{i,j}, \mathbf{X}_{i,j}) \right) \tag{7}$$

$$\hat{g}_{n2}(q) = \text{argmin} \sum_{i,j} \rho_q \left(Y_{i,j,2} - g_2(t_{i,j}, \mathbf{X}_{i,j}, Y_{i,j,1}) \right) \tag{8}$$

$$\hat{g}_{n1(BS-TV)}(q) = \text{argmin} \sum_{i=1}^{n} \boldsymbol{W}_i \sum_{j=1}^{m_i} \left(\boldsymbol{Y}_{i,j,1} - (\alpha_1(q; t_{i,j}) + \sum_{k=1}^{d} \gamma_{1k}(q; t_{i,j}) \boldsymbol{X}_{i,j,k}) \right)^2 \tag{9}$$

$$\hat{g}_{n2(BS-TV)}(q) = \text{argmin} \sum_{i=1}^{n} \boldsymbol{W}_i \sum_{j=1}^{m_i} \left(\boldsymbol{Y}_{i,j,1} - (\alpha_2(q; t_{i,j}) + \beta_2(q; t_{i,j}) \boldsymbol{Y}_{i,j,1} + \sum_{k=1}^{d} \gamma_{2k}(q; t_{i,j}) \boldsymbol{X}_{i,j,k}) \right)^2 \tag{10}$$

Where:

$$\boldsymbol{W_i} = \frac{1}{m_i}$$

And according to the equations (7) and (8) we written the model in (6) (see: [5], [12]), as:

$$\left(a_{q\boldsymbol{u}}, \mathbf{b}_{q\boldsymbol{u}}^{\top}, \boldsymbol{\beta}_{q\boldsymbol{u}}^{\top}\right)^{\top} = \underset{(a, \mathbf{b}^{\top}, \boldsymbol{\beta}^{\top})^{\top} \in \mathbb{R}^{d+p}}{\text{argmin}} E\left[\rho_q(\boldsymbol{Y_u} - \mathbf{b}^{\top}\boldsymbol{Y_u^{\perp}} - \boldsymbol{\beta}^{\top}\boldsymbol{X} - a)\right] \tag{11}$$

$$\hat{q}_{(BS-TVD)M}(q) = argmin \sum_{i=1}^{n} \boldsymbol{W}_i \sum \left(\rho_q\left(\boldsymbol{Y} - (\boldsymbol{b}^{\top}\boldsymbol{Y_u^{\perp}} + \boldsymbol{\beta}^{\top}X + a)\right) \right)^2 \tag{12}$$

- ✓ **Third stage:** here we adopted Ivanov equation to calculation the evaporation, which depends on the annual temperature and the amount of relative humidity, as the lack of humidity in the months in which the temperature rates are high increases with it the evaporation processes, so we conclude that the values of evaporation in the air increase when there is a lack of atmospheric air humidity, so the more moisture in the air the evaporation process decreases.

Where, the relationship between the amount of evaporation and the amount of rainfall is positive relationship (i.e. the greater the amount of evaporation the greater the amount of rainfall, and the less the amount of evaporation the less the amount of rainfall).

Based on the above, the Ivanov equation was adopted in the statistical programming of the proposed predictive charts to predict the amounts of rainfall (see: [1], [2]).

We can write Ivanov equation as:

$$IV = c.* a.* bb \tag{13}$$

Where:

$$a = ((T1 + 25).\hat{}2) \tag{14}$$

$$b = (100 - H2) \tag{15}$$

$$bb = b./100 \tag{16}$$

$$c = 0.0018$$

T1: represent temperature.

H2: represent humidity.

Practical side

Because the limited sources of water on which Iraq depend, so the rain is considered a climatic resource of high value because of its effects in determining the proportion of agricultural and industrial activities, and thus the proportion of commercial and economic activity of the country.

So in this paper we will study the phenomenon of predicting the amounts of rainfall, depending on the climatic data of temperature and humidity for Iraq (Baghdad) by built the chart of prediction amounts of rainfall, where this chart explain to us whether the season is rainy or not. Chart built by using nonparametric methods and depending on the data of the Central Statistical Organization.

Now, we will going to construct the contours for this chart depending on the value of q where $q \in (0,1)$, by modeling equations in the theoretical side to be applied with real data, (see: [3], [5], [13]), which will be displayed as below:

Table 1: Climatic data of humidity in Baghdad

Baghdad	Humidity
	Year
42	2009
40	2010
41	2011
40	2012
45	2013
43	2014
41	2015
41	2016
38	2017
45	2018
45	2019

Table 2: Climatic data of temperature in Baghdad

Baghdad		Temperature
Maximum	Minimum	Year
31.2	17.1	2009
33	18	2010
30.4	16.4	2011
31.6	16.6	2012
30.3	16.1	2013
31.9	17	2014
31.9	16.7	2015
31.9	16	2016
32.3	16.4	2017
31.6	17.1	2018
31.7	17.3	2019

Table 3: Climatic data of rainfall in Baghdad

Baghdad	Rainfall
	Year
67.5	2009
92.5	2010
96	2011
184.4	2012
296.7	2013
108	2014
190.9	2015

104.5	2016
71.6	2017
284.2	2018
137	2019

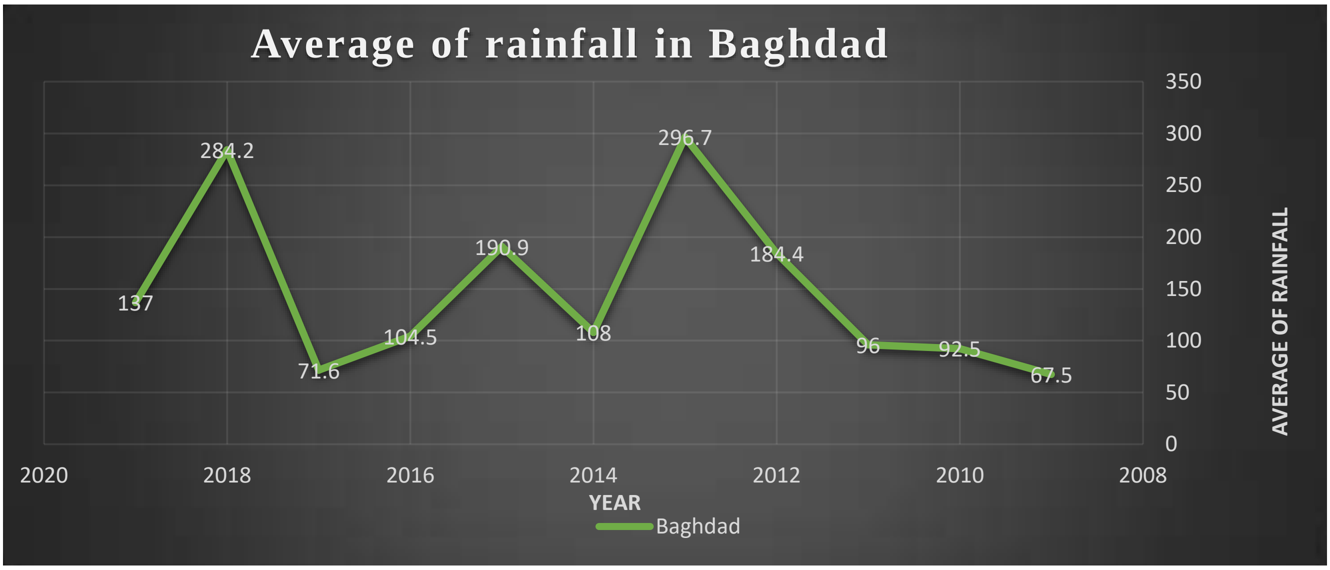

Figure 1: Chart represents plotting average of rainfall in Baghdad

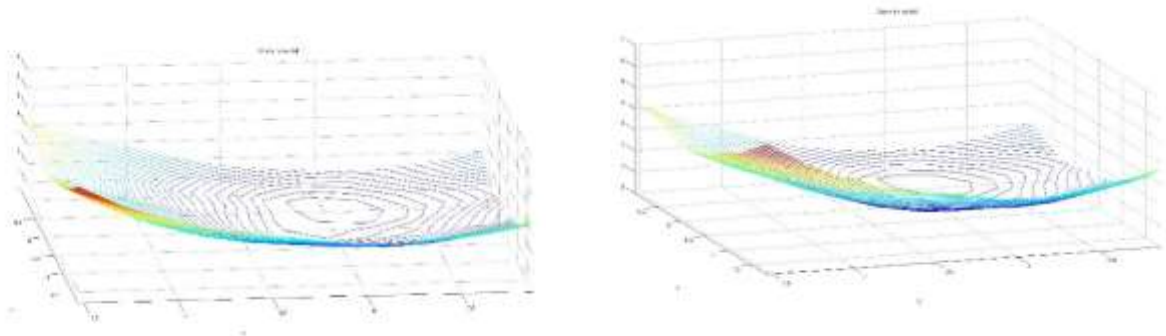

Figure 2: Represents plotting contours for charts of prediction amounts of rainfall only

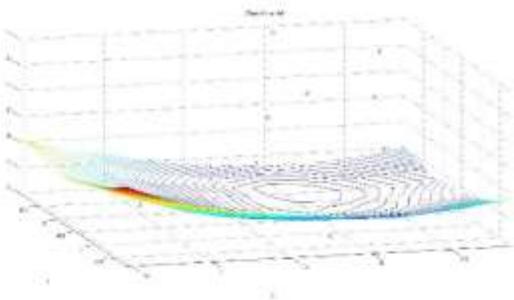
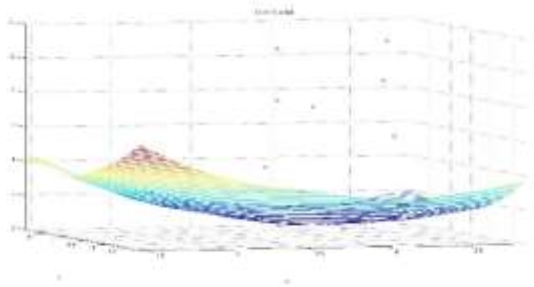

Figure 3: Represents plotting contours for charts of prediction amounts of rainfall with the data of the rain

The MAE of this model is: 1.19

Conclusion

In this paper, we studied prediction of the amounts of rainfall expected depending on the temperature and humidity, where built the chart of prediction amounts of rainfall, where this chart explain to us whether the season is rainy or not, this chart built by using nonparametric methods and depending on the data of the Central Statistical Organization. Where we study and discussed two stages, first stage we built the chart depending on the combined of the two concepts (time varying coefficient) (depth) which gave MAE = 1.19. Note that, we used the nonparametric method (B-spline) and in the second stage we plotted the real data on the proposed chart, where the basis of all is reliance is on an Ivanov equation, see the figures above. We conclude from the proposed of predictive chart in this research and as shown in the above graphics showed us that the season in which the evaporation rate was low and resulting from the mathematical equation that was obtained depending on the temperature and relative humidity gave the lowest amount of rainfall (and vice versa) .

Recommendations:

1. Taking care to accurately record measurements of climatic phenomena to enable researchers to use real data that give accurate results for all studies.
2. Green belt leaf expansion.
3. Reducing air pollution rates, which helps to maintain an increase in evaporation rates and the correct exploitation of high temperatures.
4. Proper exploitation of river water by educating citizens to rationalize consumption.
5. Paying attention to the cleanliness and urination of river water and not throwing waste and heavy water into it.

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دراسة تأثير تغير إحدى الظواهر المناخية على حياة الإنسان والحد من مخاطرها بعين إحصائية

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المستخلص

نظراً للتغيرات المناخية التي أثرت بشكل مباشر على طبيعة الحياة على الكرة الأرضية، اتجهت معظم الدراسات الإحصائية الحديثة إلى دراسة هذه التغيرات، مما من شأنه أن يزود علماء المناخ والباحثين بالمعلومات حيث يجيبون على العديد من الاستفسارات المعقدة المتعلقة بالتنبؤات المناخية، كما يساعد أيضاً لإيجاد حلول للمشكلات التي تنتج عن هذه التغيرات والحد من مخاطرها، إما عن طريق تجنبها أو الحد من تلك المخاطر، بالإضافة إلى الدور المهم لهذه الدراسات في وضع الخطط المستقبلية التي من شأنها حماية البشرية من عواقب التغيرات المناخية، والتي أثرت على مختلف مجالات الحياة، بما في ذلك الزراعة والصناعة وغيرها. ولأن الأساليب البارامترية الإحصائية تحتاج إلى شروط ومعايير قد يصعب تحقيقها، لذلك كان الاتجاه في هذا البحث نحو استخدام الأساليب غير البارامترية، وعلى وجه الخصوص (Spline) لدراسة إحدى ظواهر التغير المناخي لما تتميز به من مرونة وإمكانية تطبيقها في مختلف جوانب الحياة.

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