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Research-2-Practice Forum on Renewable Energy, Water and Climate Security in Africa
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Category: Research and Scientific Contributions

The main topics of the extended abstract should fit within the areas of water, energy, climate change, the nexus within water, energy and climate change. The abstract should also be in line with ongoing projects and priorities of the research agenda at PAUWES as a contribution to the Agenda 2063 of the African union.

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Past and Projected changes in Rainfall and Temperature over East Africa

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Short Abstract

This study presents the past and future variations in mean rainfall and temperature over East Africa (EA) based on reanalyzed datasets, and Coupled Model Intercomparison Project Phase 5 (CMIP5). Past climate is limited to 1951-2010 while climate simulations for a baseline period (1961–1990) and projection period (2071–2100), are compared. There is an overall reduction in rainfall, while temperature trend is positive over EA. CMIP5 models overestimate and underestimate seasonal rainfall of October–December (OND) and March–May (MAM), respectively. Rainfall is projected to increase under the RCP4.5 and 8.5 scenarios. Larger increases in rainfall will occur in OND than in MAM. During the last half of the 21st century, EA is likely to warm by 1.7–2.8 and 2.2–5.4 °C under the RCP4.5 and RCP8.5 scenarios, respectively, relative to the baseline period. The central parts of Kenya and the Lake Victoria Basin will witness the highest increases in seasonal rainfall. Understanding the future climate variability in EA is important for planning purposes especially for sectors like agriculture that are mainly weather dependent. However, these results are based on relatively course resolution models prone to bias and therefore should be used with caution.

Keywords: Climate projection; Rainfall; Temperature; CMIP5; East Africa

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1. Introduction

Rainfall is the most important weather parameter is East Africa (EA) region (Muthama et al. 2012). This is because the economy of the region is mainly reliant on rain fed agriculture. The region in the region exhibits very high spatiotemporal variability owing to the large water bodies and the topography of the region (Indeje et al 2000). The overdependence on rainfall for a living has left the population in the region very vulnerable to the ongoing climate variability and climate change. The most common extreme rainfall events in the region are drought and floods. There is thus need for understanding the past, current and future trends of climate variability so as to devise effective adaptation measures to the observed and the projected changes in climate.

Different studies have looked at rainfall variability in the region on varying spatial scales and most studies are limited to political boundaries. There are limited coherent studies looking at variability of both rainfall and temperature over EA. This is happening in the background of varying reports on the variability especially of rainfall and the growing uncertainty in the accuracy and reliability of the existing climate projections. The existence of limited studies is explained by a number of factors among them poor data quality, lack of expertise and facilities among others (Omondi et al. 2014).

This study looks into the past, and future climate variability using both reanalyzed and model datasets. Use of accurate, timely and reliable information on the projected climate will help in saving lives and minimizing destruction of property.

2. Methods

The study utilized reanalyzed rainfall and temperature data from Climate Research Unit (CRU). The data has a resolution of 0.5 by 0.5° (Harris et al. 2014). The data is preferred over observed data across EA since it is continuous and relatively long. Analysis of projected rainfall and temperature was carried out using ensemble mean of CMIP5 models for two Representative Concentration Pathways; RCP4.5 and RCP8.5. The RCPs are adequately discussed by Taylor et al. (2012).

Trend analysis is investigated using sequential Mann-Kendall (MK) test. The method is discussed in detail and used in previous studies in EA by a number of studies (Ongoma and Chen 2017; Ongoma et al. 2018). Sen's slope estimator is used to measure the magnitude of the trend. Probability density functions (PDFs) are used to assess the variability in datasets of equal time periods.
To get a good understanding of the climate variability over EA, the rainfall is looked at on region to region basis, based on the existing homogeneous rainfall zones as proposed by Indeje et al. (2000).

3. Results and discussion

The EA region dominantly experiences bimodal rainfall pattern; March-May (MAM 'long rains') and the October –December (OND 'short rains') (Camberlin and Philippon, 2002; Ongoma and Chen 2017). The rainfall is generally high in the Lake Victoria region and reduces towards north-eastern Kenya which is mainly Arid and Semi-Arid (ASAL). The decadal anomalies of MAM rainfall is presented in Figure 1. It is evident that rainfall is reducing; recent decades show more negative anomalies as compared to the previous decades. The same observation has been reported in related studies (Maidment et al., 2015; Ongoma and Chen 2017).

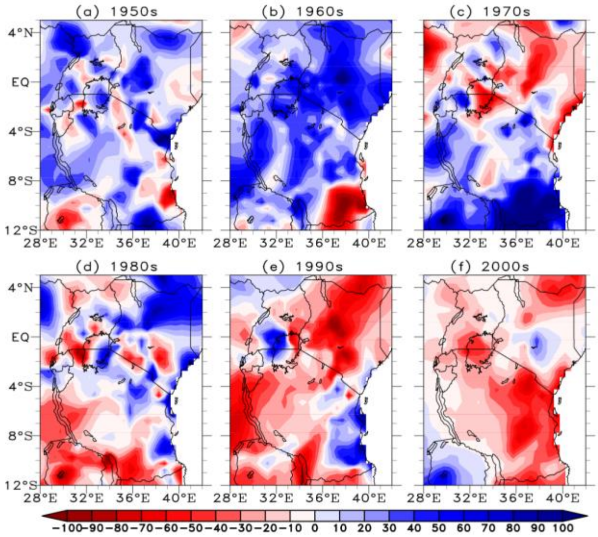

Figure 1: Decadal MAM rainfall anomalies (mm) over East Africa based on CRU data, 1951–2010

The observed reduction is the long rain is a worrying trend in EA. This is because the MAM season is the main crop growing season. This is implies that a reduction/failure in MAM rainfall is associated with crop failure and consequently food shortage in EA leading to suffering and deaths of people and livestock.

Temperature is observed to increase significantly over the EA (Table 1). Although temperature variability is not high over EA owing to its geographical location, its slight change greatly affects some of the crops. Examples of crops are tea and coffee that are grown in highland areas of Kenya which are generally cool. Omumbo et al. (2011) reported that the warming over Kenya is associated with thriving of mosquitoes of *Anopheles* specie that are known to cause malaria in the region.

Table 1: A summary of Mann-Kendall test analysis for temperature at 95% confidence level, based on CRU data, 1951–2012

	Z -Score	Sen's slope	Significance
Max. Temp.	4.847	0.016	Significant
Min. Temp.	4.677	0.014	Significant
Mean Temp.	4.883	0.015	Significant
Diurnal Temperature Range (DTR)	0.316	0.000	Insignificant

Global models project increase in temperature over EA (Figure 2). The highest increase in temperature will be reported in the south of Tanzania, stretching into the Lake Victoria Basin. Adhikari et al. (2015) reported that the projected increase in temperature is likely to reduce crop productivity over EA.

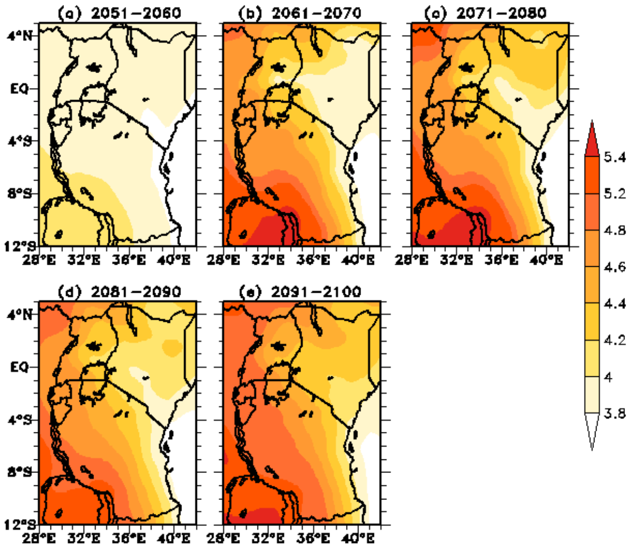

Figure 2: CMIP5 model ensemble mean temperature change (∘C) projected under RCP8.5 for (a) 2050s, (b) 2060s, (c) 2070s, (d) 2080s, and (e) 2090s relative to the baseline period (1961–1990)

Considering rainfall variability over the homogeneous rainfall zones over EA, it is apparent that the entire region will record increase in rainfall (Table 2). The rainfall is projected to increase with increase in radiative forcing. The projected changes in rainfall are in contradiction with the ongoing reduction in rainfall. A relatively recent study of rainfall in part of EA termed this situation as a paradox of East African Climate (Rowell et al. 2015). The reliability of CMIP5 models in simulating rainfall over EA has not been focussed on in this study. However, related studies have reported that the models perform poorly in reproducing climate over the region (Yang et al. 2015).

Table 2: Sen's slope (mm year^{-1}) of the projected annual rainfall over the EA homogeneous rainfall regions based on CMIP5 ensemble mean, 2006–2100

Region	Scenario	
	RCP4.5	RCP8.5
R1	0.86	1.50
R2	1.10	2.30
R3	2.00	3.30
R4	0.90	1.77
R5	0.94	1.53
R6	1.42	2.67
R7	0.72	2.27
R8	1.46	2.99

Given that most parts of the study region as ASALs, increase in rainfall will likely be associated with occurrence of flash floods. These floods are associated with loss of lives and destruction of property.

4. Conclusions

Rainfall exhibits high variability over EA. The rainfall shows a decreasing trend. This is happening when most of the CMIP5 models project increasing rainfall over the same region. The situation has been termed in as the 'paradox of Eastern Africa climate'. On the hand, there is significant increase in temperature that is projected to increase by 2 – 5 °C by then end of the 21st century relative to the baseline period.

However, the CMIP5 models do not simulate rainfall over EA well and thus the results herein should be applied with caution. There is need for diagnostic research to establish the exact cause(s) of the observed climate variability over EA. In the background of increasing climate variability and occurrence of climate change, there is need for provision for accurate, timely and reliable climate products to avert the negative impacts associated with climate variability and climate change. Thus, there is need for multi-disciplinary co-operation in the climate projection and planning processes to build the confidence of users regarding the accuracy and reliability of climate products. With regard to the accuracy of CMIP5 models, there is need for further research to improve their ability to reproduce the climate of EA. This is an involving exercise both financially and in terms of human resource and the study therefore call for multidisciplinary and international approach, encompassing the local researchers and the experts from the European institutions.

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