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An assessment of historical and future rainfall and temperature patterns over Uganda Using a Regional Climate model.

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Declaration

I PASCAL Ssentumbwe, hereby certify that this thesis or dissertation is a result of my original research work and I present it without any reservations for external examination.

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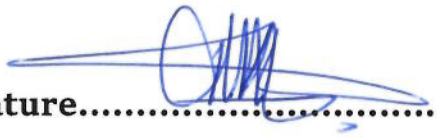

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The research work culminating in to this dissertation was conducted under my guidance and supervision.

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Dedication

I dedicate this to my Daughter Marie Samara Nantumbwe, my wife Racheal and my entire family members.

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List of Acronyms

AOGCM	:	Atmospheric Ocean General Circulation Model
CMIP5	:	Coupled Model Inter-comparison Project—Phase 5
CORDEX	:	Co-ordinated Regional Climate Downscaling Experiment
CRU	:	Climate Research Unit.
DD	:	Dynamical Downscaling
DJF	:	December, January and February
EA	:	East Africa
GCM	:	Global Circulation Model
GDP	:	Gross Domestic Product
GHG	:	Green House Gas
GPCC	:	Global Precipitation Climatology Centre
GIS	:	Geographical Information Systems
Ha	:	Hectare
IPCC	:	Intergovernmental Panel on Climate Change
IDW	:	Inverse Distance Weighted.
IPCC	:	Intergovernmental Panel on Climate Change
ITCZ	:	Inter-Tropical Convergence Zone
IOD	:	Indian Ocean Dipole
JJA	:	June, July and August
MAM	:	March, April and May
MJO	:	Madden-Julian Oscillation
MT	:	Metric Tone
MoWE	:	Ministry of Water and Environment.
NOAA	:	National Oceanic and Atmospheric Administration
NSE	:	Nash – Sutchliffe Efficiency
PDF	:	Probability Density Function
QBO	:	Quasi-Biennial Oscillation
RCM	:	Regional Climate Model
RCP	:	Representative Concentration Pathways
RMSE	:	Root Mean Square Error
SD	:	Statistical Downscaling.
TS	:	Time series.
UEA	:	University of East Anglia.
UNMA	:	Uganda National Meteorological Authority.
UNFCCC	:	United Nations Framework Convention on Climate Change
USAID	:	United States Agency for International development.
UBOS	:	Uganda National Bureau Of Statistics
WCRP	:	World Climate Research Programme
WMO	:	World Meteorological Organization

Abstract

Knowledge about future climate provides valuable insights into how the challenges posed by climate change and variability can be addressed. This study assessed the historical and future rainfall and temperature under CORDEX-African line over Uganda using Climate Limited-area Modelling Community (CLMcom-CCLM4) model data when driven by three Global Climate Models (CNRM-CERFACS-CNRM, ICHEC-EC-EARTH and MPI-M-MPI-ESM) for the period 1976-2005 (Historical), 2021-2050 (Near future) and 2070-2100 (Far future). Correlational analysis, spatial analysis and error index evaluation were used in the study. Results showed that the model performed fairly well in reproducing rainfall and temperature; and Uganda may reach the expected global temperature increase of up to 5.8°C. The findings also indicate that there are problems of using the model in performance over Uganda and future studies should be done to improve on the model performance.

CHAPTER ONE: INTRODUCTION

1.1. Background

The fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) explicitly shows the world is warming faster than estimated before and that humans caused most of that change over the last decades (IPCC 2007). Several studies also show that rainfall is likely to increase in humid areas and decline in semi-arid areas across the tropics (Hulme *et al.*, 2001; Hulme *et al.*, 2005; Christensen *et al.*, 2007). The rainfall and temperature patterns over eastern Africa are highly variable both in space and time. The region is already witnessing dire consequences of erratic climatic conditions that are likely to be associated with regional climate change (FEWS NET 2011; Anyah and Qiu 2012). The region experiences serious food insecurity and resource based conflicts in addition to recurring droughts and floods that have dramatic socioeconomic impacts (UNEP 2011; World Bank 2012).

Recent economic assessments (World Bank 2012) show that no sustainable development can be attained in the region without effective regional systems for climate risk reduction including climate change adaptation.

Again, according to IPCC (2007) report, climate change will continue, at a pace determined by past, present and future emissions of heat-trapping gases. The effects of climate change that have already occurred are widespread and significant, affecting agriculture, energy, human health, terrestrial and marine ecosystems, water resources, and some industries across the world and especially the African continent. According to the report, while it is difficult to precisely predict the future consequences of climate change, there is sufficient knowledge, understanding and broad scientific consensus on the current impacts and risks posed by climate change.

Global Climate Models (GCMs) are the most appropriate tool for addressing future climate change. For instance, GCM data have been used to describe the climate processes of many African regions and to produce the climate information for applications in different socioeconomic sectors including agriculture, water, and health (Alley *et al.* 2007).

However, in order to formulate adaptation and mitigation policies in response to climate change impacts for the affected countries like Uganda, reliable climate change information is usually required at finer spatial scales than that of a typical GCM grid-cell; which is usually about 300 x 300 km (Hudson and Jones, 2002). Thus, although GCMs provide adequate simulations of atmospheric general circulation at the continental scale, they do not capture the detail required for regional and national assessments. This is particularly true for heterogeneous regions in Africa,

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