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Dominant atmospheric circulation patterns associated with abnormal rainfall events over Rwanda, East Africa

Jean Paul Ngarukiyimana,[a] Yunfei Fu,[a]* Yuanjian Yang,[a] Bob Alex Ogwang,[b] Victor Ongoma[c] and Didier Ntwali[d]

[a] *School of Earth and Space Sciences, University of Science and Technology of China, Hefei, China*
[b] *Uganda National Meteorological Authority, Kampala, Uganda*
[c] *School of Atmospheric Sciences, Nanjing University of Information Science and Technology, Nanjing, China*
[d] *Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China*

ABSTRACT: The study investigated the dominant atmospheric circulation patterns associated with abnormal rainfall over Rwanda during the March–May (MAM) rainfall season in 1981–2010. The data sets used in this study include: rainfall, wind, sea surface temperature (SST), and humidity. Correlation and composite analysis and Percent of Normal Index (PNI) were deployed in this study. In the wet years (1987, 1988, and 1998), the country was dominated by moisture convergence, which is in line with wind anomalies that exhibits strong westerly winds from the Atlantic Ocean and southeasterly winds originated from the Indian Ocean. These winds carry moist air mass passing over Congo to the study area, leading to wet events. On the other hand, easterly winds were noted over the study area during the dry years (1984, 2000, 2007, and 2008). The observed wet years coincided with the El Niño events, while the dry years are noted during the La Niña episodes. The dry years exhibited a wide spread of moisture divergence anomaly at the low level and were characterized by the sinking motion as opposed to the wet years with the rising motion. The anomalies of velocity potential/divergence further showed that the wet (dry) years were characterized by convergence (divergence) at the low level. The results also show that there exists a low positive correlation between mean MAM rainfall and SST over the Indian Ocean, which shows minimum influence of the Ocean. On the other hand, it was noted that rainfall amounts is significantly correlated at 95% confidence level with the elevation (altitude) of a given station. This study improves the understanding of the occurrence of wet and dry events in Rwanda, which is helpful in future monitoring of these events.

KEY WORDS abnormal rainfall; wet; dry; abnormal circulation; Rwanda

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1. Introduction

Wet and dry events, which may result in flood and drought episodes, respectively, are the main meteorological disasters that cause devastating socio-economic impacts in Rwanda) (MIDMAR, 2012). Scientists around the world have made a great contribution to understanding these extreme events (e.g. Xin *et al.*, 2006, 2008). Over East Africa, some studies have suggested that the increase of observed dry condition has been especially severe during the March–May (MAM) 'long-rain' season (Williams and Funk, 2011; Lyon and DeWitt, 2012). Since 1999, there has been a substantial decline of the long-rain (Lyon and DeWitt, 2012). Scientists have confirmed the occurrence of drought during the long-rain season. An example of a new finding regarding a post-1998 increase in drought frequency during the long-rain season over the Horn of Africa was reported (Lyon, 2014). Generally, this decrease was attributed to the anticyclonic flow that develops over the Arabian Peninsula (although not necessarily exclusively) rather than anthropogenic climate change (Lyon, 2014). Despite the efforts to understand the occurrence of extreme climate events over Greater Horn of Africa (GHA), no exclusive case studies have been carried out in Rwanda. Rwanda (Figure 1(a)) is prone to frequent wet and dry conditions and highly vulnerable to those extreme weather events since its economy is mainly driven by weather-dependent sectors (Bart, 1993; MINITERE, 2006; Republic of Rwanda, 2011). For example, the severe droughts in Bugesera in 1999/2000 and 2006/2007 significantly harmed the livelihoods and welfare of the people there (REMA, 2007). The crop failure during the 2000 drought resulted in the dependence on external food supplies in the Bugesera district (WFP/FEWS-NET, 2003; REMA, 2007). It is important to note that not only extreme wet/dry conditions but also late rainfall onsets and early rainfall cessations play a significant role in leading to crop failure. The Nyagatare, Gatsibo, Ngoma, and Kirehe districts in the eastern province and the eastern parts of Nyanza and Gisagara districts in the southern province are characterized by the high frequency of rainfall deficit, making them prone to

*Correspondence to: Y. Fu, School of Earth and Space Sciences, University of Science and Technology of China, 96 Jinzhai Road, Hefei, Anhui 230026, P.R. China. E-mail: fyf@ustc.edu.cn; ngahojp@mail.ustc.edu.cn