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Evaluation of temperature parameters in Kayseri province with CLIGEN

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Abstract — One of the critical consequences of climate change, expecting in the future but beginning to appear nowadays, is the increase in average earth temperatures. The Mediterranean basin we live in is one of the regions that this climate change will most affect. Therefore, simulation studies using climate models gain importance. In this study, Kayseri station's 39-year temperature changes between the 1980-2018 years were simulated using the CLIGEN climate model. The relationship between observed and predicted temperatures was determined utilizing the Mann-Kendall statistical method. CLIGEN estimated the annual average, minimum and maximum average temperatures above the detected value. These values have shown that the study area may encounter a drought problem and be affected by climate change soon.

Subject Classification (2020):

1. Introduction

The performance of solar energy system changes based on wind velocity, ambient temperature and clamminess. These factors are identified according to their change over time [1]. Air temperature is expressed as the amount of moisture retained in the atmosphere [2]. Individual precipitation events and increases in precipitation intensity happen based on the increases in temperature [1].

Surface air temperature is one of the most important factors [3]. Global climate change indicators are used to indicate the change of surface temperature over time. These are (1) positive recycling between ambient temperature and carbon cycle [4]. (2) earth temperature, which controls soil air and soil failure [5], cause and effect between global warming and decreasing bio-diversity [6], the changes in plant phenology [7] and growing season [8].

Temperature is an essential parameter in many environmental factors [9]. These models use the average temperature over a certain period. In the general directorate of meteorology, temperature data of the past 150 years read automatically with digital tools. These tools evaluate temperature actuarially

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[10,11]. Although the daily maximum and minimum temperature data show normal distribution, it has been observed that it does not show the normal distribution in many conditions. Data shows distribution below or above normal, but they are moving away from normal.

The method used to evaluate the daily maximum and minimum temperature data is crucial. Because the temperature values found as a result of the simulation must be close to the observed temperature values. LARS-WG and CLIGEN provided in [12] performed well to simulate long-term climate data in the Western Lake Erie Basin (WLEB). CLIGEN calculates temperature values that are not affected by precipitation. There was no statistically significant relationship between observed and expected values as a consequence of the analysis. Therefore, the climate model must be suitable for the climatic conditions of the area [12]. There are many studies on the changes in daily temperature values due to climate change during the 20th century and at present. In these works, the effects of temperature changes on agricultural, forest, environment and human were evaluated with a climate model. Several stochastic weather generators (SWGs) have been developed over the last few decades, such as the Weather GENerator (WGEN) [13, 14], the CLIMate GENerator (CLIMGEN) [15], the CLImate GENerator (CLIGEN) [16, 17] and the Long Ashton Research Station-Weather Generator (LARS-WG) [18]. They have been widely used to simulate daily weather time series for impact studies [18, 19, 20, 21, 22].

According to the preliminary research, there is no study on the trend of long-term temperature data simulated with the CLIGEN climate model in Kayseri and the effects on agricultural production. This study aimed to use the CLIGEN climate model to simulate temperature values obtained from the Kayseri Meteorological Station from 1980 to 2018 and compare observed and simulated temperature values with annual, monthly, and seasonal evaluations of the model's performance in Kayseri climate conditions.

2. Material

The sea rises to a height of 1050 meters. It is Central Anatolia's third-largest city. Kayseri has many steppe climate characteristics. Summers in Kayseri are hot and dry, while winters are cold and snowy. Erciyes Mountain, at 3.916 meters, is the province's highest peak, and it encompasses a significant portion of the province, and volcanic soils make up a significant portion of the agricultural region. The average annual air temperature is 18.21°C, with 399.6 mm of precipitation recorded at the Turkish State Meteorological Service's Kayseri Meteorological Station between 1980 and 2018. The wettest months are July and August, with the least amount of rain falling in May.

Kayseri is located in the central Kızılırmak area of Central Anatolia (Figure 1). The height of the sea is 1050 m. It is the third-largest city in Central Anatolia. There are many steppe climate characteristics in Kayseri. In Kayseri, summers are hot and dry; winters are cold and snowy. The highest mountain of the province is Erciyes Mountain, with a height of 3.916 meters, and a large part of the agricultural area is made up of volcanic soils. The average annual air temperature is 18.21°C, and the annual amount of precipitation between 1980 and 2018 was measured 399.6 mm in the Kayseri Meteorological Station of the Turkish State Meteorological Service. The lower precipitations are found in July and August, and the highest precipitations are in May.

Figure 1. Geographic position of the studied province to Turkey.

3. Methods

3.1 Meteorological Data

This work contains an analysis of surface air temperature trends obtained from Kayseri meteorological stations. The locations of the stations are presented in Figure 1, and their main parameters are given in Table 1 by the meteorological Service of Kayseri.

3.2 CLIGEN

CLIGEN is a climate model that simulates climatic parameters such as precipitation, maximum and minimum temperature, solar radiation, relative humidity, wind direction and intensity (Figure 2). It makes daily weather forecasts using the Markow chain, which predicts the probability of a wet day P (W|W) following a wet day and a dry day P (W/D) following a wet day. The simulations use the amount of precipitation on a wet day and the skewed normal distribution. [16]. The predicted air temperature with CLIGEN may be higher than the temperature of the dry day following a dry day and may be lower than the temperature of the wet day following a wet day. [23,13]. WEPP model estimates the temperature using the equation given below:

$$T_{\max} \coloneqq T_{\mathrm{mx}} + (ST_{\mathrm{mx}}) * v * B \quad (1)$$

$$T_{\max} \coloneqq T_{mn} + (ST_{mn}) * v * B \quad (2)$$

Here, $T_{\max}$ and $T_{\max}$ are the simulated maximum and minimum temperatures. Tmx and Tmn are the maximum and minimum temperatures observed in each month. STmx and STmn are the standard deviation values of the observed maximum and minimum temperatures. 'v' is the normal standard deviation, and B is the probability of being wet-dry. The B value is calculated according to the formulas given below:

$$T_{\max} \coloneqq T_{\mathrm{mx}} + (ST_{\mathrm{mx}}) * v * B \quad (1)$$

$$T_{\max} \coloneqq T_{mn} + (STmn) * v * B \quad (2)$$

$$B\ (W/D) = 1 - (P(W/D))/PF \quad (3)$$

$$B\ (W/W) = 1 - (P(W/W))/PF \quad (4)$$

$$B\ (D/D) = (P(D/D))/PF \quad (5)$$

$$B\ (D/W) = (P(D/W))/PF \quad (6)$$

P (W/D) is the wet days after a dry day, and P (W/W) is the wet day after a wet day. PF is a factor based on the probability of wet and dry and is calculated by the formula given below:

$$PF\ = P(W\backslash D)(1-(W\backslash D))\ +\ P(W\backslash W)(l-P(W\backslash WO) \quad (7)$$

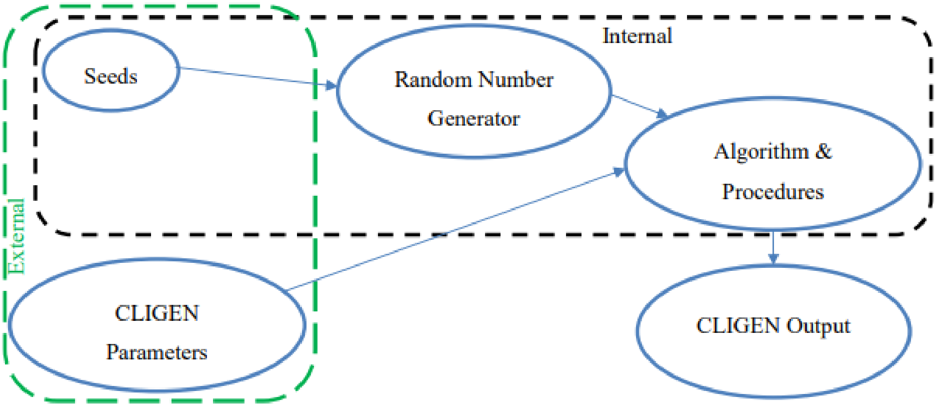

Figure 2. Mechanism of daily temperatures process in CLIGEN

Descriptive statistical data such as mean, standard error, median value, minimum and maximum for data series and average standard error statistics were used in determining which years some measured climatic data showed excess. An evaluation of the trends in climatic variables is essential for understanding the effect of climate change on temperature, precipitation which has a direct and adverse impact on hydrological, agricultural and economic. Various statistical methods are available to determine trends in climatic and hydrologic variables [24-27]. In hydro-meteorological data, the non-normal distribution and the censored character are typical, and the Mann-Kendall can handle such issues [27,28]. Therefore, in the present research, these methods were selected to detect in variation the annual and seasonal precipitation measured in the Kayseri station. A detailed description of the methods used is given below.

3.3 Mann-Kendall Test

This study's statistical approach used the Mann–Kendall test [29,30] to indicate statistically significant trends. The Mann–Kendall test is widely used in the analysis of climatologic time series; for example, temperature and precipitation [31], extreme temperatures [32], hail [33,34], aridity [35], evapotranspiration [36], and atmospheric deposition [37], and also in hydrological time series [38] and other geophysical time series, such as soil freezing and thawing [39] because it is simple and robust and can overcome values below the detection limit and missing values.

In using the Mann–Kendall test to define statistically significant trends, two hypotheses were tested: the null hypothesis H_0, that there is no trend in the time series and the alternative hypothesis H_a, that there is a trend in the time series for a given significance level. Probability p in per cent [31,40] was calculated to determine the level of confidence in the hypothesis. If the computed value p is lower than the chosen significance level α (e.g., α = 5 %), the H_0 (there is no trend) should be rejected, and the Ha (there is a significant trend) should be accepted, and if p is greater than the significance level α, then the H_0 (there is a significant trend) is accepted (or cannot be rejected). For calculating probability p and hypothesis testing, XLSTAT statistical analysis software was employed (Internet 2).

It is considered that accepting the H_a indicates that a trend is statistically significant. On the other hand, the acceptance of H_0 implies that there is no trend (no change), whereas, in practice, the trend equation usually indicates the opposite, that is, a trend. Therefore, to reduce the contradictions in analysing the temperature trends between two independent statistical approaches -the trend equation and the Mann-Kendall test- the modified interpretation of the Mann-Kendall test will be offered. Moreover, this interpretation makes it possible to obtain more diverse results.

It is quite clear that, with decreasing probability p, statistical confidence in the H_0 decreases, and confidence in the Ha increases, and vice versa. Because probability p takes values between 0% and 100%, for this study, a modified interpretation of the Mann–Kendall test was introduced, and four levels of confidence were defined. When the computed probability p is: (1) less or equal to 5%, the trend is significantly positive/negative; (2) greater than 5% and less than or equal to 30%, the trend is moderately positive/negative; (3) greater than 30% and less than or equal to 50%, the trend is slightly positive/negative; and (4) greater than 50%, there is no trend. As can be seen, in cases (1) and (4), both interpretations of the Mann–Kendall test have the same meaning: there is a significant trend and no trend. Differences occur in cases (2) and (3), where the Mann–Kendall test claims there is no trend, and the modified Mann–Kendall test allows a trend with reduced levels of confidence.

4. Results and Discussion

4.1 Annual Average Temperatures

Observed and simulated annual average temperatures were determined as 21.91 and 18.21°C, respectively. The relationship between them is given graphically in Figure 3. The determination coefficient was R^2: 0.83, which was a very high value. The model has simulated the annual average temperatures above the observed value. The data distribution above the 1:1 line also indicates this result (Figure 3). The global warming caused by the greenhouse effect strengthened because of the greenhouse gas accumulation in the atmosphere, became more evident, especially after the 1980s, and reached its highest value in the 1990s [41]. These climate changes cause hydrological cycle fluctuations, increasing the extreme hydrological events' severity and frequency. These events, which occur depending on the annual average temperature, also affect the soil structure and quality. Although it shows a positive effect in the short term, it causes a deterioration in the long term.

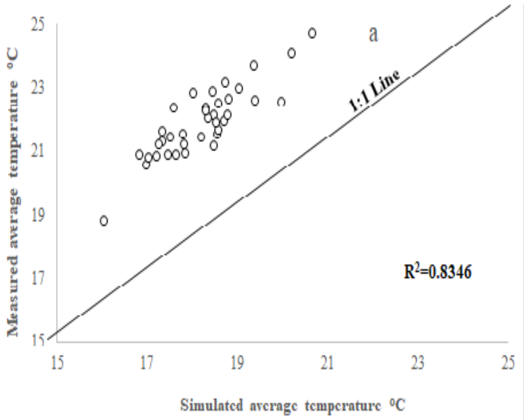

Figure 3. Relationship between observed and simulated annual average temperature

Since climate systems have variable and complex structures, it is very challenging to make accurate predictions. Climate change simulations are used to make climate projections despite the difficulties it entails. However, today's simulation studies may be inadequate due to the lack of reliable data on soil properties and soil management practices [42]. Global-scale statistical analyses cannot be reliable due to the insufficient and unreliability agricultural data having been obtained in some regions. Besides, analyses based on more reliable data obtained from another world region cannot be sufficient to create global simulations [43]. Because climate models such as CLIGEN complete the missing data using statistical analysis, they have a higher performance than other climate models. The temperature trend increasing since the mid-1990s has also been observed in the working area temperatures (Figure a). An increasing trend is in question, especially since the early 2000s. CLIGEN simulated the annual average data very close to the observed values. There is an increase in observed and simulated annual average temperatures after 2012 (Figure 4 a, b).

In [44], the CLIGEN climate model simulates the long-term average temperature data for Kayseri, Sivas, and Yozgat meteorological stations. As a result of the study, an increase in temperatures was observed. These values vary depending on the region and season.

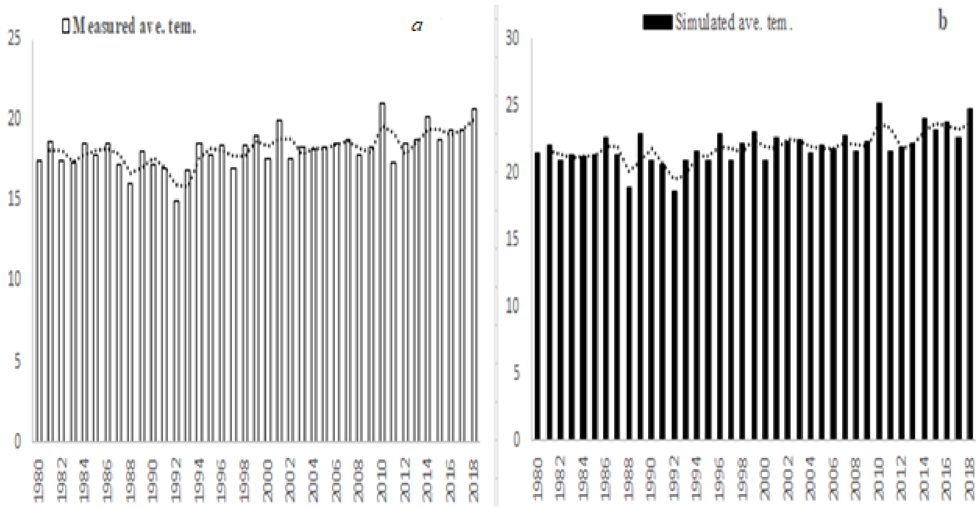

Figure 4. Trend change of observed and simulated annual mean temperatures

According to the Mann-Kendall method, trend analysis results of the annual average temperature data are given in Table 1. Figure 4 exhibits that there is a trend among the annual average temperature data.

Table 1. Mann Kendall analysis result for the annual average temperature

Parameters	Average	Standard deviation	Lower Limit	Upper Limit	Kendall's tau	p
CLIGEN	21.922	1.320	18.541	25.118	0.414	0.000
OBSERVED	18.224	1.183	14.955	21.058	0.385	0.001

H_0: There is no trend in the series. H_a: There is a trend in the series. Since the p values calculated for both variables are less than $\alpha = 0.05$, the H_0 hypothesis should be rejected, and the alternative hypothesis, the H_a hypothesis, should be accepted. So, there is a trend in the series.

4.2 Minimum Average Temperatures

Observed and simulated minimum temperatures were determined and graphically shown in Figure 5. The temperatures are 3.55 and 6.42°C, respectively, and the determination coefficient is 0.95. When Figure 4a is examined, the data are observed to show a distribution above the 1:1 line. The graphic showing the model performance by months is given in Figure 5b. The model has predicted the temperature values for especially March and November months, which are very low ordinarily, as very high. The precipitation seen in these months is quite variable, and the number of wet days is high. Therefore, the model has exaggerated the minimum temperature values (Figure 5). Besides, the model made close estimates to the observed value in July, August and September. These months are relatively dry in Kayseri province. Therefore, the model water budget does not change. When the minimum temperature changes by month are examined, the difference is observed as the lowest in January, February, November, and December and the highest in June and July (Figure 5b).

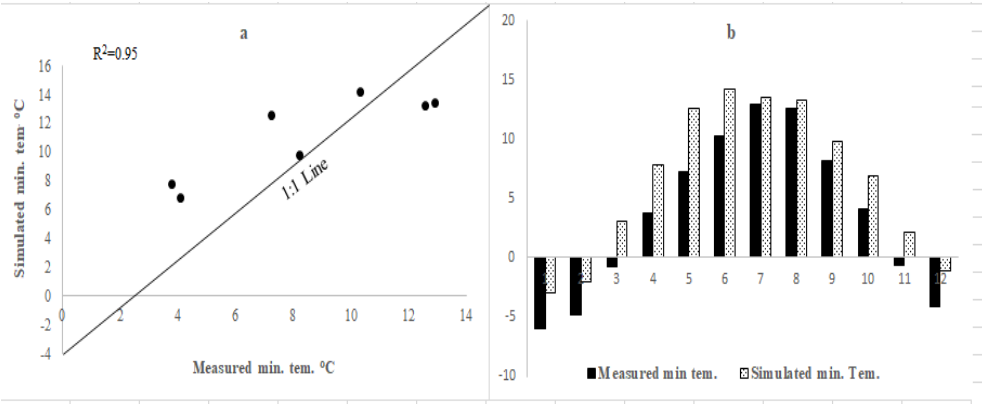

Figure 5. a) Relationship between observed and simulated minimum temperatures, b) Variation of observed and simulated minimum temperatures to months

The H_0 hypothesis cannot be rejected since the calculated p values for both variables are greater than α = 0.05. Thus, there is no trend in the series (Table 1).

Table 2. Mann Kendall analysis result for the minimum temperature

Parameters	Average	Standard deviation	Lower Limit	Upper Limit	Kendall's tau	p
CLIGEN	4.424	6.382	-4.833	12.903	0.091	0.755
OBSERVED	7.279	6.010	-2.050	14.220	-0.091	0.755

4.3 Maximum Temperatures

The observed and simulated maximum temperatures are 18.15 and 21.86°C, respectively. The relationship between them is shown graphically in the Figure. The determination coefficient is R^2=0.96. The model has overestimated the maximum temperatures compared to observed values (Figure 6a). The data disperse above the 1:1 line. In particular, the model has estimated the temperature values of January and December very high (Figure 66b). The rainfall reduction in the subtropical zone has become efficient in Turkey and the eastern Mediterranean basin since the 1970s [45,46]. The significant downward tendency in precipitation and drought events emerges more obviously in winters. Therefore, these reductions in precipitation cause the model to over-predict its temperatures.

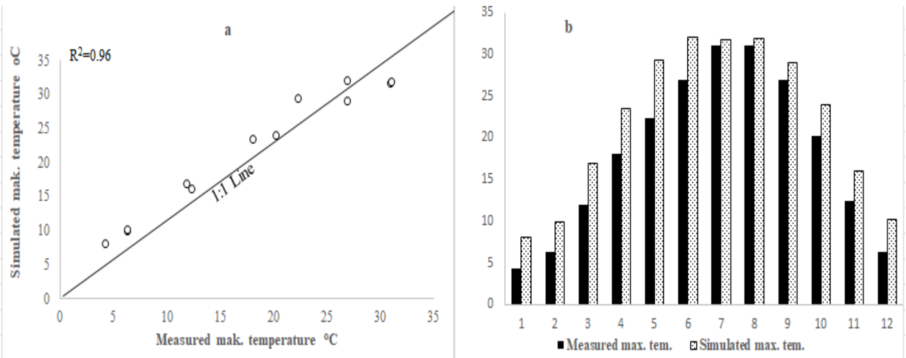

Figure 6. a) Relationship between observed and simulated maximum temperatures, b) Variation of observed and simulated maximum temperatures to months

The H_0 hypothesis cannot be rejected since the calculated p values for both variables are greater than $\alpha = 0.05$. So, there is no trend in the series (Table 3).

Table 3. Mann Kendall analysis result for the maximum temperature

Parameters	Average	Standard deviation	Lower Limit	Upper Limit	Kendall's tau	p
CLIGEN	23.106	8.546	9.964	31.993	-0.018	1.000
OBSERVED	19.408	9.164	6.330	31.040	0.127	0.640

5. Conclusion and Discussion

Climate change is considered to be one of the most critical environmental problems of today. Today, the climate change problem, affecting every phase of our lives, including nature, city life, industry, economy, technology, human rights, agriculture, food, clean water, and health, obliges the governments for a solution.

In parallel with the rapid growth trend that started after the industrial revolution, a significant warming trend is observed in global average surface temperatures due to CO_2 and other greenhouse gases accumulating in the atmosphere. According to the most recent international assessments, there has been an increase in global average surface temperatures of about 0.4-0.8°C in the last century. This warming trend became more evident after the 1980s, and in this period, high-temperature records were broken almost every year. The year 1998 was recorded as the hottest year globally averages since 1860 when instrumental temperature observations were started. Climate models predict that the global average surface temperature will increase between 1 and 3.5 °C until the year 2100 compared to 1990, and depending on this increase, the observed changes in the climate continue.

Besides, mostly as in the world's largest cities in the last 35-40 years, also in large cities in Turkey, where air pollution, rapid population growth, and intense urbanization are widespread, heating at night temperatures, cooling in daytime temperatures, and a decrease in daily temperature widths are observed generally. These trends are particularly evident in the hot, dry, cloudless summer seasons.

A CLIGEN climate model is a novel model that has recently been used in our country. In many regions globally, the model's performance has been evaluated, and very successful results have been obtained. It is significant to increase the simulation works performed with regional climate models to conduct more realistic climate forecasts in Turkey. Climate models such as CLIGEN consider the climate and the hydrological properties of the soil. To reduce soil losses, policies and measures can be determined through projection studies carried out with these models. As a result of these precautions, significant contributions can be made to the country's economy.

Author Contributions

All authors contributed equally to this work. They all read and approved the last version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] G. Lenderink, E. V. Meijgaard, *Linking İncreases in Hourly Precipitation Extremes to Atmospheric Temperature and Moisture Changes,* Environmental Research Letters, 5(2), (2010) Article ID: 025208, 1–9.

[2] M. Martinkova, M. Hanel, *Evaluation of Relations Between Extreme Precipitation and Temperature in Observational Time Series from the Czech Republic,* Advances in Meteorology, 2016 (2016) Article ID: 2975380, 1–9.

[3] T. G. Romilly, M. Gebremichael*, Evaluation of Satellite Rainfall Estimates over Ethiopian River Basins*. Hydrology and Earth System Sciences, 15, (2011) 1505–1514.

[4] F. S. Chapin III, J. McFarland, A.D. McGuire, E.S. Euskirchen, R. W. Ruess, K. Kielland, *The Changing Global Carbon Cycle: Linking Plant–Soil Carbon Dynamics to Global Consequences.* Journal of Ecology, 97, (2009) 840–850.

[5] P. S. Bindraban, Coauthors, *Assessing the Impact of Soil Degradation on Food Production,* Current Opinion in Environmental Sustainability, 4, (2012) 478–488.

[6] P. J. Mayhew, G. B. Jenkins, T. B. Benton, *A Long-Term Association Between Global Temperature and Biodiversity, Origination and Extinction in The Fossil Record*. Proceedings of the Royal Society B, 275, (2008) 47–53.

[7] J. Penuelas, M. Fernández-Martínez, H. Vallicrosa, J. Maspons, P. Zuccarini, J. Carnicer, T. G. M. Sanders, I. Krüger, M. Obersteiner, I. A. Janssens, P. Ciais, J. Sardans, *Increasing Atmospheric* CO_2 *Concentrations Correlate with Declining Nutritional Status of European Forests,* Communications Biology, 3, (2020) Article Number: 125, 1–11.

[8] H. Steltzer, E. Post, *Seasons and Life Cycles*. Science, 324, (2009) 886–887.

[9] L. Ye, H. Z. Tang, J. A. Verdoodt, E. Van Ranst, *Spatial Patterns and Effects of Soil Organic Carbon on Grain Productivity Assessment in China*. Soil Use and Management, 24, (2008) 80–91.

[10] J. Hansen, M. Sato, R. Ruedy, K. Lo, D. W. L, M. Medina-Elizade, *Global Temperature Change,* Proceeding of the National Academy of Sciences of the United States of America, 103(39), (2006) 14288–14293

[11] S. Rahmstorf, *Response to Comments on a Semiempirical Approach to Projecting Future Sea-Level Rise*, Science, 317, (2007), 1866.

[12] S. Mehan, T. Guo, M. W. Gitau, D. C. Flanagan, *Comparative study of different stochastic weather generators for long-term climate data simulation.* Climate, 5(2), (2017) 1–40.

[13] C. W. Richardson, *Stochastic Simulation of Daily Precipitation, Temperature, and Solar Radiation*, Water Resources Research, 17, (1981) 182–90.

[14] C. W. Richardson, D. A. Wright, *WGEN: A Model for Generating Daily Weather Variables,* U.S. Depart. Agr, Agricultural Research Service. Publ. ARS-8, (1984) 1–86.

[15] C. O, Stockle, R, Nelson, R, *Climgen, A Weather Generator Program*. Biological Systems Engineering Department, Washington State University, Pullman, Washington, USA. A. D, 1999.

[16] Nicks, G. A. Gander, *A Weather Generator for Climate Inputs to Water Resource and Other Models,* Computers in Agriculture. Michigan 49085, USA. 1994.

[17] A. D. Nicks, L. J. Lane, G. A. Gander, Weather generator, Ch. 2. In: Flanagan D. C, and Nearing M A. USDA—Water Erosion Prediction Project: Hillslope Profile and Watershed Model Documentation, NSERL Report No. 10. West Lafayette, Ind.: USDA—ARS—NSERL, 1995.

[18] M. A. Semenov, E. M. Barrow, W. G. LARS, *A Stochastic Weather Generator for Use in Climate Impact Studies,* User Manual, 2002.

[19] D. S. Wilks, R. L. Wilby, *The Weather Generation Game: A Review of Stochastic Weather Models,* Progress in Physical Geography: Earth and Environment, 23, (1999) 329–357.

[20] X. C. Zhang, *Spatial downscaling of global climate model output for site-specific assessment of crop production and soil erosion*. Agricultural and Forest Meteorology, 135(1–4), (2005) 215–229.

[21] D. Chen, M. Hu, Y. Guo, R. A. Dahlgren, *Changes in River Water Temperature Between 1980 and 2012 in Yongan Watershed, Eastern China: Magnitude, Drivers and Models,* Journal of Hydrology 533, (2016) 191–199.

[22] C. L. Hanson, K. A. Cumming, D. A. Woolhiser, C. W. Richardson, *Microcomputer Program for Daily Weather Simulations in The Contiguous United States*. USDA—ARS Publ. ARS—114, Washington D.C., 1994.

[23] A. D. Nicks, J.F. Harp, *Stochastic Generation of Temperature and Solar Radiation Data*. Journal of Hydrology, 48(1-2), (1980) 1–7.

[24] N. W. Arnell, N.S. Reynard, *The Effects of Climate Change Due to Global Warming on River Flows in Great Britain*. Journal of Hydrology, 183(3–4), (1996) 397–424.

[25] P. Frich, L. V. Alexander, P. M. Della-Marta, B. Gleason, M. Haylock, A.K. Tank, T. Peterson, *Observed Coherent Changes in Climatic Extremes During the Second Half of The Twentieth Century*. Climate Research, 19(3), (2002) 193–212.

[26] U. C. Udo-Inyang, I. D. Edem, *A Changes in Precipitation Analysis of Precipitation Trends in Akwa Ibom State, Nigeria*. Journal of Environmental and Earth Science, 2(8), (2012) 60–71.

[27] M. A. Rahman, L. Yunsheng, N. Sultana, *Analysis and Prediction of Precipitation Trends over Bangladesh Using Mann–Kendall, Spearman's Rho Tests and ARIMA Model.* Meteorology and Atmospheric Physics, 129(4), (2017) 409–424.

[28] V. Kumar, S. K. Jain, Y. Singh, *Analysis of Long-Term Precipitation Trends in India*. Hydrological Sciences Journal–Journal des Sciences Hydrologiques, 55(4), (2010) 484–496.

[29] M. G. Kendall, *Rank correlation methods*. London, 1975.

[30] R. O. Gilbert, *Statistical Methods for Environmental Pollution Monitoring*, 1987.

[31] N. Karmeshu, *Trend detection in annual temperature & precipitation using the Mann Kendall Test – a case study to assess climate change on select states in the northeastern United States*. Master's thesis, University of Pennsylvania. Philadelphia, 2012.

[32] J. Wibig, B. Glowicki, *Trends of Minimum and Maximum Temperature* in Poland, Climate Research, 20(2), (2002) 123–133.

[33] M. B. Gavrilov, L. Lazić, A. Pešić, M. Milutinović, D. Marković, A. Stanković, M.M. Gavrilov, *Influence of Hail Suppression on The Hail Trend in Serbia*. Physical Geography, 31(5), (2010) 441–454.

[34] M. B. Gavrilov, S.B. Marković, M. Zorn, B. Komac, T. Lukić, M. Milošević, S. Janićević, *Is Hail Suppression Useful in Serbia? – General Review and New Results*. Acta Geographica Slovenica 53(1), (2013) 165–179.

[35] I. Hrnjak, T. Lukić, M. B. Gavrilov, S. B. Marković, M. Unkašević, I. Tošić, *Aridity in Vojvodina, Serbia*. Theoretical and Applied Climatology, 115, (2014) 1–2.

[36] H. Tabari, S. Marofi, A. Aeini, P. H. Talaee, K. Mohammadi, *Trend Analysis of Reference Evapotranspiration in The Western Half of Iran*. Agricultural and Forest Meteorology, 151(2), (2011) 128–136.

[37] K. Drapela, I. Drapelova, *Application of Mann-Kendall Test and The Sen's Slope Estimates for Trend Detection in Deposition Data from Bílý Kříž (Beskydy Mts., the Czech Republic) 1997-2010*, Beskydy, 4(2) (2011) 133–146.

[38] S. Yue, C. Wang, *The Mann-Kendall Test Modified by Effective Sample Size to Detect Trend in Serially Correlated Hydrological Series.* Water Resources Management, 18(3), (2004) 201-218.

[39] T. Sinha, K. A. Cherkauer, *Time Series Analysis of Soil Freeze and Thaw Processes in Indiana*. Journal of Hydrometeorology, 9(5), (2008) 936–950.

[40] M. B. Gavrilov, I. Tošić, S. B. Marković, M. Unkašević, P. Petrović, *The Analysis of Annual and Seasonal Temperature Trends using The Mann-Kendall Test in Vojvodina, Serbia*. *IDŐJÁRÁS* (accepted). Budapest. 2015.

[41] N. Stern, *The Economics of Climate Change,* The Stern Review, Cambridge. 2007.

[42] D. Wallach, D. Makowski, J. Jones, *Working with Dynamic Crop Models—Evaluation, Analysis, Parameterization, And Applications*, (Amsterdam: Elsevier). (2006) 462.

[43] D. B. Lobell, *Prioritizing Climate Change Adaptation Needs for Food Security in 2030*, Science, 319, (2008) 607–10.

[44] B. H. Özkaynar, S. Demir, Y. Akdoğan, *Statistical Evaluation of Maximum and Minimum Temperatures through CLIGEN Climate Model,* Journal of Agricultural Faculty of Gaziosmanpasa University, 37(3), (2020) 190–201.

[45] M. Türkeş, *Spatial and temporal analysis of annual rainfall variations in Turkey*, International Journal of Climatology, 16, (1996) 1057–1076.

[46] M. Türkeş, *Global Warming is Breaking Records*, TÜBİTAK Bilim ve Teknik Dergisi, 370, (1998) 20–21.