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Trend Analysis of Long-term Temperatures in Tbilisi, Georgia

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Abstract

The study examines the trend analysis of temperatures in Tbilisi City, Georgia by using non-parametric Mann Kendall test. Data covered monthly air temperature of Tbilisi for the period of 1901-2012. Although no significant trend was seen for the whole temperature data according to the 95% confidence level, some months showed significantly increasing trends. January, April, July and September months showed significantly increasing trend while no trend was identified for the other months with respect to 95% confidence level. Annual temperatures were also analyzed and a highly increasing trend was identified for the Tbilisi City.

Keywords: Long-term Temperatures, Tbilisi, Trend Analysis

Introduction

Temperature is one of the most important parameter for hydro-meteorology and climate which can be utilized for identifying the climate of any region and climate change analysis. Temperature changes may cause drought, flood, loss of agricultural productivity and biodiversity. Therefore, trend analysis of temperatures is important for climate analyst and water resources planners (Sun , Miao , & Du, 2015), (Sharmaa , Pandaa, Pradhanb, Singhc, & Kawamurad, 2016)

Analyzing long term changes in weather parameters has a vital importance in the studies related to identifying the climate change (Tabari, Somee, & Zadeh, Testing for long-term trends in climatic variables in Iran, 2011). Trends in precipitation and temperature were studied by several researches (Kampata, Paridaa, & Moalafhia, 2008), (Zhang, Xu, Zhang, Chen, & Liu, 2009) and (de la Casa & Nasellob, 2010). The temporal and spatial trends in temperatures and diurnal temperature for the period 1929–1999 were made by (Türkeş & Sümer, 2004). Trends in seasonal and annual temperatures of Jordan were studied by (Smadi, 2006). A decreasing trend in diurnal temperature range and an increasing trend in annual minimum temperature were identified by (Hamdi, Abu-Allaban, & Al-Shayeb, 2009) in his study at six stations in Jordan.

The aim of the study is to define the possible trends of Tbilisi City, Georgia.

Mann Kendall

Mann-Kendall is the non-parametric which is usually used to get monotonic trends (Pohlert, 2016) and analyzes the sign of the difference of trend data (Donald W. Meals, 2011). The test statistic (S) is computed as follows;

(1) $$S = \sum_{i=2}^{n} \sum_{k=1}^{i-1} sign(SR_i - SRT_k)$$

(2) $$sign(SR_i - SR_k) = \begin{cases} +1\ for\ (SR_i - SR_k) > 0 \\ 0\ for\ (SR_i - SR_k) = 0 \\ -1\ for\ (SR_i - SR_k) < 0 \end{cases}$$

(3) $$\sigma^2 = \frac{n(n-1)(2n+5) - \sum_{j-1}^{m} t_j(t_j-1)(2t_j+5)}{18}$$

when SR_i and SR_k are the common solar radiation values per a year i and k. t_j is ties number for j^{th} value and m is the number of tied values. Z transformation is obtained by Equation 4.

(4) $$Z = \begin{cases} \frac{S-1}{\sigma^2} & if\ S > 0 \\ 0 & if\ S = 0 \\ \frac{S+1}{\sigma^2} & if\ S < 0 \end{cases}$$

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Null hypothesis is rejected when there is no trend if |Z| > |Z_(1-α/2) | to test monotonic trend in a significance level.

Application and results

Long-term air temperature data of Tbilisi, Georgia used in this study was obtained from the web site of World Bank (http://sdwebx.worldbank.org/climateportal/index.cfm?page= downscaled_data_download&menu=historical). Data includes monthly values for the period of 1901-2012. Trends of whole data and each month were analyzed by using non-parametric Mann-Kendall test with respect to 90% and 95% confidence levels.

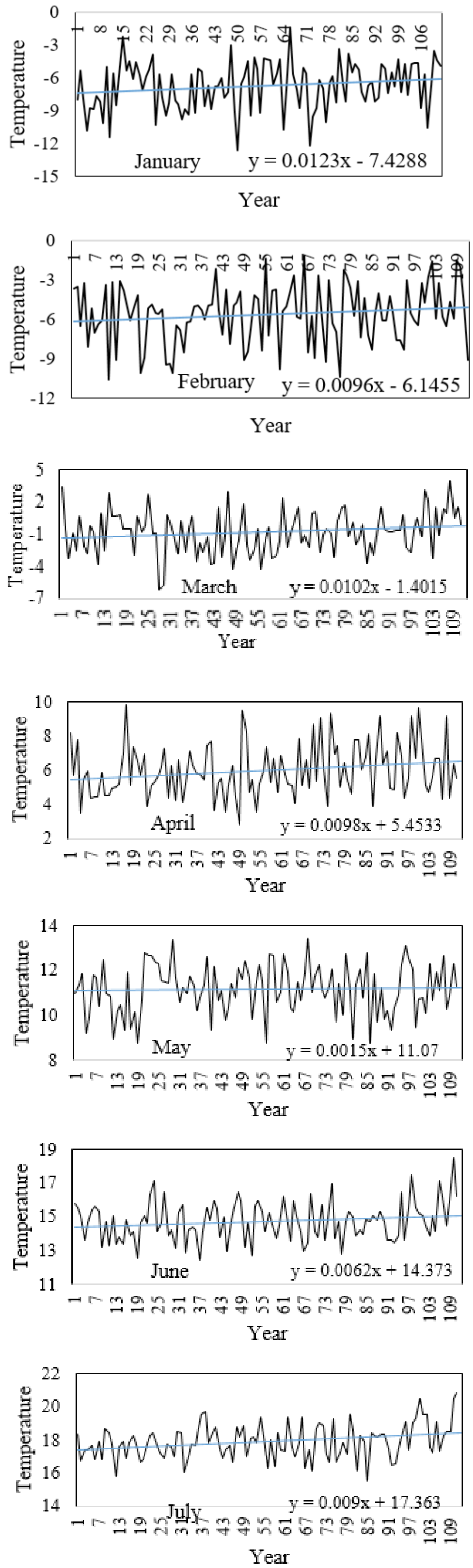
Mann-Kendal test results of the monthly mean air temperatures are provided in Table 1. From the table, it is apparent that whole data and all months show increasing trend except November. Whole data show increasing trend which is close to 90% confidence level. According to the test results, January, April, July and September have significantly increasing trends with respect to 95% confidence level. However, March, June, August and October months also show increasing trends which are close to 90% confidence level. Annual data was also obtained by averaging all monthly data for each year and tested by Mann Kendall. Its Z value was calculated as high as +3.591 which indicates significantly increasing trend according to the 95% confidence level.

Table 1. *Mann-Kendall test results for monthly mean air temperatures (for α=10% and α=5%, two-tailed confidence levels)*

Data range	Months	Calculated Z value
1901-2012	Whole data	+1.298
	January	+2.077**
	February	+1.174
	March	+1.474
	April	+2.233**
	May	+0.593
	June	+1.577
	July	+2.607**
	August	+1.577
	September	+2.324**
	October	+1.514
	November	-0.500
	December	+0.324
	Annual	+3.591**

The critical values for the 90% (*) and 95% (**) confidence levels are 1.645 and 1.96, respectively.

Time variations and linear trends of monthly air temperatures are illustrated in Figure 1. Increasing trends are obviously seen for each month from this figure. All these confirm the statistics given in Table 1.



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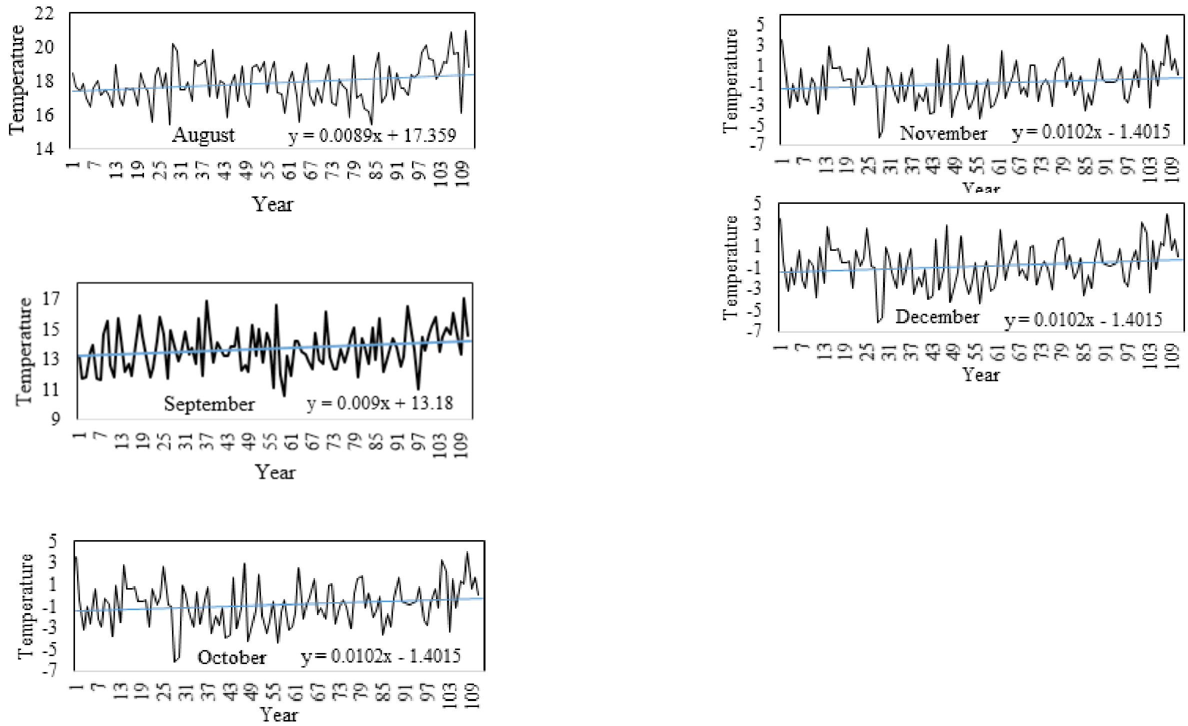

Figure 1. *Time variations and linear trends of air temperatures of each month.*

Linear trends of whole data and annual temperature values are shown in Figure 2 and 3, respectively. Highly increasing trends clearly seen from the figures especially for the annual temperatures.

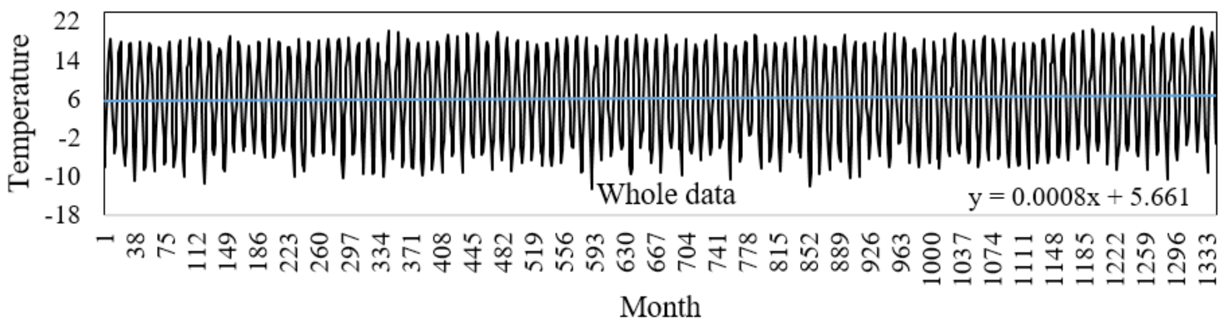

Figure 2. *Time variations and linear trends of whole air temperature data.*

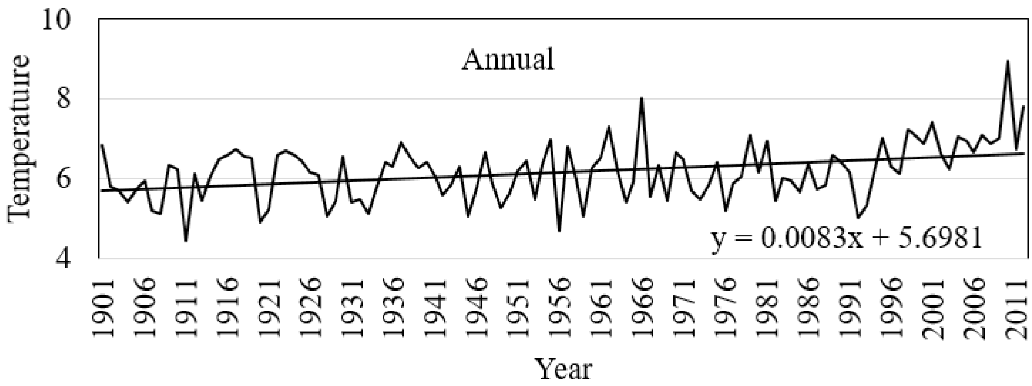

Figure 3. *Time variations and linear trends of annual air temperatures.*

It has been reported that the atmospheric CO_2 increases in all over the world and this increase alongside increments in other radioactive gases is believed to change the earth's energy balance. Anthropogenic changes in the world's climate identified with these increments were confirmed, and further changes are expected (Haskett, Pachepsky, & Acock, 2000). In light of worldwide circulation models, it was reported that an increment in ambient CO_2 concentrations increased the global air temperature by 1.4–5.8 °C from the pre-industrial level (Komatsu, Fukushima, & Harasawa, 2007) and (Tabari, & Talaee, 2011).

The outcomes generally showed that significant trends occurred in the summer series when compared to other seasons. Warmer summers or springs may bring about more energy demand for air conditioning and irrigation services and an expansion in water consumption (Turkes et al., 1996).

Conclusions

Trends of annual and monthly air temperatures are analyzed in the study. Monthly mean temperatures of Tbilisi City of Georgia were utilized and non-parametric Mann Kendal test was applied to available data. Data covered the period of 1901-2012. No significant trend was seen for the whole data while the annual temperatures showed significantly increasing trend. Trends of each month were also investigated. Significantly increasing trend was identified for the months of January, April, July and September with respect to 95% confidence level. On the other hand, March, June, August and October months also indicated increasing trends which are close to 90% confidence level. The study revealed an increasing trend in temperatures of Tbilisi City. These results may be useful for the authorities who control the consumption of water and energy demand.

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