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Statement on the Status of Tanzania Climate in 2018

TANZANIA METEOROLOGICAL AGENCY (TMA)

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STATEMENT ON THE STATUS OF TANZANIA CLIMATE 2018

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Table of Contents

List of Figures

Abbreviations

ENSO	El Niño–Southern Oscillation
IDW	Inverse Distance Weighting
IOD	Indian Ocean Dipole
ITCZ	Inter-Tropical Convergence Zone
MAM	March, April, May
NDJFMA	November, December, January, February, March, April
OND	October, November, December
SSTs	Sea Surface Temperatures
SSTA	Sea Surface Temperature Anomalies
SWFDP	Severe Weather Forecasting Demonstration Project
TMA	Tanzania Meteorological Agency

Foreword

The global surface temperature has continued to increase mainly due to the effects of increased greenhouse gases from human activities. In 2018, the global mean temperature increased by 0.98±0.12 °C above the pre-industrial baseline period (1850–1900). This has contributed to increased incidences of extreme weather and climatic events that have greatly impacted the economy and livelihood of the communities around the world. In Tanzania anomalous warmer temperatures were observed almost over the entire country in 2018. This attributed to increased incidences of extreme weather and climatic events such as heavy rainfall and strong winds. These events have contributed to flooding in low land areas, destruction of infrastructure and loss of lives and properties.

In order to reduce these impacts, the Tanzania Meteorological Agency (TMA) assesses and publishes reports on the state of the status of Tanzania climate annually. These reports provide comprehensive information of weather and climate events that occurred in respective year.

This statement is the eighth issue since 2011. It provides comprehensive information on the status of the climate in 2018, focusing on spatial and temporal distribution of temperature, rainfall, extreme climate events, and their associated impacts. Observed rainfall and temperature data collected from meteorological stations across the country are mainly used for the analysis. In addition, information associated with weather and climate events obtained from other relevant sources, such as disaster management authority and media are used to characterize the events.

TMA would like to take this opportunity to express sincere gratitude to all stakeholders for continuous support, constructive comments, and feedbacks. More suggestions for improving these statements are highly appreciated.

Dr. Agnes L. Kijazi
Director General Tanzania Meteorological Agency
and Permanent Representative of Tanzania with WMO

1. Introduction

The impacts of climate change and variability are increasingly felt at the global, national, and local scales. Increasing greenhouse gases emissions mainly from human influence remained the major factors accelerating changes in climate at all scales. Increased in frequency and intensities of extreme weather and climate events, particularly higher temperatures, strong winds, floods and droughts are the major weather and climate phenomena experienced in different parts of the world. The impacts of these events are associated with devastating socio-economic and ecological implications such as loss of lives and properties.

In recent years, Tanzania has witnessed many extreme climate events that have had detrimental impacts to socio-economic development. These events have contributed to the loss of lives and properties, destruction of infrastructures and environment, and other social economic livelihood.

In order to reduce the impacts and facilitate informed decision making in climate sensitive sectors, TMA conducts a robust and comprehensive climate analysis and provides an authoritative up-to-date annual statement on the status of Tanzania climate. The statement provides information on the current status of climate, extreme climatic events and their associated impacts with the goal of enhancing awareness and understanding of climate variability and change among stakeholders.

This statement provides analyses of rainfall and temperature at annual, seasonal and monthly time scales in 2018 over different regions in Tanzania. Maximum and minimum temperature anomalies, rainfall anomalies, cumulative rainfall, extreme weather and climatic events and associated socio-economic impacts and major drivers of weather and climatic events are contained in the report.

2. Temperature distribution

In the year 2018, the country experienced relatively high fluctuation of temperature throughout the year. The annual average temperature over different stations across the country ranged from 18.2 – 27.7 °C. The regions along the coast experienced highest temperature, while the southwestern highlands experienced lowest temperature. Higher temperatures were observed from October and continued through February, whilst the low temperatures were observed from May to August. The annual minimum and maximum temperatures across the stations in Tanzania ranged from 11.6 – 24.3 °C and 24.8 – 31.5 °C respectively.

2.1 Annual mean, maximum and minimum temperature anomalies

In the year 2018, the country experienced anomalously warmer temperature with annual mean of 23.9 °C, which is 0.3 °C above the long-term average (1981-2010). Higher positive temperature anomalies were observed almost over the entire country with exception of Shinyanga, parts of Mwanza and Tabora regions, which observed anomalously lower annual mean temperature in the range of 0 to 0.5°C below the long term average (Figure.1).

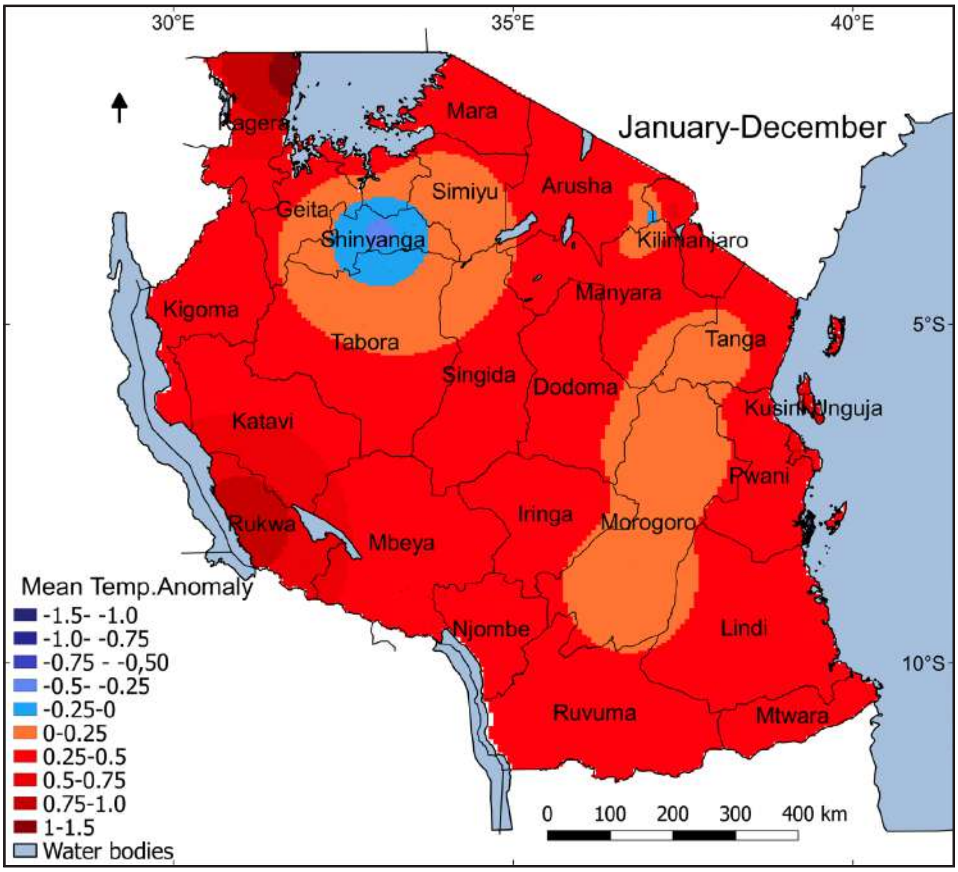

Figure 1: 2018 annual mean temperature departures (°C) from long-term average

The country experienced annual maximum temperature (Tmax) of 28.8 °C which is 0.1 °C above the long-term average and annual minimum temperature (Tmin) of 19 °C which is 0.5 °C above the long-term average. Minimum temperature anomalies across the regions are higher when compared to maximum temperature anomalies. This finding is in agreement with what have been reported in different countries in the world that minimum temperature is increasing at higher rate than the maximum temperature. Almost all regions experienced annual mean minimum temperature in the range of 0.25°C to 1.5°C above the long term average with exception of Ruvuma and parts of Lindi regions that experienced annual mean minimum temperature in the range of 0.25°C to 1°C below the long term average. On the other hand, lower annual maximum temperature anomaly in the range of 0.25°C to 1°C below the long term average were experienced over the Lake Victoria basin, northeastern highlands and central regions, while western, southern and coastal regions experienced maximum temperature in the range of 0.25°C to 1.5°C above the long term avarage (Figure 2).

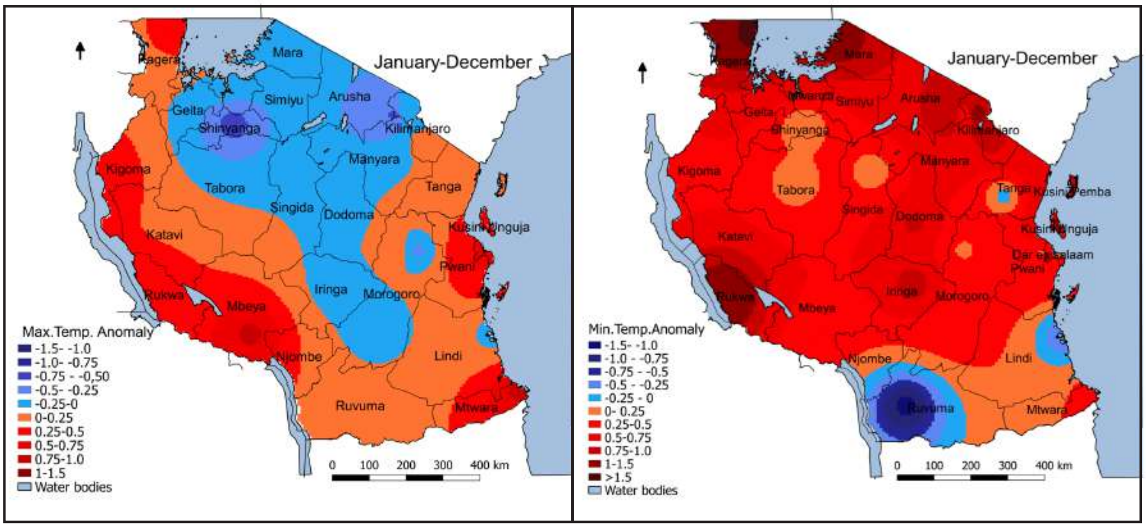

Figure 2: Annual maximum (left panel) and minimum (right panel) temperature departures (°C) from long-term average for 2018

2.2 Monthly maximum temperature anomalies

Most regions of the country experienced below average monthly maximum temperatures (Tmax) during January, March, April, May, July and October. In January, March and April, monthly maximum temperature of 1 °C below the long-term average were observed over the Lake Victoria, northeastern highlands, central and southern regions (Figure 3a). Monthly maximum temperature of 2.7 °C below the long-term average were observed in Singida during January, while 3.1 °C and 2.0 °C below the long term average were observed in Kilimanjaro during January, March and April. On the other hand, maximum temperature above long term average was observed over most parts of the country during February, June, August, September, November, and December, while February being the warmest month of the year 2018.

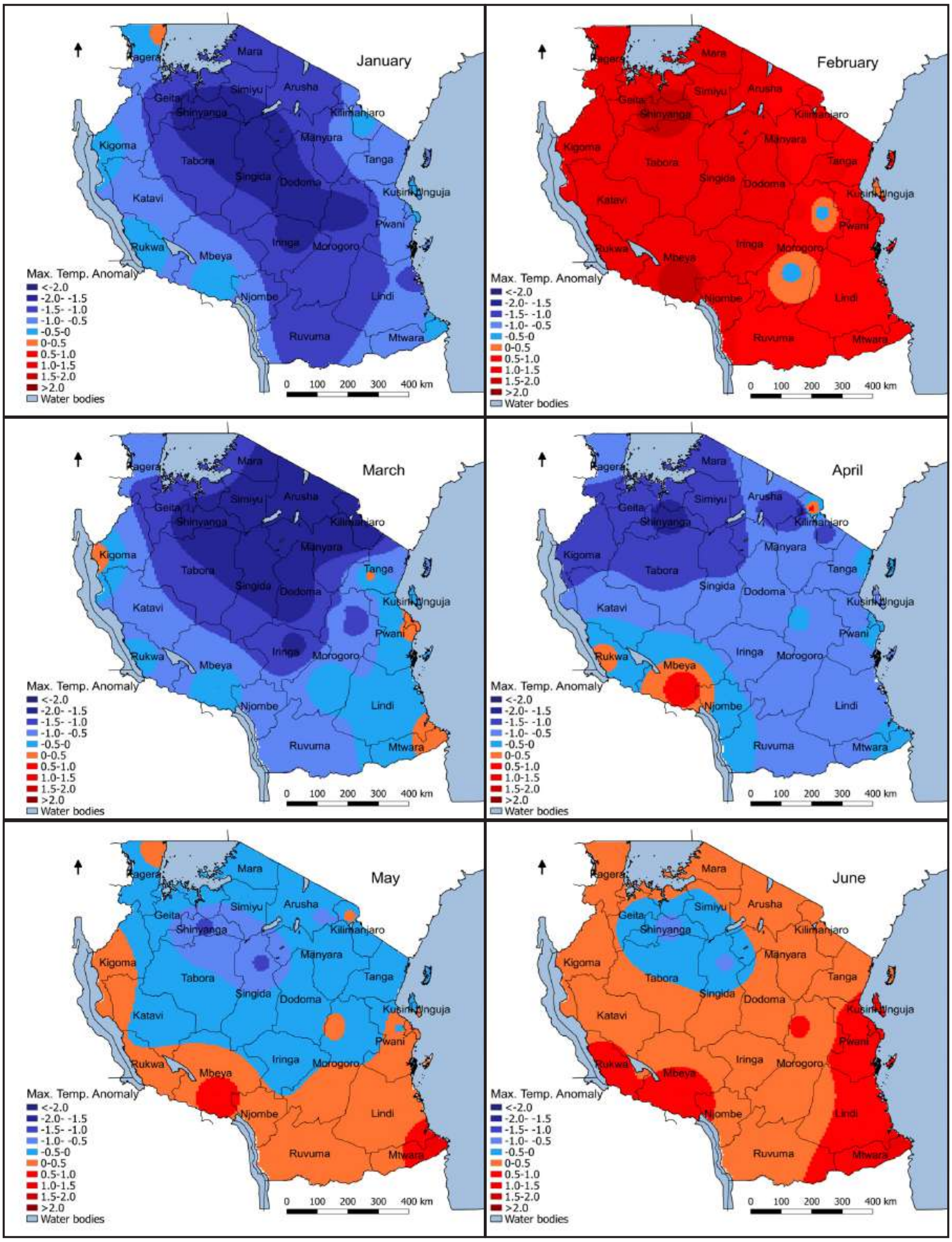

Figure 3a: Monthly maximum temperature departures from long-term average (°C) for January – June 2018

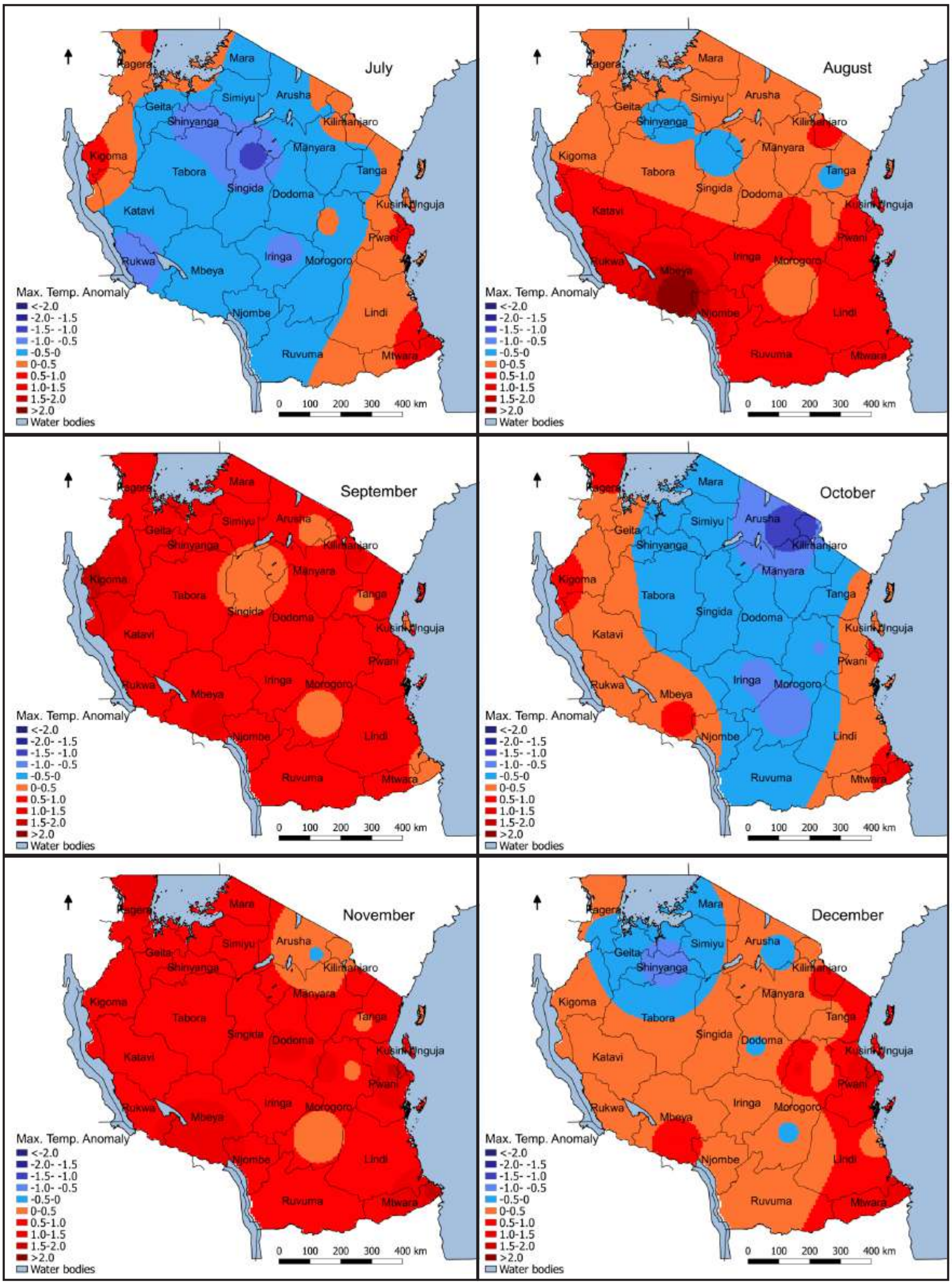

Figure 3b: Monthly maximum temperature departures from long-term average (°C) for July – December 2018

2.3 Monthly minimum temperature anomalies

Most parts of the country experienced minimum temperature above the long term average except in January, March and April where minimum temperature below the long term average were observed over southern parts of the country (Figures 4a and 4b). In July, August, September and November minimum temperature exceeding 1°C above the long-term average were observed over the Northeastern highlands, Rukwa and Katavi regions. On the other hand, minimum temperature below the long-term average was observed over Ruvuma region except during November and December where minimum temperatures above long-term average were observed.

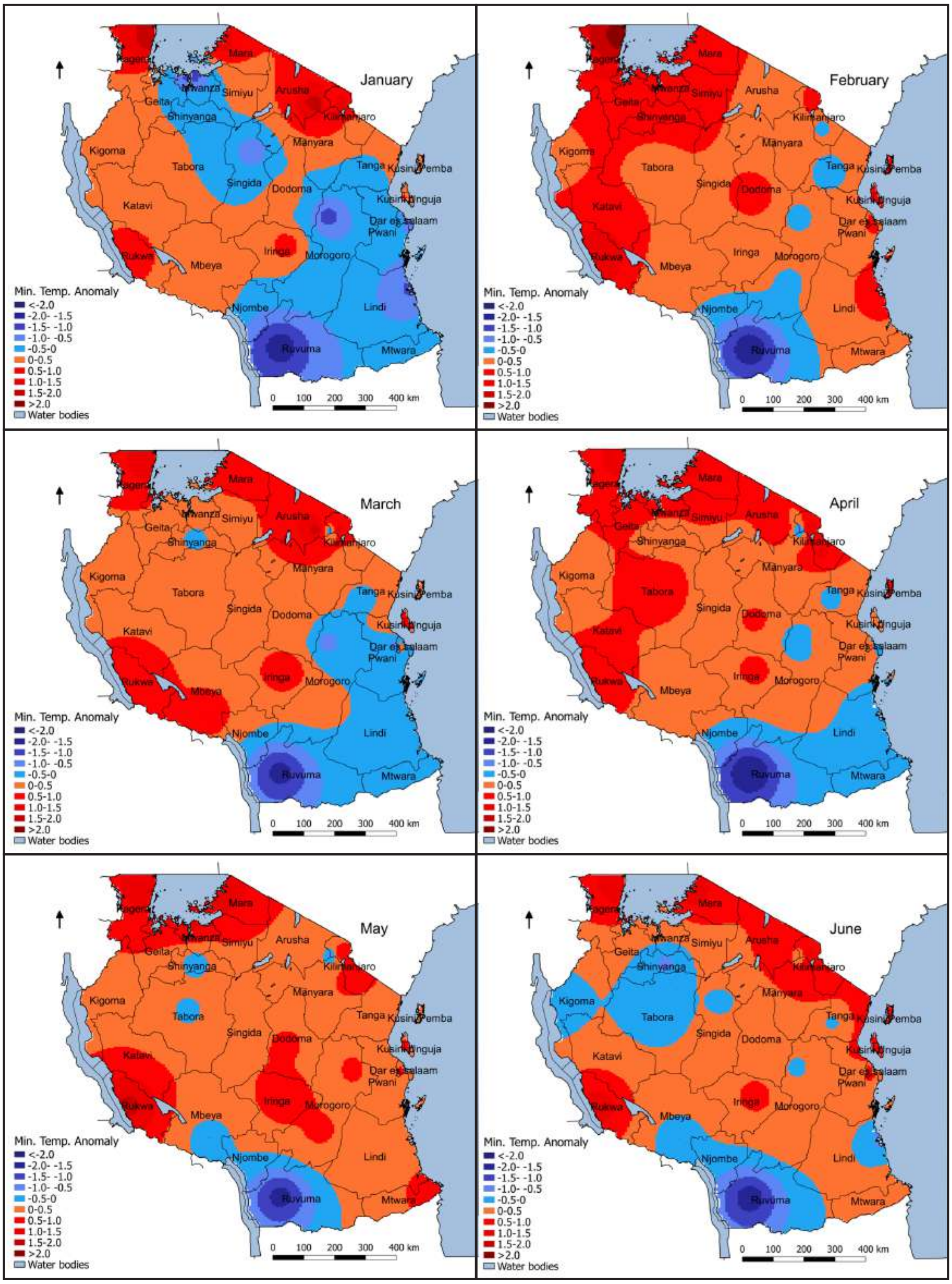

Figure 4a: Monthly minimum temperature departures from long-term average (°C) for January – June 2018

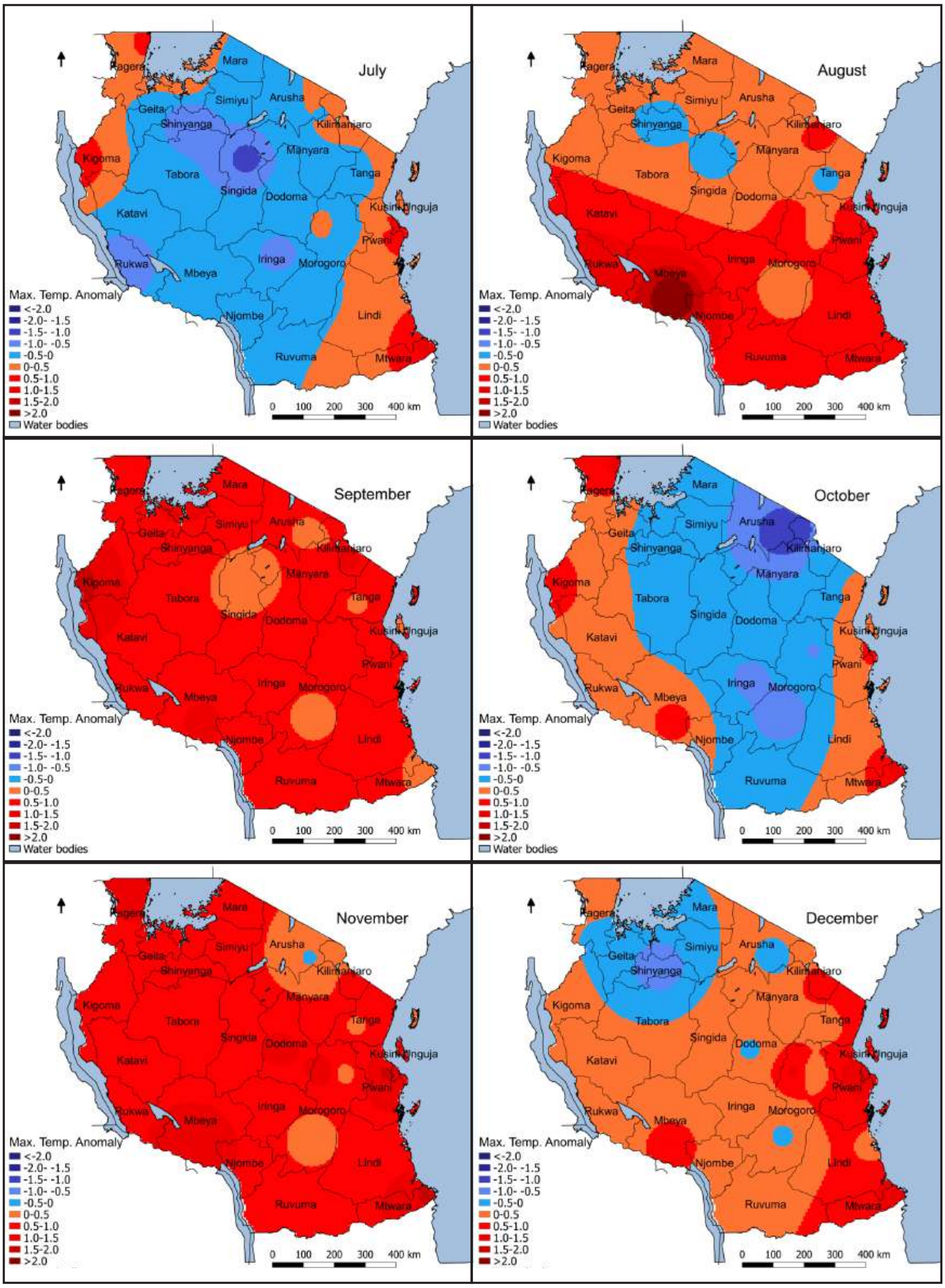

Figure 4b: Monthly minimum temperature departures from long-term average (°C) for July – December 2018

3. Rainfall distribution

The rainfall distribution and variability in the country is driven by multiple factors including East African Monsoon, El-Niño Southern Oscillation (ENSO), westerly winds from Congo basin, Tropical Cyclones and Inter-Tropical Convergence Zone (ITCZ). ITCZ and its migration north and south across the equator is among the main factors affecting distribution and variability of rainfall in Tanzania and the entire East Africa. The migration of ITCZ lags behind the overhead sun by 3-4 weeks over the region. The ITCZ migrate to southern regions of Tanzania in October-December, reaching southern part of the country in January-February and reverses northwards in March, April and May.

Due to this movement, some areas experience single and double passages of the ITCZ. The areas that coincide with single passage are known as unimodal areas. These include the southern, southwestern, central, and western parts of the country, which receive rainfall from November to April or May (NDJFMA, also known as *msimu* rains). Areas that experience double passage are known as bimodal, and include northern coast, northeastern highlands, Lake Victoria basin and the Islands of Zanzibar (Unguja and Pemba). These regions receive two distinct rainfall seasons; the long rain season (also known as *masika*), which starts mainly in March and continues through May (MAM) and the short rainfall season (also called *vuli*), which starts in October and continues through December (OND). January and February is the transition period (relatively dry) for bimodal areas while June, July, August, and September are dry months for the entire country.

In 2018, the spatial distribution of rainfall over the country during msimu 2017/2018-rainfall season was generally normal (amount of rainfall between 75-125% of long term average). However, above normal rainfall (amount of rainfall exceeding 125% of long term average) was observed during masika 2018 rainfall season. On average January, March and April 2018 received higher amounts of rainfall than February, May, October and December.

3.1 Annual rainfall distribution

The country annual average rainfall was 1091.8 mm, which is 78.6 mm higher than the long-term average rainfall. Pemba Island recorded the highest annual rainfall amount of 1941.1 mm, while Iringa reported the lowest rainfall amount of 559.4 mm. Most parts of the country experienced normal rainfall with exception of few areas in the northeastern highlands and parts of Pemba and Morogoro region that experienced above normal rainfall (Figure 5).

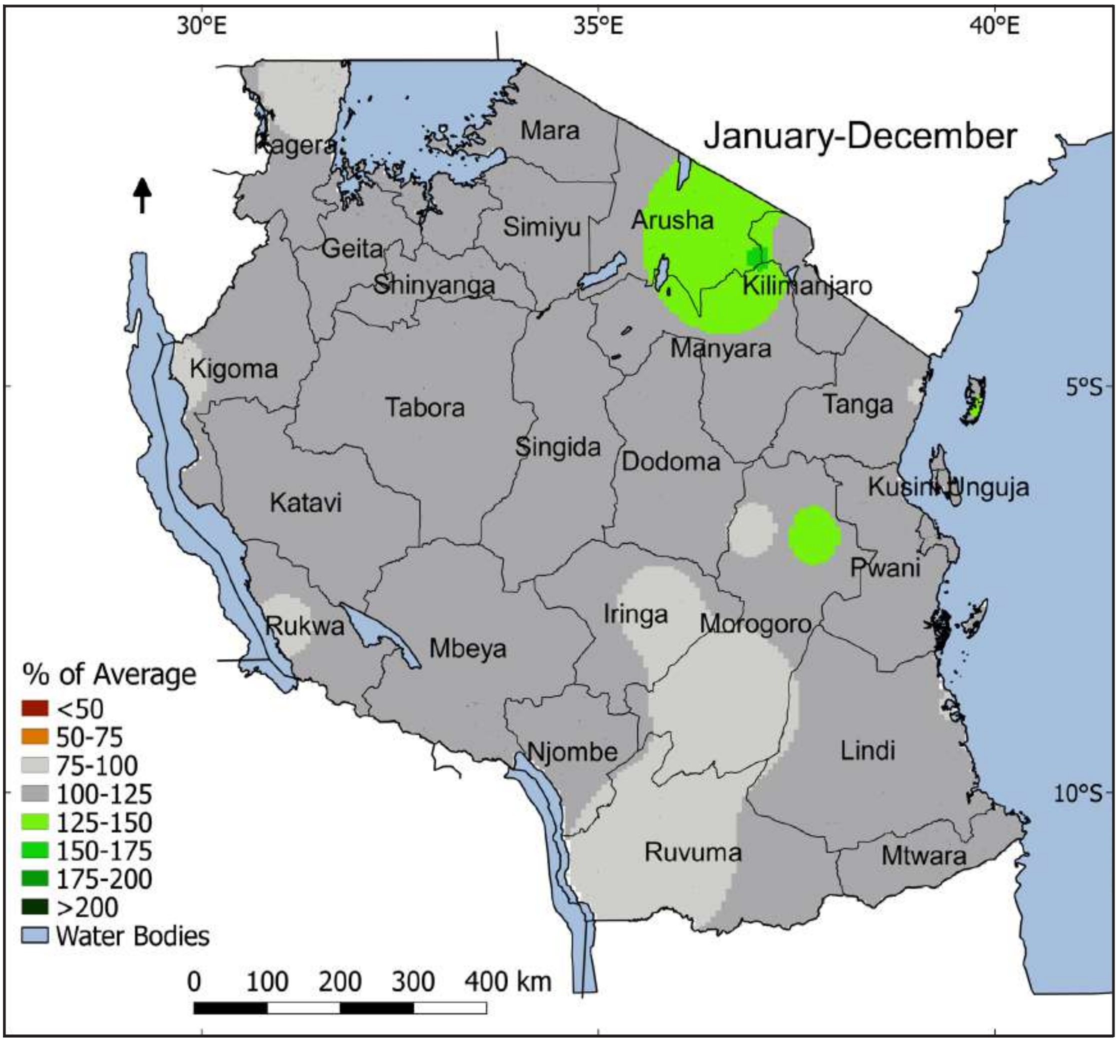

Figure 5: Annual rainfall for 2018 expressed as a percentage of the long-term average

3.2 Seasonal rainfall distribution

Most parts of the country received normal rainfall during msimu 2017/2018-rainfall season (Figure 6 top panel right). However, there were patches of above normal rainfall over Tabora, Mbeya, and Mtwara where the total amounts of rainfall recorded in these areas were 1647.8 mm, 1124.9 mm, and 1320.9 mm respectively. During masika season, above normal rainfall was observed over most parts of the country except northeastern parts of Tanga, southern parts of Morogoro, Mbeya, Kagera, Ruvuma, and Njombe regions, which received normal rainfall. Northeastern highlands and parts of northern coast received amount of rainfall exceeding 150% of long term average (Figure 6 top panel right).

On the other hand, normal rainfall was observed over most parts of the country during vuli season except parts of the northern coast, Iringa, Morogoro, Kagera and Mtwara, which received below normal rainfall (Figure 6 bottom panel).

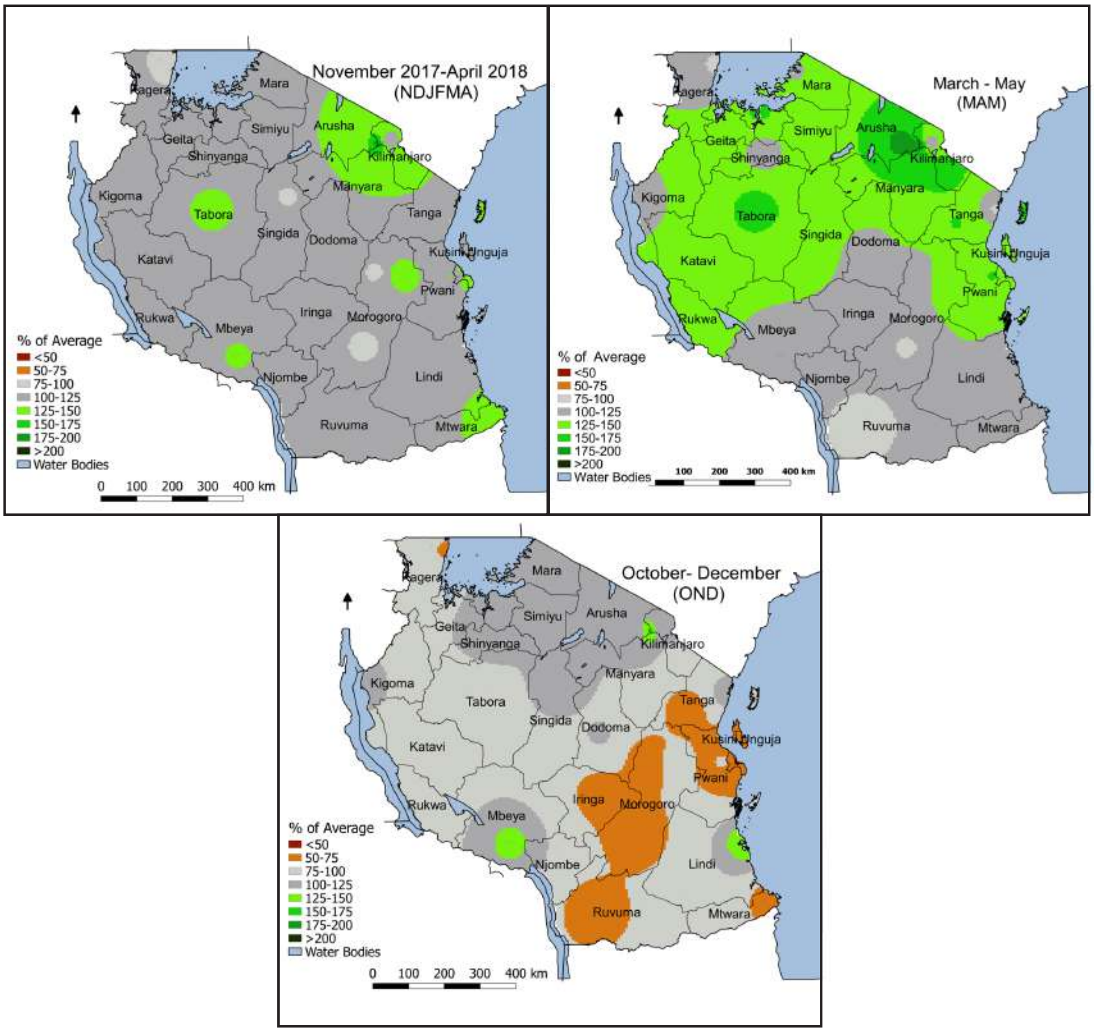

Figure 6: Seasonal rainfall distribution during 2018, expressed as percentage of long term average for November 2017– April 2018 (top panel left), March – May (top panel right) and October–December 2018 (bottom panel)

3.3 Monthly rainfall distribution

Most parts of the country received above normal rainfall during January, March and April (Figure 7a). Higher percentage of rainfall amounts exceeding 150% of the long term average were observed over Morogoro, Dodoma, parts of Manyara and Arusha regions during January; over northern coast, northeastern highlands extending to eastern parts of Lake Victoria basin during March and mainly over western region extending to central parts of the country and south of Lake Victoria basin during April. In March for example, large parts of northeastern highlands and Tanga region received rainfall amounts of 612.3 mm, which was as higher as 200% of the March, long term average.

It should be noted that, during dry months, small deviation of rainfall amounts from the long-term average might present a very high percentage of change either above or below normal. Thus, these deviations may not be translated to heavy rainfall or very dry conditions

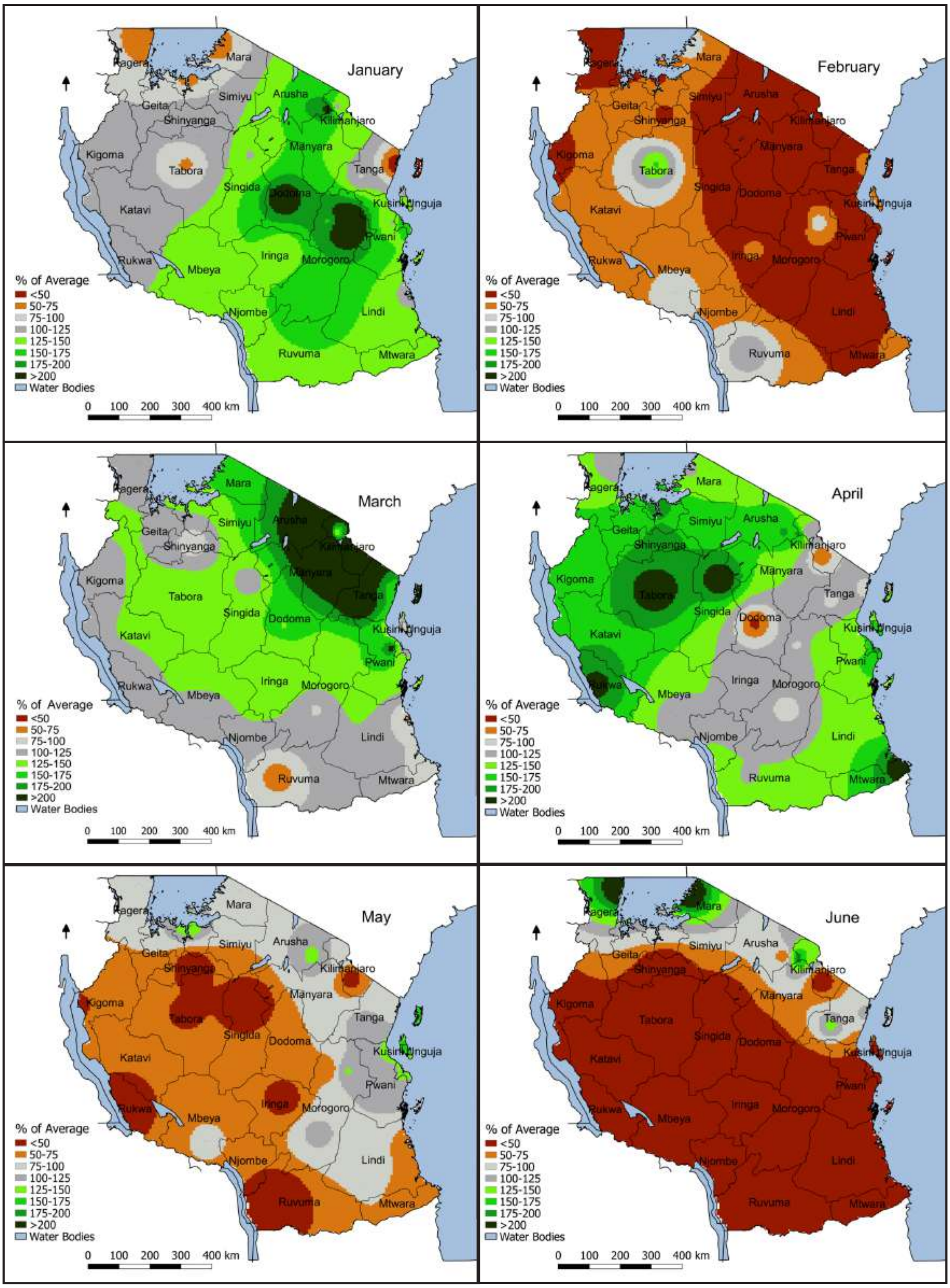

Figure 7a: Monthly rainfall distribution as percentage of long-term average for January – June 2018

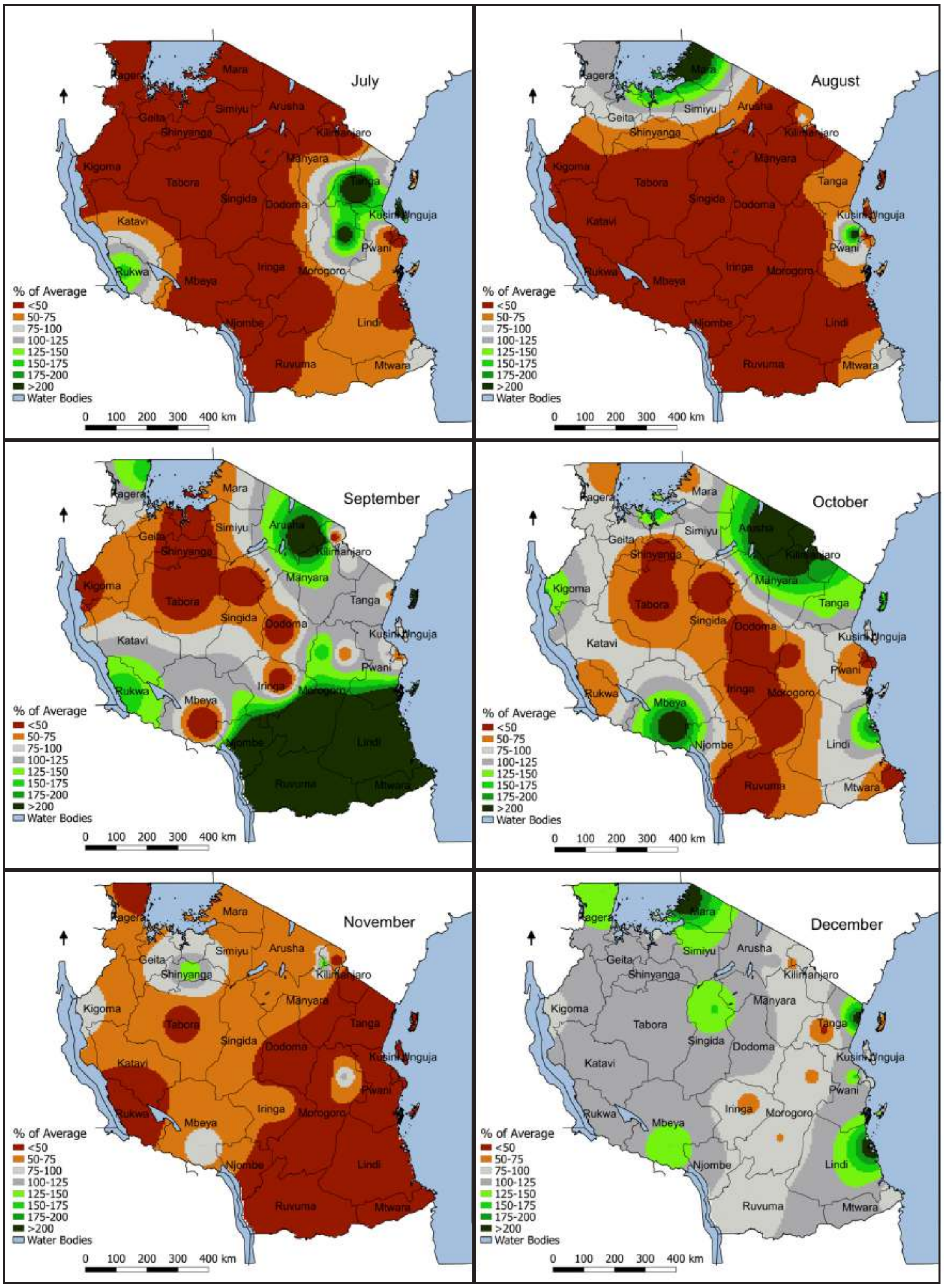

Figure 7b: Monthly rainfall distribution as percentage of long term average for July – December 2018

3.4 Cumulative rainfall distribution

In this statement, cumulative rainfall analysis is used to characterize rainfall performance compared to long-term average for different areas in the country. In unimodal areas the trend of cumulative rainfall during November 2017– April 2018 *msimu* season indicates below normal cumulative rainfall over Kigoma and Mtwara; above normal rainfall in Dodoma and Songea (Figure 8a). In addition, Tabora stations received less rainfall compared to long term average from November to March and only higher amount during April, which increased this amount nearly to slightly above average rainfall.

In the bimodal areas cumulative trend for Dar es Salaam, Morogoro, Arusha, Moshi, Mwanza Musoma and Zanzibar received above normal, while Shinyanga and Bukoba received below normal rainfall amounts during masika season (Figures 8b and 8c). The highest deviation of total rainfall was observed over northern coast and northeastern highlands. For example, Arusha, Dar es Salaam and Zanzibar received between 300 and 400 mm of rainfall above long-term average.

The *vuli* 2018 showed poor temporal distribution (Figures 8d and 8e). Some stations in the bimodal areas (Dar es Salaam, Zanzibar and Bukoba) received below normal while Musoma, Tanga, and Shinyanga, received slightly above normal rainfall.

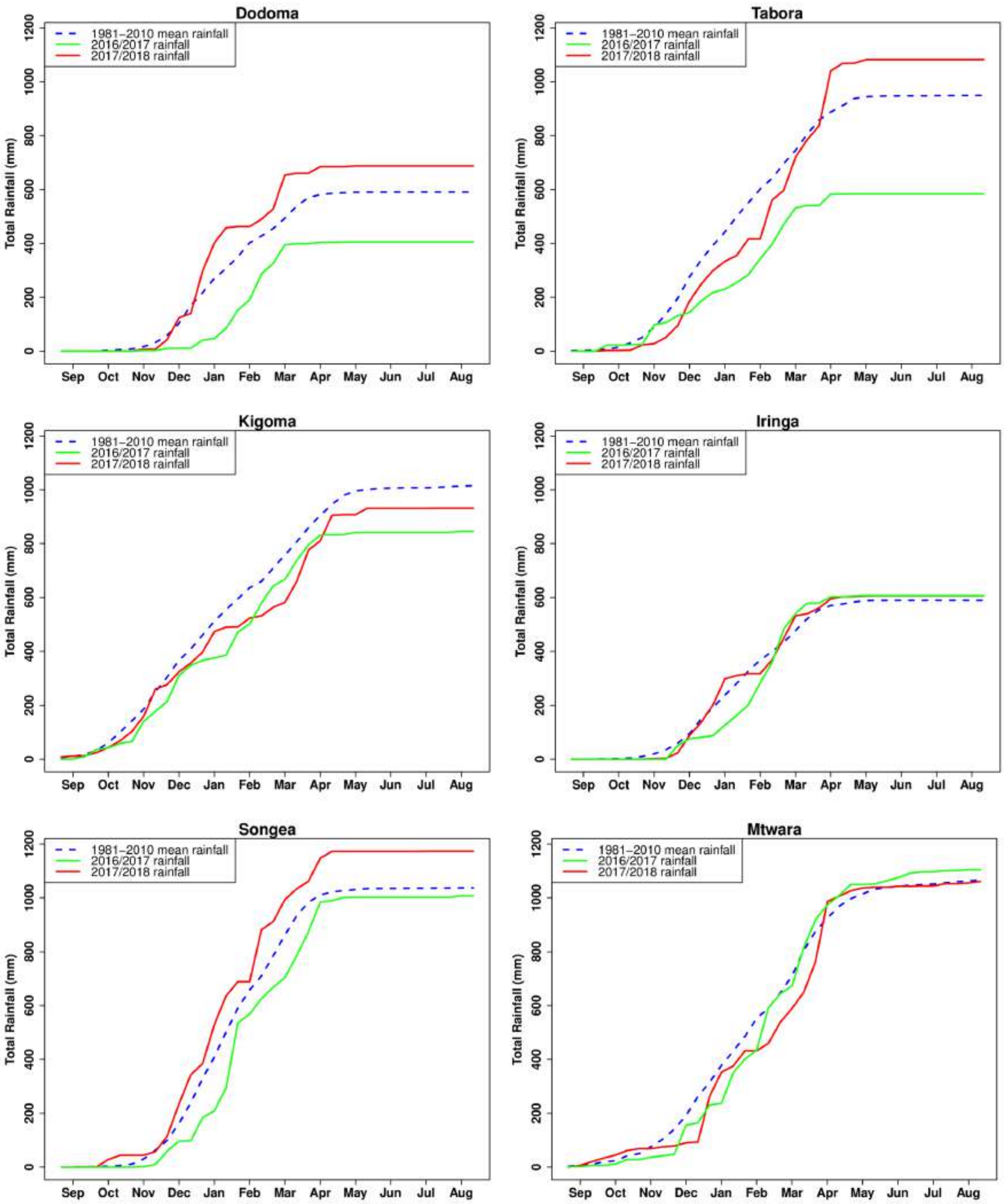

Figure 8a: Cumulative rainfall plots for *msimu* season for Dodoma, Tabora, Kigoma, Iringa, Mtwara and Songea presented as accumulation of dekadal rainfall totals for each month starting from September 2017 to August 2018

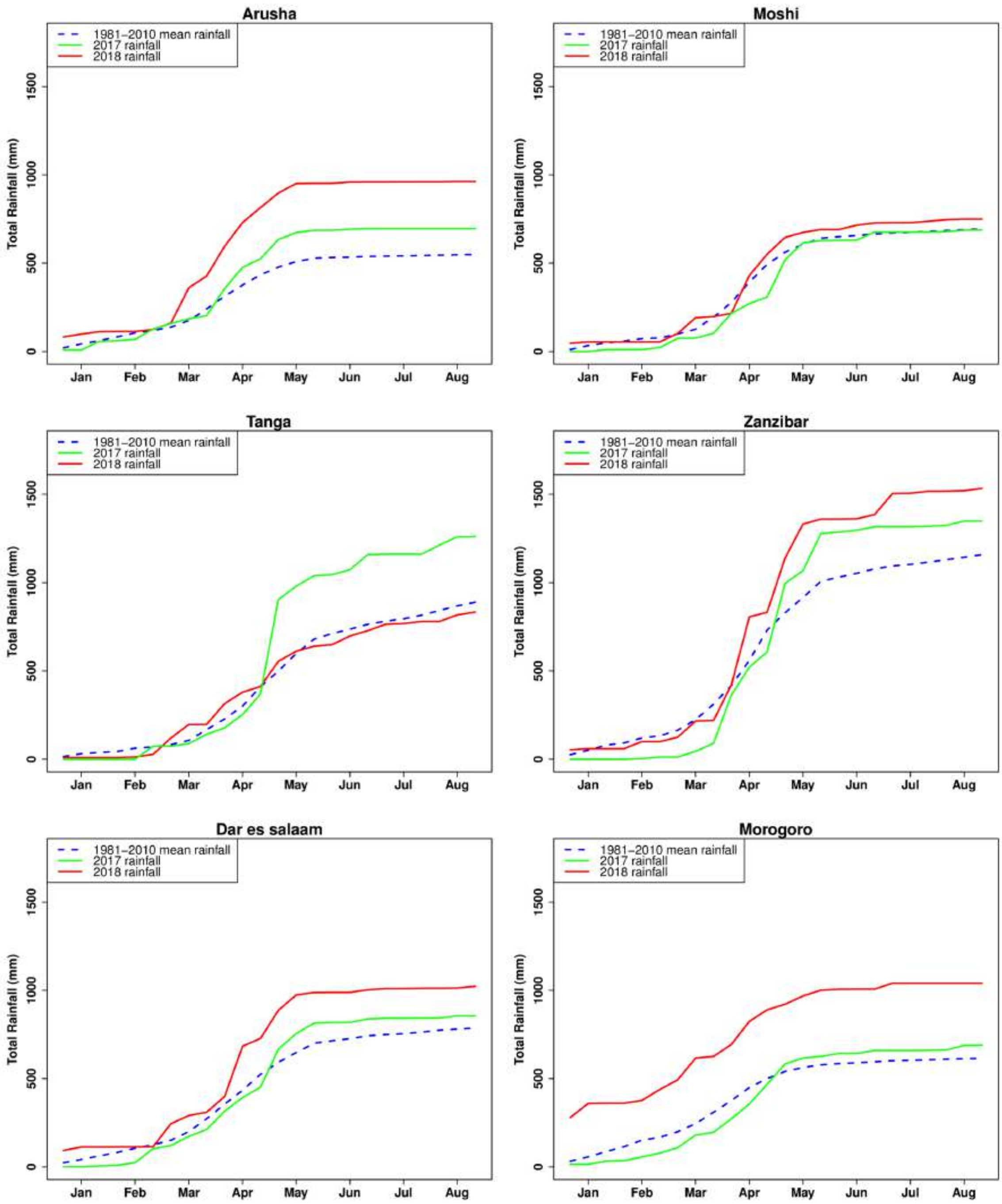

Figure 8b: Cumulative rainfall plots for *Masika* season for Dar es Salaam, Morogoro, Tanga, Zanzibar, Arusha, and Moshi presented as accumulation of dekadal rainfall totals for each month starting from January to August 2018

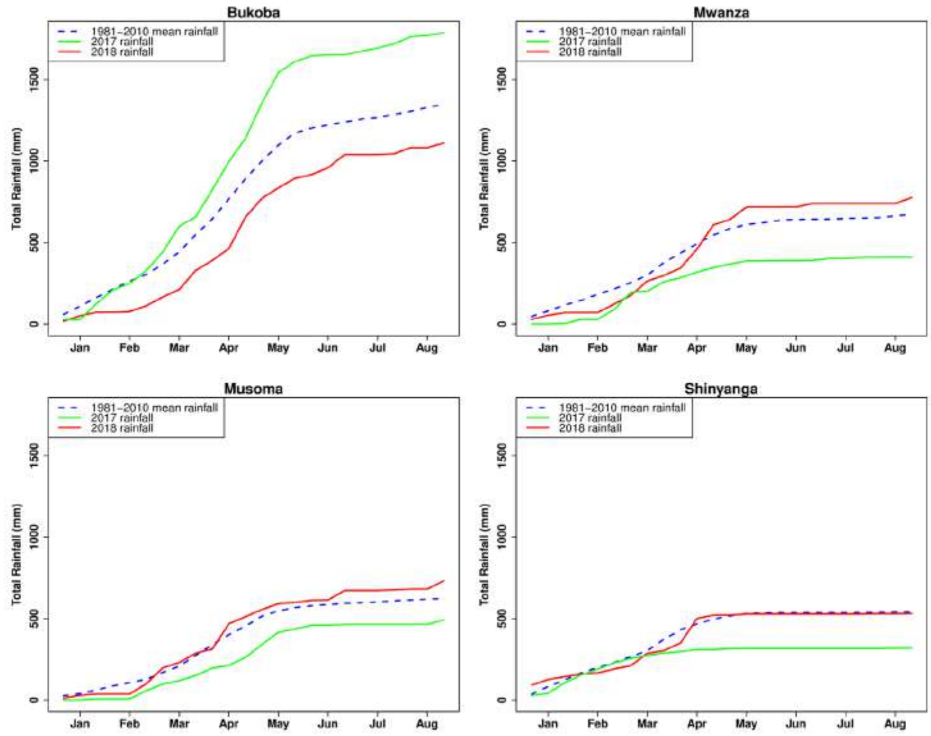

Figure 8c: Cumulative rainfall plots for *masika* season for Bukoba, Mwanza, Musoma and Shinyanga presented as accumulation of dekadal rainfall totals for each month starting from January to August 2018

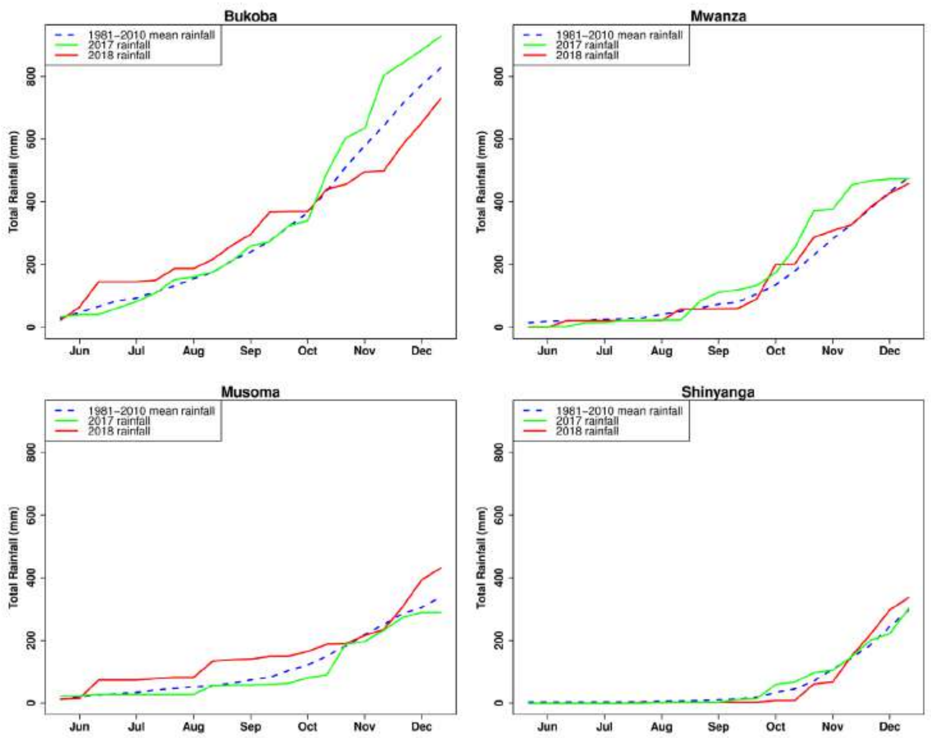

Figure 8d: Cumulative rainfall plots for *vuli* season for Bukoba, Mwanza, Musoma and Shiny anga presented as accumulation of dekadal rainfall totals for each month starting from June to December 2018

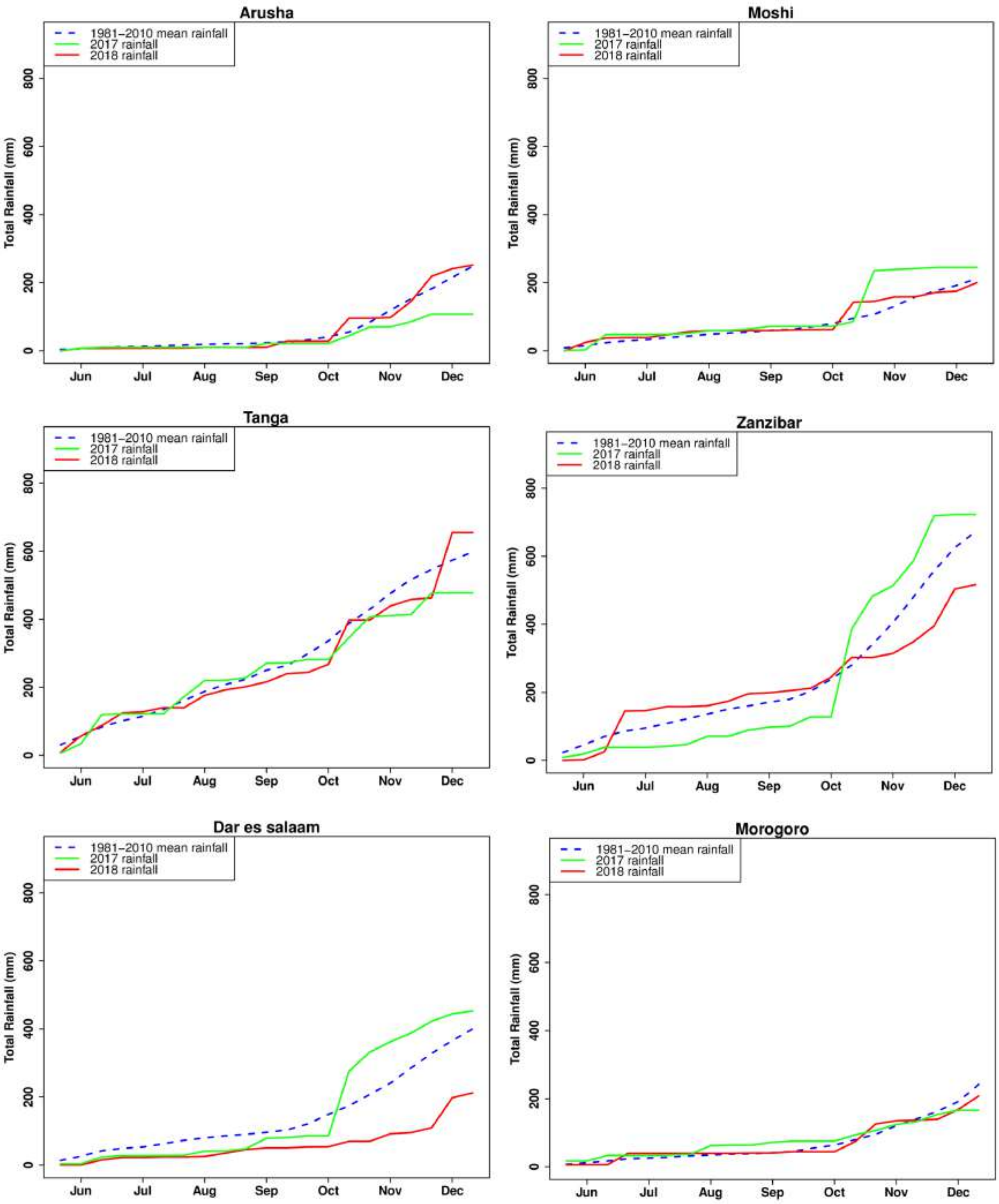

Figure 8e: Cumulative rainfall plots for *vuli* season for Dar es Salaam, Morogoro, Tanga, Zanzibar, Arusha, and Moshi presented as accumulation of dekadal rainfall totals for each month starting from June to December 2018

4. Extreme weather and climatic events

In the year 2018 extreme weather and climate events continued to manifest in the country. Flooding events affected many parts of the country especially northeastern highlands, northern coast, Lake Victoria basin and central parts of the country during January, March, April, May, October, November and December. Rainfall for this period especially March was twice the long-term average mostly over northeastern highlands. At least 20 deaths were attributed to flooding, fallen walls, while the highest numbers of death were reported from Dar es Salaam.

4.1 Extreme rainfall events

In 2018 different parts of the country received extreme rainfall exceeding 50 mm in 24hours. On 1 January 2018, rainfall amount of 112.5 mm was recorded at Mtwara station, and on 10 January 2018, rainfall amount of 85.3 mm was recorded at Morogoro. Heavy rainfall was also recorded over few areas in the central, western and southern parts of the country whereby on 27 February 2018 the highest amount of 86.3 mm was reported at Songea.

During March, most stations in the Lake Victoria basin, northeastern highlands and northern coast (except Tanga region) recorded high amount of rainfall exceeding 50 mm. The highest amount of rainfall was recorded on 2 March at Pemba (86.1 mm) and Same (70.6 mm).

April 2018 was the only month with many rainfall events exceeding 50 mm. For example, between 13 and 15 April, heavy rainfall occurred over northeastern parts of the country, at least seven stations in the northern parts of the country (Zanzibar, Pemba, Dar es Salaam, Kibaha, Ilonga, and Mwanza) recorded above 50 mm of rains. In this event, Zanzibar station recorded a total amount of 228.4 mm in two days (14 and 15 April) each day with rainfall amount exceeding 100 mm. In addition, a neighbour station in Dar es Salaam (Port) reported 226.4 mm in two days, with 164.5 mm recorded in one day (15 April 2018). This is the second highest amount of rainfall in record for this station. The highest amount of rainfall ever recorded for this station was 173.2 mm in 1995. On the other hand, extreme rainfall events were recorded on 8 April in, Zanzibar, (113.7 mm) and Arusha (94.5 mm). Furthermore, on 30 April 2018, 90.5 mm was recorded at Pemba station.

Between first and 13 May 2018 heavy rainfall occurred over some areas in northeastern parts of the country (Zanzibar, Dar es Salaam, Pemba and Pwani regions). Up to 89 mm of rain was recorded over Pemba and Dar es Salaam on 1 May 2018 and 4 May 2018 respectively.

On 31st October 2018 Nyakibindi secondary school in Shinyanga region recorded 24 hours total rainfall of 299.8 mm, which is the highest amount of rainfall on record since the station started in June 2018. Other 24 hours total rainfall events exceeding 50 mm in October were, 64.7 mm, recorded over Mwanza on 18 October 2018, 94.1 mm recorded over Pemba on 24 October 2018, 75.7 mm recorded over Tanga on 25 October 2018 and 53.2 mm recorded over Bukoba on 10 October 2018.

November was the driest month of the year 2018 among the months falling in rainfall seasons, but significant extreme rainfall events were recorded over few stations. Notable extreme 24 hours total rainfall reaching 135.7 mm was observed at Mlingano agromet station on 16th November 2018.

This amount is the third highest 24 hours total rainfall on record since the station was established in 1935. The highest on record for Mlingano was 146.6 mm recorded on 5 November 2006, and the second highest was 146.0 mm recorded on 21 November1969. Other rainfall events greater than 50 mm for November was 60.5 mm recorded over Kigoma on 11 November 2018, 64.5 mm recorded over Kilimanjaro on 17 November 2018, and 57.1 mm recorded over Shinyanga on 24 November 2018.

In December, few rainfall events greater than 50 mm were observed across the country. Tanga recorded 24 hours rainfall of 141 mm on 18 December 2018, which is the highest on record for December since the station was established in 1946. Other extreme rainfall for December was 96.4 mm recorded over Tabora on 9 December 2018, 70.0 mm recorded over Tumbi-Tabora on 23 December 2018, 66.5 mm recorded over Matangatuani on 31 December 2018 and 62.3 mm recorded over Igeri on 20 December 2018.

4.2 Extreme temperature events

In the year 2018, large number of higher daily maximum temperature (Tmax) events exceeding 35 °C (40 events) occurred during February and was experienced over the northern parts of the country especially the northeastern highlands and few areas in the northern coast. Few cases of higher daily maximum temperature events exceeding 35 °C (23 events) were also observed over same location during January, March, November and December. The highest daily Tmax value recorded for the year was 37 °C, and was observed at Moshi and Kilimanjaro international Airport stations, on 26 February 2018. This temperature record is ranked the 12 and 13 on record for February in the two stations respectively. The second highest daily Tmax value for the year 2018 was 36.9 °C recorded at Ilonga Agromet station (Morogoro) on 6 December 2018. This temperature record is ranked number eight on record since the station was established. However, the extreme maximum temperatures for this year are slightly lower than last year's (2017) extreme temperature by at least one-degree Celsius.

Furthermore, southwestern highlands and southern region were the coldest parts during June, July and August. Large number of lower daily minimum temperature events less than 5 °C (39 events) were observed at Mbeya, Sumbawanga and Songea stations. The lowest minimum temperature of 1.5 °C was observed at Mbeya station on 6 August 2018. This is the lowest observed temperature in this decade since 2011, but lower temperatures up to -8 °C has been observed at this station in the past years.

Minimum temperatures were relatively higher for some months especially along the coastal areas. Port met station was leading by recording higher minimum temperature value reaching 28 °C for some months such as February, March, November and December, and the highest night temperature value of 28.5 °C was observed on 28/02/2018.

5. Major drivers of weather and climate events

There are several factors contributed to the observed severe weather and extreme climatic events in different parts of the country. This ranges from factors observed at global scale, regional scale and even at local scale.

The weak La Niña condition over the equatorial Pacific Ocean spanned from October 2017 to March 2018, the condition changed to ENSO-neutral during April and continued through September 2018 and gradually changed to a weak El Niño condition during the last quarter of the year 2018. The ENSO neutral condition alone was expected to bring normal rainfall condition over the country especially to areas receiving bimodal rains during MAM season, but other factors especially, the presence of tropical cyclones lead to above normal rainfall condition that was observed during 2018 MAM season. Weak El Niño condition over Pacific Ocean did not favour the OND season especially the northern coast because of the little response shown by atmosphere towards this condition. In addition, other factors including the SSTs evolution over the Indian Ocean basin dominated the weather.

Indian Ocean dipole (IOD) index was in neutral phase (but positive values) from February through August 2018, and changed to positive phase during September to November, before retreating to neutral phase during December. The positive phase index strengthened more during September with the IOD index value reaching 0.8 °C. The IOD positive phase was in line with weak El Niño condition over Pacific Ocean. The two-oceanic condition are normally associated by above average rainfall condition over East Africa, but this time they did not bring any impact towards OND rainfall season especially over the northern coast of Tanzania.

Positive Sea Surface Temperature Anomalies (SSTA) continued to dominate in the western Indian Ocean closer to the Tanzania coast from February to May, July to August and December while neutral to negative SSTA dominated over the same region during June and September to November. On the other hand, negative SSTA persisted in the eastern Indian Ocean from January through December 2018. Warm SSTs closer to the coast of Tanzania favored development of convective activities during MAM rainfall season and in December during OND season. Warmer SSTs supported by anomalous easterly wind flow in some months such as February, April and May caused influx of abundant moisture from the Indian Ocean towards the country. This condition is partly linked with the heavy rainfall events that were observed over different parts of the country especially coastal areas and northeastern highlands during January, April and May 2018.

On the other hand, observed neutral to cooler SSTs closer to the coast of Tanzania (accompanied with warmer SSTs over the central extending to North Indian Ocean) during October and November suppressed rainfall activities over the coastal areas by deflecting warm moist northeasterly wind away from the country. The affected areas included northern coast (Tanga, Dar es salaam and Morogoro regions) and Kilimanjaro region.

The tropical cyclone season over the Indian Ocean that started from December 2017 to March 2018 contributed much to the observed heavy precipitation over different parts of the country especially during January and March 2018. There were about five tropical cyclones namely, Ava, Irving, Berguita, Dumazile and Eliakim whose induced westerly winds influenced the drag of abundant moisture from Congo forest towards the country especially the northeastern highlands, northern coast central and southern parts of the country.

In contrary, anomalous easterly wind flow observed during February weakened westerly winds from Congo forests during this month, hence reducing influx of moisture from Congo leaving the country dry especially western, central and southern parts of the country. This condition is associated with the below normal rainfall observed over most parts of the country especially unimodal areas during February.

Apart from global and regional factors the existence of quasi-stationary systems near or within the country are responsible for the occurrence of individual severe events (heavy rainfall) that occurred during 2018, especially those in March, April, and May. These systems, such as near equatorial troughs, cold phases of Madden Julian oscillations (MJO) and the Inter Tropical Convergence Zone were in most cases associated with well-developed thunderstorms.

6. Weather and climate related impacts

In 2018, several climates related effects and associated impacts were documented and ranges from heavy rainfall, severe thunderstorm, strong wind, and flooding and extreme higher temperatures. About 20 deaths were declared and destruction of roads, bridges and farm fields were reported. For example, following the February 2018 overflow of Mkondoa River in Morogoro region, 2 people and 63 cattle were reported dead; and over 9,345 people left homeless. Furthermore, about 8652 acres of Rice and maize farms fields were destroyed, the central railway line connecting Gulwe (Mpwapwa-Dodoma) and (Kilosa-Morogoro) was destroyed and 3800 people were in danger for using contaminated water after 22 wells were destroyed by the flooding river. Other impacts include destruction of 331 houses while others, 1395 were flooded by water.

Following heavy rainfall events between 13th and 15th April 2018, in Dar es Salaam, several impacts were observed in different parts. For example, 14 people were confirmed dead, transport lines were shut down for several hours and schools were closed for two days due to flooded roads and destruction of infrastructures in Dar es Salaam. In addition, 9 houses were washed away by flooded Msimbazi river and Over 600 families remained homeless.

Figure 9: Effects of flooding over the city of Dar es salaam, Tanzania on 16th April 2018 (Source http://www.mwananchi.co.tz/)

Furthermore, the April extreme rainfall caused transport and shop services closed for more than six hours due to flooded roads, while in Zanzibar flood destroyed road infrastructure with more than 120 houses were flooded. Generally, heavy rainfall events during April caused massive destruction of infrastructures, peoples settlements and hectors of farm fields in different parts of the country especially, Lake Victoria zone, northeastern highlands and northern coast, whose impact data could not be obtained.

Six students from Emaco vision English Medium were killed by thunderstorm strike while 25 others were injured following heavy rainfall in Geita on October 2018. In Sumbawanga district, at least two people were reported dead, 57 people injured and 373 rural houses destroyed by rainwater following heavy rainfall on 7th December 2018. It was estimated that at least 1,965 communities were displaced because of the flood event.

On 13/12/2018 strong wind accompanied with heavy rainfall in Manyoni Singida and Saranda ward destroyed 42 houses while other 124 house roofs were removed by strong wind. In addition, a two years old baby was killed from a fallen brick during the heavy rainfall event.

Figure 10: Houses completely wiped because of strong winds accompanied with heavy rainfall

Summary and conclusion

In 2018, most parts of the country experienced anomalously warmer air temperatures, with higher positive anomalies observed for minimum temperatures compared to maximum temperature, especially in the second half of the year. February, September and November were the warmest months of year, while January, March, April and May were the coolest months with respect to long term mean. On average, areas surrounding Lake Vitoria experienced anomalously warmer nights for almost the whole year compared to other parts of the country. Notably, Ruvuma region experienced anomalous minimum temperature from January through October. Extreme high temperatures were mainly observed over northeastern parts of the country during February and December.

The observed country annual total rainfall was 78.6 mm higher than the long-term total rainfall. However, this excess rainfall was observed during MAM rain season and mostly over northeastern highlands and parts of the northern coast. Normal to above normal rainfall was mostly observed over most parts of the country during NDJFMA and MAM rainy seasons while normal to below normal rainfall was observed during OND rainy season. Specifically, below normal rainfall was observed over the northern coast including Morogoro and parts of Kagera region. For unimodal areas (November 2017–April 2018), the bigger part of the season's total rainfall fell during November–December 2017 for southern sector of the country whereas more rains fell during March and April 2018 for western and central parts of the country.

In terms of spatial distribution, the wettest months in the year were January, March and May across the country. On the other hand, February and November were the driest months. Temporal distribution of rainfall was different between stations, while some stations received more rains in the beginning of the season and less towards the end, the opposite was also observed for other stations.

The extreme weather events (temperature and rainfall) were reported over different parts of the country. Although they were not record-breaking events from historical perspective but had significant socio-economic implications across the country. The impacts included loss of lives and properties, damage to infrastructures, destruction of farms and settlements.

The impacts of severe weather could be much reduced if weather forecast and warnings issued by TMA were closely followed and effectively utilized by the public and government sectors in their day-to-day planning of socio-economic activities.

8. Appendix

8.1 Climate of Tanzania

8.1.1 Temperature distribution

Temperatures across the country are normally characterized by relatively less fluctuation throughout the year. The annual long term average temperature over different stations in Tanzania ranges from 14.4–26.4 °C. Regions with the highest temperatures are along the coast and western parts of the country. The season with high temperatures starts from October, continuing through February or March, whilst the cold season is from May to August. The annual minimum (Tmin) and maximum (Tmax) air temperatures across the stations range from 9.6–22 °C and 19.1–30.7 °C, respectively.

8.1.2 Rainfall distribution

The rainfall distribution and variability in the country is driven by multiple factors including East African Monsoon, El-Niño Southern Oscillation (ENSO), and westerly winds from Congo, Tropical Cyclones, and Inter-Tropical Convergence Zone (ITCZ). ITCZ and its migration north and south across the equator are among the main factors affecting distribution and variability of rainfall in Tanzania and the entire East Africa. The migration of ITCZ lags behind the overhead sun by 3-4 weeks over the region. The ITCZ migrate to southern regions of Tanzania in October-December, reaching southern part of the country in January-February and reverses northwards in March, April and May. Due to this movement, some areas experience single and double passages of the ITCZ. The areas that coincide with single passage are known as unimodal areas.

These include the southern, southwestern, central, and western parts of the country, which receive rainfall from November to April or May (NDJFMA, also known as msimu). Areas that experience double passage are known as bimodal, and include northern coast, northeastern highlands, Lake Victoria basin, and the Islands of Zanzibar (Unguja and Pemba). These regions receive two distinct rainfall seasons; the long rain season (also known as masika), which starts mainly in March and continues through May (MAM) and the short rainfall season (also called Vuli), which starts in October and continues through December (OND). January and February is the transition period (relatively dry) for bimodal areas while June, July, August, and September are dry months for the entire country.

8.2 Percentage rainfall

Percentage rainfall is obtained by taking the ratio of the (monthly/yearly) total rainfall to long-term average of monthly total rainfall multiplied by 100. The percentage value greater than 125 is regarded as above normal rainfall and that between 75 and 125 is normal rainfall. The percentage value less than 75 is below normal.

8.3 Temperature anomaly

Temperature anomaly is calculated by taking the difference between the observed values (monthly, seasonal and annual) and the long-term mean. Anomalies were computed with respect to the
1981-2010 base period means.

8.4 Cumulative rainfall analysis

Cumulative rainfall is defined as the rainfall that has accumulated in a period of time (e.g. 10 day or monthly interval). Cumulative rainfall analysis is used to characterize observed rainfall performance and trends for different areas in the country. The cumulative rainfall departure from long-term average is a concept used to evaluate the temporal correlation of the seasonal rainfall with the long-term average rainfall. The concept has hydrologic meaning in the short term as a generalized evaluation of either insufficient or abundant rainfall. In addition, the cumulated rainfall saves as a tool to detect the start and end of the seasons and the presence of wet or dry spells in the season.

In this statement, cumulative rainfall is an accumulation of observed dekadal rainfall from a selected reference point. Dekadal rainfall for 2018 was calculated by observing the following protocols:

• For unimodal areas, rainfall from September 2017 to August 2018 was accumulated, because rainfall season over these areas starts from November in the previous year to April in the following year. While,

• For bimodal areas accumulated rainfall from January to August 2018 was used to characterize rainfall for MAM season and rainfall from June to December 2018 was used to characterize rainfall for OND seasons.

• Dekadal baseline climatology from 1981-2010 was calculated by following same protocol as it is done in calculating decadal values for individual season.

8.5 Spatial analysis for Temperature and rainfall distribution

Temperature and rainfall were analyzed as point data for the selected stations all over the country. 28 stations were used for rainfall analysis and temperature analysis. They were analyzed by the Inverse Distance Weighting (IDW) interpolation method in Quantum GIS to generate spatial distribution maps. The IDW interpolator assumes each input point has local influence that diminishes with distance. It weights the points closer to the processing cell greater than those far away. The IDW algorithm effectively is a moving average interpolator that is usually applied to highly variable data.

8.6 Severe weather definition and indicators

The indicators for severe weather used in this statement adopted the thresholds prescribed by Severe Weather Forecasting Demonstration Project (SWFDP) in East and Southern Africa for rainfall greater than 50 mm in 24 hrs. However extreme weather and climatic events can also be described by other statistical terms such as percentiles and on the magnitude of impact caused even if it does not reach the prescribed threshold.