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An optimal model for studying UVI parameter on different regions of Iraq

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Abstract
The UV index is considered to be a useful medical indicator for monitoring the effect of sun radiation, as UVI is a measure for the amount of ultraviolet sunlight relevant for erythema. This study aimed to explore the behavior of the UVI parameter according to creating new optimal statistical models due to different periods of time from 1st of July 2002 to 16th June 2024 per (days, months, and years) in different regions of Iraq (Baghdad, Basra, and Mosul). As well as offering influence models either for prediction equations or to forecast estimates of UVI parameters in the next periods of preceding time series. Several suggested models were introduced for studying the influence of "obsolescence time periods," such as "linear, logarithmic, inverse, quadratic, cubic, power, compound, S-shape, logistic, growth, and exponential, which represented their outcomes of "auto-regression ANOVA".
Results showed that "Inverse" auto-regressive model has recorded the best model for all of the studied religions per days, as well as UVI parameter was frequently increased in Basra region, then gradually decreased in Baghdad, and the lowest level was recorded in Mosul during the studied period, while "Quadratic" of polynomial auto-regressive model, has recorded the best model among all of the studied religions per months, as well as UVI parameter were frequently increased dramatically as temperatures rised during the months of the year,, with the same differences recorded across regions, and finally" Cubic" of polynomial auto-regressive model, has recorded the best model among all of the studied religions per years, as well as UVI parameter were frequently increased severely during the last third of the studied time series per years, with the same differences recorded across different regions. The present research might have a practical role in environmental management. Consequently, the data produced from the current research can be utilized to assess and address the environmental effects of UVI exposure, including its impacts on humans, plants, animals, and water quality.

Keywords: UVI parameter, obsolescence of time series, influence of an optimal auto-regressive models, predication and forecasting equations

Introduction
UVIndex is considered to be a useful medical indicator for monitoring the effect of sun radiation [1]. As well as UVI is a measure for the amount of ultraviolet sunlight relevant for erythema (sunburn) [2, 3]. UV radiation has a shorter wavelength and higher energy than visible light. It affects human health both positively and negatively. Short exposure to UVB radiation generates vitamin D, but can also lead to sunburn depending on an individual's skin type and can cause human diseases depending on a wavelength-depending weighting factor to the spectral UV irradiance [4].
Therefore, the effect of Ultraviolet radiation on human body has been investigated by many researchers, D' Orazio *et al*, 2013 [5] mentioned that the Risk of skin cancer is heavily influenced by UV exposure and by skin pigmentation. In turn, Norval *et al*, 2008 [6] reviewed the effect of chronic ultraviolet radiation on the human immune system and the study concluded that repeatedly irradiating individuals with UVR is likely to continue to result in down regulation of immunity.
While, Tang *et al*, 2024 [7] and Hart *et al*, 2019 [8] indicated that the biological effects of UV exposure extend beyond the skin and include the treatment of inflammatory diseases, solid tumors and certain abnormal behaviors.
Moreover, McKenzie *et al*, 2009 [9] developed an algorithm and used to relate vitamin D production to the widely used UV index, to help the public to optimize their exposure to UV radiation. McKenzie *et al*, 2009 [9] study concluded that in the summer at noon, there should

at mid-latitudes be sufficient UV to photosynthesize optimal vitamin D in 1 min for full body exposure, whereas skin damage occurs after 15 min. Further, while it should be possible to photosynthesize vitamin D in the winter at midlatitudes, the amount of skin that must be exposed is larger than from the hands and face alone.

Based on the above, Knowledge of the amount of UV radiation received by plants and animals near the Earth's surface is important in a wide range of fields such as cancer research, forestry, tropospheric chemistry, agriculture, oceanography and solar chemistry. However, the UV solar irradiance at the ground varies greatly with local time, latitude and season, primarily because of the changing elevation of the sun in the sky [4, 10, 11].

Many countries used different measurements and instruments to detect UVI such as stations and networks [1]. In turn, several researchers calculated the UVI depending on specific parameters such as the distribution of ozone and aerosol or using a determined equation [3, 12, 13, 14, 15]. The other method is to use an auto-regression equation, which has been obtained by fitting observed UVIs to a limited set of atmospheric parameters. This method, pioneered by Environment Canada which is computationally efficient, easy to use and has been adopted by others [16, 17]. The equation of Burrows *et al*. (1994) [16], however, is limited to a specific range of Solar Zenith Angle (SZA) values that are relevant for noontime in the Canadian summer, and does not reproduce the measurements taken at the tropical station at Paramaribo.

In Iraq, the UVI increased dramatically in the recent years. So, awareness, and understanding of the impact of the UVR on the Iraqis people health should be taken under consideration. Accordingly, this paper focuses on the computation of the UVindex (UVI) using statistical model of measuring UVI based on different areas in Iraq.

Aim of the study

The aim of this study is to study the behavior of the UVI according to different periods of time for different regions of Iraqi country. As well as offers a predicted model for either prediction or forecasting of UVI parameter in the next periods of the studied time series in Iraq.

Materials and Methods

This study was done under the collaboration between the Institute of Medical Technology- Baghdad and the Ministry of Science and Technology-Iraq. The data was collected from the Tropospheric Emission Monitoring Internet Service (https://www.temis.nl/index.php).

As well as the data was collected from Vantage Pro2™ (6152, 6153) and Vantage Pro2 Plus (6162, 6163) Wireless weather stations which consist of two components: The Sensor Suite, which contains and operates the external sensor array, and the console, which offers the user interface, data presentation, and calculations (Figure 1). These wireless stations are present in Ministry of Science and Technology-Iraq.

Fig 1: Wireless Vantage Pro2™ and Vantage Pro2™ plus Stations

The UVI has been measured in different regions in Iraq (north, middle and south) and through different periods of time (daily, monthly and yearly) for 22 years. The statistical analysis has been done by using SPSS (version 24, IBM Corp.). The mean and the standard error were calculated. After examination the normal distribution by using Shapiro-Wilk test. The mean differences and P-values of UVI among different area were assessed using the Auto-regression ANOVA test. A correlation coefficient was used to compare between the data from these two stations.

Results

The current study evaluates satellite and ground-based readings of the UV index from 2002 to 2024. A new statistical model was introduced to study the behavior of the UVI according to different periods of time and different regions of Iraqi country. As well as to offer a suggested model for future prediction and forecasting of UVI in Iraq.

In the present study, in order to be certain that a chosen auto-regression equations is the best one among several suggestion models for studying influence of "Obsolescence period of time(per day, months and years) for UVI parameter in each of studied regions (Baghdad, Basra, and Mosul) regions, and in light of this, the following models of linear and nonlinear that can be transformed to linear form was proposed: (Linear, Logarithmic, Inverse, Quadratic, Cubic, Power, Compound, S-Shape, Logistic, Growth and Exponential), which represented their outcomes of (Auto-regression ANOVA) in the Table (1).

The results showed that "Inverse" model has been registered the best model for all studied regions, since obtaining the highest test statistic values among proposed models. In addition to that, most of leftover models has acceptable and meaningful influence of "Obsolescence period of time on UVI" parameter, since they are accounted equalized their probability levels of significant for testing auto-regression ANOVA (i.e. Covariance among UVI) along the effect of Obsolescence time period per days by the side of (1-7-2002 to 16-8-2024), exceptional for those that recorded a level of significant greater than 0.05.

Table 2 showed auto-regression of inverse models which were tested in two tailed alternative statistical hypotheses. Slopes values (The long term trend) has been estimated strong and too highly significant effects of studied parameter at *P*<0.001 along obsolescence period of time in each of studied regions. The constant term, which was one of the several sources of fluctuations not included in the model under study, demonstrated that the initial value was significant independent of the independent variable's influence (The lagging of studied period) on the studied function "UVI" parameter, and statistically it has been too highly significant at P<0.001 in each of studied regions. Accordingly, to preceding results, the predicted equations of time series "UVI" could be estimated and given by:

For Baghdad city: $\hat{Y}i = \{7.030807 + 11.348173/ X_i\}$

For Basra city: $\hat{Y}i = \{7.919096 + 11.392838/ X_i\}$

For Mosul city: $\hat{Y}i = \{6.359174 + 12.100415/ X_i\}$

Table 1: Auto- Regression ANOVA for influence obsolescence period of time series per days, months and years on UVI Parameter

Dep.	Independent: Obsolescence for period(days, months and years) from 1st of July 2002 to 16th June 2024																		
	Proposed Statistical Models	Baghdad						Basra						Mosul					
		Time per days		Time per months		Time per years		Time per days		Time per months		Time per years		Time per days		Time per months		Time per years	
		F-value	Sig. Level	F-value	Sig. Level	F-value	Sig. Level	F-value	Sig. Level	F-value	Sig. Level	F-value	Sig. Level	F-value	Sig. Level	F-value	Sig. Level	F-value	Sig. Level
UVI	Linear	5.490	0.019	0.020	0.895	14.02	0.001	2.760	0.097	0.070	0.801	8.520	0.008	7.430	0.006	0.004	0.953	18.20	0.000
	Logarithmic	0.150	0.698	0.590	0.461	8.820	0.007	0.090	0.770	0.450	0.519	5.470	0.029	0.310	0.578	0.670	0.432	8.690	0.008
	Inverse	19.84	0.000	2.130	0.175	4.380	0.049	21.03	0.000	2.010	0.187	3.480	0.076	21.70	0.000	2.160	0.172	2.570	0.124
	Quadratic	4.250	0.014	75.34	0.000	10.92	0.001	3.300	0.037	118.7	0.000	7.820	0.003	5.230	0.005	53.17	0.000	16.67	0.000
	Cubic	4.110	0.006	44.67	0.000	18.05	0.000	2.970	0.031	71.68	0.000	12.08	0.000	4.360	0.005	31.80	0.000	18.81	0.000
	Growth	4.630	0.032	0.050	0.822	13.92	0.001	3.130	0.077	0.120	0.737	8.400	0.009	5.800	0.016	0.030	0.876	18.09	0.000
	Power	0.300	0.585	0.510	0.490	8.870	0.007	0.010	0.909	0.370	0.554	5.440	0.030	0.430	0.514	0.610	0.452	8.730	0.008
	S - Shape	13.65	0.000	2.310	0.160	4.440	0.047	14.25	0.000	2.060	0.181	3.500	0.075	14.42	0.000	2.470	0.147	2.590	0.122
	Compound	4.630	0.032	0.050	0.822	13.92	0.001	3.130	0.077	0.120	0.737	8.400	0.009	5.800	0.016	0.030	0.876	18.09	0.000
	Exponential	4.630	0.032	0.050	0.822	13.92	0.001	3.130	0.077	0.120	0.737	8.400	0.009	5.800	0.016	0.030	0.876	18.09	0.000
	Logistic	4.630	0.032	0.050	0.822	13.92	0.001	3.130	0.077	0.120	0.737	8.400	0.009	5.800	0.016	0.030	0.876	18.09	0.000

Shaded model reported the best fitness Equation, as a result of recording the highest test statistic value

Table 2: Auto -regression outcomes of obsolescence over time period per days on (UVI) parameter for studied of different Regions

Dependent variable: (UVI) in Baghdad city					
Simple Correlation Coefficient	0.04949	Inverse Auto-regression Tested in two tailed alternative Statistical hypothesis			
Determination Coefficient R Square	0.00245				
F (Statistic)	19.8374	Sig. Level	0.0000 (THS) (*)		
Variables in the Equation					
Variable	B	SE.B	Beta	t-test	Sig. level
Time Lagged (1)	11.348173	2.547907	0.049485	4.454	0.0000
(Constant)	7.030807	0.036346	-	193.442	0.0000
Predicted equation is Inverse Model: $\hat{Y}$ i $= b_0 + (b_1/X_i)$					
Dependent variable: (UVI) in Basra city					
B	0.05095	Inverse Auto -regression Tested in two tailed alternative Statistical hypothesis			
Determination Coefficient R Square	0.00260				
F (Statistic)	21.03254	Sig. Level	0.0000 (THS) (*)		
Variables in the Equation					
Variable	B	SE.B	Beta	t-test	Sig. level
Time Lagged (1)	11.392838	2.484197	0.050951	4.586	0.0000
(Constant)	7.919096	0.035437	-	223.469	0.0000
Predicted equation is Inverse Model: $\boldsymbol{\hat{Y}}$ **i** $= \boldsymbol{b_0} + (\boldsymbol{b_1/X_i})$					
Dependent variable: (UVI) in Mosul city					
Simple Correlation Coefficient	0.05175	Inverse Auto-regression Tested in two tailed alternative Statistical hypothesis			
Determination Coefficient R Square	0.00268				
F (Statistic)	21.69573	Sig. Level	0.0000 (THS) (*)		
Variables in the Equation					
Variable	B	SE.B	Beta	t-test	Sig. level
Time Lagged (1)	12.100415	2.597844	0.051745	4.658	0.0000
(Constant)	6.359174	0.037058	-	171.599	0.0000
Predicted equation is Inverse Model: $\hat{Y}$ i $= b_0 + (b_1/X_i)$					

(*) **THS:** Too Highly Significant at P<0.001

Figure (2) showed long term trends of inverse shapes concerning of "Influence of Obsolescence of studied period of time on UVI" parameter, along different of studied regions (Baghdad, Basra, and Mosul) regions.

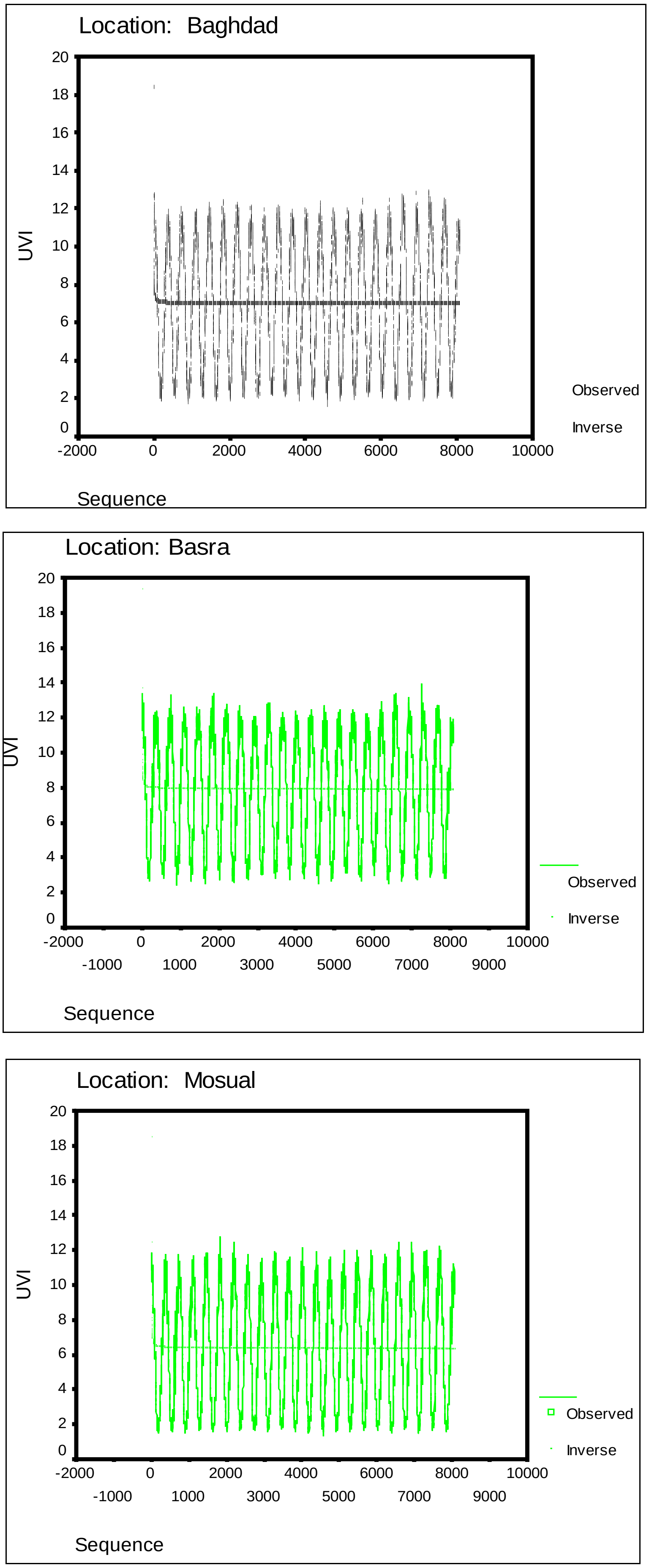

Fig 2: Inverse long term trends auto-regression predicted equations of Influence Obsolescence period of time (per days) for UVI parameter

In accordance to UVI per months, the results showed that "Polynomial Quadratic" model has been registered the best model among all of the studied regions, since obtaining the only too highly significant level at P<0.001 among the proposed models, while all of the leftover models were not acceptable their influence models of "obsolescence period of time (per months) of UVI" parameter, since they are accounted non-significant testing auto-regression ANOVA (i.e. Covariance among UVI along the effect of obsolescence time period per months by the side of (2002 - 2024) yrs., exceptional of "Polynomial Cubic" model which represented significant level at P<0.001(Table 3).

Table (3) showed auto-regression of "Polynomial Quadratic" model, which were tested in two tailed alternative statistical hypothesis.

Table 3: Auto-regression outcomes of Obsolescence over time period (per months) on (UVI) parameter for the studied of different Regions

Dependent variable: (UVI) in Baghdad city					
Simple Correlation Coefficient	0.97141	Quadratic Polynomial Auto-regression Tested in two tailed alternative Statistical hypothesis			
Determination Coefficient R Square	0.94364				
F (Statistic)	75.34057	Sig. Level	0.0000 (THS) (*)		
Variables in the Equation					
Variable	**B**	**SE.B**	**Beta**	**t-test**	**Sig. level (*)**
Time	3.761419	0.318361	4.086984	11.815	0.0000
$Time^2$	0.292358-	0.023840	-4.242111	-12.263	0.0000
(Constant)	-1.604182	0.900145	-	-1.782	0.1084
Predicted equation is Cube Polynomial Model: $\hat{Y}\,i = b_0 + b_1X_i + b_2{X_i}^2$					
Dependent variable: (UVI) in Basra city					
B	0.98156	Quadratic Polynomial Auto-regression Tested in two tailed alternative Statistical hypothesis			
Determination Coefficient R Square	0.96346				
F (Statistic)	118.65757	Sig. Level	0.0001 (THS) (*)		
Variables in the Equation					
Variable	**B**	**SE.B**	**Beta**	**t-test**	**Sig. level (*)**
Time	3.655745	0.249497	4.080965	14.652	0.0000
$Time^2$	0.286822-	0.018683	-4.275782	-15.352	0.0000
(Constant)	-0.325068	0.705437	-	-0.461	0.6559
Predicted equation is Cube Polynomial Model: $\hat{Y}\,i = b_0 + b_1X_i + b_2{X_i}^2$					
Dependent variable: (UVI) in Mosul city					
Simple Correlation Coefficient	0.85891	Quadratic Polynomial Auto-regression Tested in two tailed alternative Statistical hypothesis			
Determination Coefficient R Square	0.73772				
F (Statistic)	18.17.81377	Sig. Level	0.0000 (THS) (*)		
Variables in the Equation					
Variable	**B**	**SE.B**	**Beta**	**t-test**	**Sig. level (*)**
Time	3.818024	0.318361	4.066154	9.990	0.0000
$Time^2$	0.295060-	0.023840	-4.196346	-10.310	0.0000
(Constant)	-2.499841	0.900145	-	-2.313	0.0460
Predicted equation is Cube Polynomial Model: $\hat{Y}\,i = b_0 + b_1X_i + b_2{X_i}^2$					

(*) **THS:** Too Highly Significant at *P*<0.001.

Slopes values of a Polynomial Quadratic model (The long term trend) has been estimated the strong and too highly significant effects of studied parameter at P<0.001 along the obsolescence period of time effects (per months) in each of the studied regions.

The constant term, one of the other sources of fluctuations not included in the model under study, demonstrated that an initial value has no significance irrespective of the influence of the independent variable (The lagging of studied period) on the studied function "UVI" parameter, and statistically it has been no significant at P>0.05 in each of the studied regions, exceptional at Mosul city, since significant effect was accounted at P<0.05.

According to preceding results, the predicted equations of time series "UVI" could be estimated and given by:

For Baghdad city

$$\hat{Y}i = \{-1.604182 + 3.761419X_i - 0.2923580\ X_i^2\}$$

For Basra city

$$\hat{Y}i = \{-0.325068 + 3.655745X_i - 0.286822\ X_i^2\}$$

For Mosul city

$$\hat{Y}i = \{-2.499841 + 0.382183\ X_i - 2.499841\ X_i^2\}$$

Figure (3) showed long term trends of Polynomial Quadratic model shapes concerning of "Influence of Obsolescence of studied period of time per months on the UVI" parameter, along different of studied regions (Baghdad, Basra, and Mosul) regions.

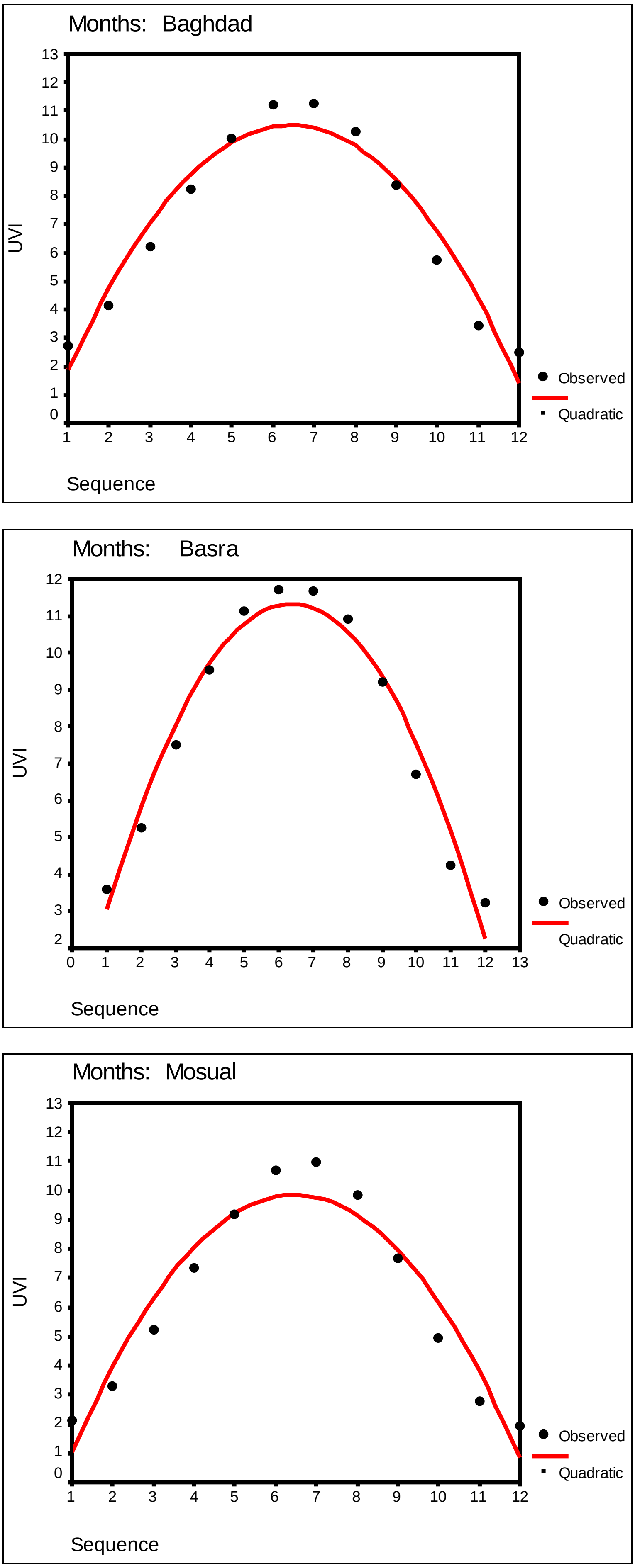

Fig 3: Cube long term trends auto-regression predicted equations of Influence Obsolescence period of time per (Months) on UVI parameter for the studied different regions

In turn UVI per years, results showed that "Polynomial Cubic" model has been registered the best model among all studied regions, since obtaining the highest test statistic values of proposed models. In addition to that, most of the leftover models has acceptable and meaningful influence of "obsolescence period of time (Per Years) by UVI" parameter, since they were accounted equalized their probability levels of significant for testing auto-regression ANOVA (i.e. Covariance among UVI along the effect of obsolescence time period per yrs. by the side of (2002 - 2024), exceptional for those that recorded a level of significant greater than 0.05 (Table 4).

Table (4) showed auto-regression of "Polynomial Cubic" models which were tested in two tailed alternative statistical hypothesis.

Table 4: Auto-regression outcomes of Obsolescence over time period per years on (UVI) parameter for the studied of different Regions

Dependent variable: (UVI) in Baghdad city					
Simple Correlation Coefficient	0.86040	Cube Polynomial Auto-regression Tested in two tailed alternative Statistical hypothesis			
Determination Coefficient R Square	0.74029				
F (Statistic)	18.05256	Sig. Level	0.0000 (THS) (*)		
Variables in the Equation					
Variable	**B**	**SE.B**	**Beta**	**t-test**	**Sig. level (*)**
Time	0.096620	0.031148	4.037775	3.102	0.0059
$Time^2$	-0.010353	0.002982	-10.69453	-3.472	0.0026
$Time^3$	0.000327	8.179E-05	7.574899	3.995	0.0008
(Constant)	6.751151	0.088191	-	76.552	0.0000
Predicted equation is Cube Polynomial Model: $\hat{Y}\text{ i} = b_0 + b_1X_i + b_2{X_i}^2 + b_3{X_i}^3$					
Dependent variable: (UVI) in Basra city					
B	0.80995	Cube Polynomial Auto-regression Tested in two tailed alternative Statistical hypothesis			
Determination Coefficient R Square	0.65602				
F (Statistic)	12.07873	Sig. Level	0.0001 (THS) (*)		
Variables in the Equation					
Variable	**B**	**SE.B**	**Beta**	**t-test**	**Sig. level (*)**
Time	0.087235	0.034628	3.773920	2.519	0.0209
$Time^2$	-0.009823	0.003315	-10.50375	-3.963	0.0080
$Time^3$	0.000315	9.0927E-05	7.556628	3.463	0.0026
(Constant)	7.690802	0.098043	-	78.443	0.0000
Predicted equation is Cube Polynomial Model: $\hat{Y}\text{ i} = b_0 + b_1X_i + b_2{X_i}^2 + b_3{X_i}^3$					
Dependent variable: (UVI) in Mosul city					
Simple Correlation Coefficient	0.85891	Cube Polynomial Auto-regression Tested in two tailed alternative Statistical hypothesis			
Determination Coefficient R Square	0.73772				
F (Statistic)	18.17.81377	Sig. Level	0.0000 (THS) (*)		
Variables in the Equation					
Variable	**B**	**SE.B**	**Beta**	**t-test**	**Sig. level (*)**
Time	0.060870	0.031602	2.519673	1.926	0.0692
$Time^2$	-0.006899	0.003026	-7.058862	-2.280	0.0343
$Time^3$	0.000237	8.298E-05	5.443735	2.857	0.0101
(Constant)	6.160439	0.089474	-	68.851	0.0000
Predicted equation is Cube Polynomial Model: $\hat{Y}\text{ i} = b_0 + b_1X_i + b_2{X_i}^2 + b_3{X_i}^3$					

(*) **THS:** Too Highly Significant at *P*<0.001; HS: Highly Significant at *P*<0.01; S: Significant at P<0.05.

Slopes values of Polynomial of cube model (The long term trend) has been estimated strong and significant effects of studied parameter in at least at *P*<0.05 along the obsolescence period of time effects (per years) in each of the studied regions.

The constant term, which was one of the several sources of fluctuations not included in the model under study, demonstrated that the initial value was significant independent of the independent variable's influence (The lagging of studied period) on the studied function "UVI" parameter, and statistically it has been too highly significant at P<0.001 in each of studied regions. According to preceding results, the predicted equations of time series "UVI" could be estimated and given by:

For Baghdad city

$$\hat{Y}i = \{6.751151 + 0.09662X_i - 0.010353X_i^2 + 0.000327X_i^3\}$$

For Basra city

$$\hat{Y}i = \{7.690802 + 0.087235X_i - 0.009823X_i^2 + 0.000215X_i^3\}$$

For Mosul city

$$\hat{Y}i = \{6.160439 + 0.06087X_i - 0.006899X_i^2 + 0.000237X_i^3\}$$

Figure4 showed long term trends of Polynomial cube model shapes concerning of "Influence of Obsolescence of studied period of time per yrs. on UVI" parameter, along different of studied regions (Baghdad, Basra, and Mosul) regions.

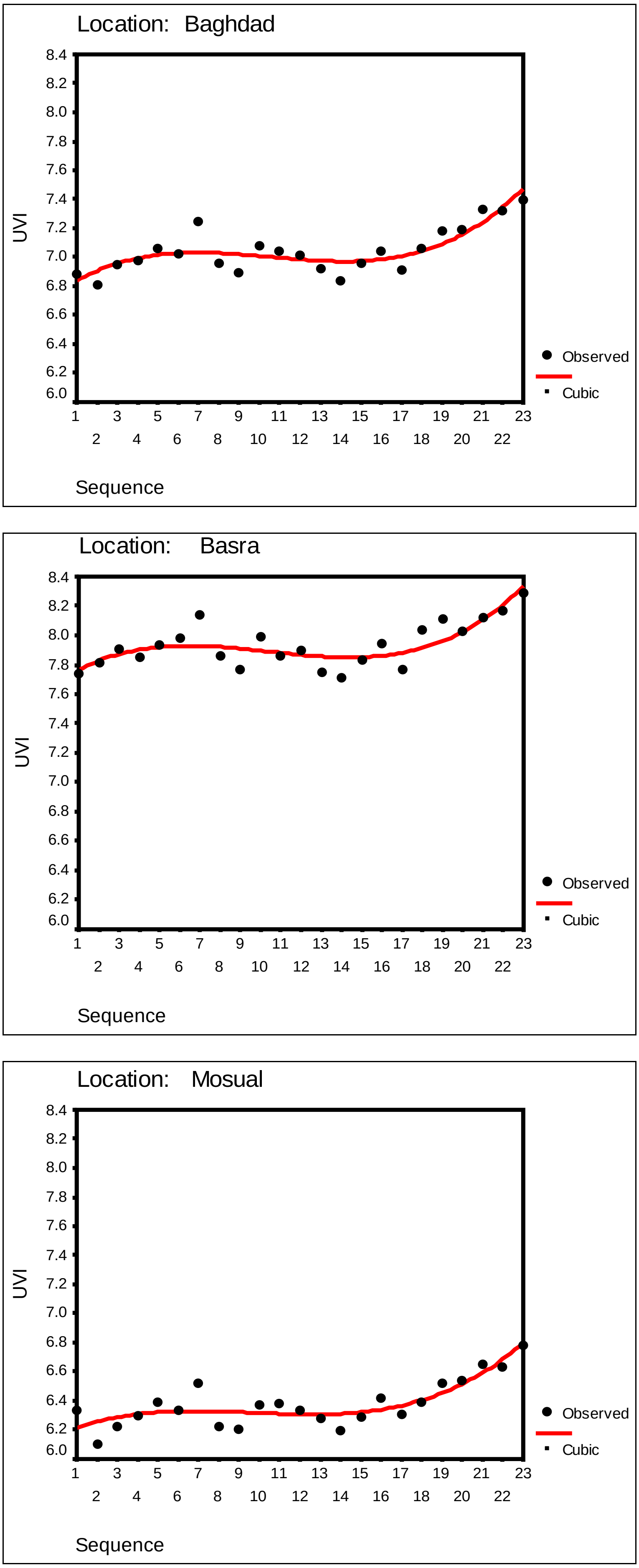

Fig 4: Cube long term trends Auto-Regression predicted equations of Influence Obsolescence period of time (per yrs.) on UVI parameter for the studied different regions

Discussion

The current study evaluates satellite and ground-based readings of the UV index from 2002 to 2024. Excellent agreement was found when comparing computations based on satellites with ground-based UVI observations, with correlations (R2) ranging from 0.90 to 0.96. These outcomes were consistent with those of De Laat *et al*. (2010) [18].

Many researchers used various classification models to predict UV parameter level categories, some of them developed a prediction model like Naive-Bayes, while other researcher tested the decision tree, random forests, and artificial neural networks methods to estimate the UV Index value (EdyErvianto et.al, 2023; H. Sulistianiand Aldino, 2020; Jun, 2021; Sahin, 2020; Liu, 2022; Wang *et al*., 2021; Yamano *et al*., 2020) [20, 21, 22, 23, 24, 26].These studies had some limitations that need to be noted to understand the interpretation of the results. As well as the previous used data sourced from a single training dataset.

Recommendations

The results of the present study can be used by authorities to providing early warranties to the public regarding risks of UVI exposure. This research provides a suggested models for future prediction and forecasting of UVI in Iraq in different regions. In turn, the predicted equations of time series will improve public awareness and health policy. As well as the useful information on the dangers of UVI exposure can help people to be more vigilant. Research can assist governments and health agencies in designing educational programs and policies to reduce health risks associated with UVI exposure. The research has applications in environmental management. Data generated from research can be used to monitor and manage the environmental impacts of UVI exposure, such as impacts on plants, animals and water quality.

Conclusion

The present study explored the temporal and spatial behavior of the Ultraviolet Index (UVI) across three major regions of Iraq—Baghdad, Basra, and Mosul—using advanced statistical modeling techniques over a 22-year period (2002-2024). By applying and comparing several linear and nonlinear auto-regressive models, the study identified the most suitable models for different time scales (daily, monthly, yearly) to predict and forecast UVI behavior. The results clearly showed that the “Inverse” model provided the most accurate fit for daily variations, the “Quadratic” model for monthly variations, and the “Cubic” model for yearly variations. These models captured both short-term fluctuations and long-term trends, confirming the robustness of statistical modeling for environmental data analysis.

Regionally, Basra consistently recorded the highest UVI values throughout the study period, reflecting its southern geographical location, higher solar radiation intensity, and climatic conditions. Baghdad showed moderate values, while Mosul, located further north, recorded the lowest UVI levels. These regional variations underline the importance of localized UVI monitoring for effective health and environmental risk management. The rising trends of UVI, especially in recent years, highlight growing environmental challenges and potential public health risks, particularly in relation to skin cancer, immune system suppression, and other UV-related diseases.

The predictive equations generated in this study provide a practical tool for forecasting UVI levels and issuing early warnings to the public. Such models can support health authorities, environmental agencies, and policymakers in designing awareness campaigns, educational programs, and protective measures to reduce harmful UV exposure. Furthermore, these findings are valuable not only for human health management but also for assessing the impacts of UVI on plants, animals, and water quality, thereby contributing to sustainable environmental management.

In conclusion, the research emphasizes that continuous monitoring and predictive modeling of UVI are crucial for Iraq. The integration of these models into public health policies and environmental planning can enhance preparedness, reduce risks, and promote resilience against the adverse effects of ultraviolet radiation.

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