



Ethiopian Meteorology Institute

Annual state of climate in Ethiopia 2023

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ABSTRACT

The impact of climate change and variability are increasingly becoming widespread with devastating socioeconomic and ecological implications across the world. The impacts are uneven across the world, region, country, and even within a single community.

Every year, the Ethiopian meteorology institute (EMI) conducts robust and comprehensive climate analysis and provides an authoritative statement on the status of Ethiopia's climate. The climate statement serves as a tool for climate monitoring and assessment of the state of the earth's climate in near real-time at national scale. In addition, it provides science based information and knowledge on observed climate trends to decision-makers for informed decision making in planning and implementation of various socio-economic activities including in climate change mitigation and adaptation. EMI continues to monitor and document weather and climate patterns and the associated extremes that is critical for understanding the dynamic of climate variability and change in the country. This information is kept available to the public, the government, policy and decision-makers, academia, the scientific and research communities, and planning agencies in and outside the country.

The 2023 annual state of the climate depicts that as the rainfall was variable from season to season. Moreover, the temperature trend indicates that a slight increment and this is in line with the global climate trend. The annual mean monthly maximum temperature were slightly warmer than long term average over most parts of the country, between 0.1 and 1.9°C except for few locations over central highland areas and bale highlands annual maximum temperature was recorded below normal and temperature anomalies were below average in the range of 0.1 and 0.27 °C. Whereas annual rainfall for the year 2023 was dominated normal rainfall compared with reference to the 1991–2021. Near normal rainfall were observed along the northern half, central, eastern, southwestern parts of Ethiopia

KEY TERMS: state of climate, climate change, Ethiopia, Rainfall, Temperature

1. INTRODUCTION

1.1. Background

Ethiopia is located within 3.30°N–15°N and 33°E–48°E, in the Horn of Africa (Figure 2b). It covers an area of about 1.14 million square kilometers (944,000 square miles), with the total population of more than 110 million. The country's topography consists of high and rugged plateaus and the peripheral lowlands. From a topographic viewpoint, the country confines the Great African Rift Valley that bisects Ethiopia into the eastern and western escarpments. It gradually slopes up from the lowland edges of Rift Valley to the eastern and western escarpments into the southern, central, western and northern mountains (Figure 2a).

Ethiopia has three rainy seasons namely; February–May (FMAM, Belg), June–September (JJAS, Kiremt) and October–January (ONDJ, Bega) seasons (Diro et al., 2011; Gissila et al., 2004; Segele & Lamb, 2005; Shanko & Camberlin, 1998). EMI uses these seasonal classifications for routine seasonal climate forecasting and monitoring of climatic features. Precipitation variations could have direct impacts on the availability of stream flow in the river systems (blue water) and soil moisture (green water) for crop production, resulting in changes in agricultural water scarcity. Although it was well recognized that precipitation variations could have impacts on water scarcity (Coffel et al., 2019).

In Ethiopia, Belg season is known as short rainy seasons in most parts of central and southern parts of the country and covers from February to May months. Kiremt season is known as long rainy season over Ethiopia particularly central and half of northern parts of the country and covers from June to September. Whereas Bega season is known as mostly sunny, dry and cold season over most parts of the country and covers from October to January (Figure 1).

As such, EMI ensures continual monitoring of weather and climate parameters and the provision of accurate, timely, and reliable climate services, including early warnings on adverse hydro meteorological hazards. This significantly contributes to resilience building, planning for adaptation, and implementing efforts to reduce the increasing negative social, environmental, and economic consequences of climate change and variability.

The 2023 climate statement provides a comprehensive summary of the main weather and climate events that occurred in Ethiopia from January to December 2023 and their associated impacts by placing them into historical perspective. The major weather and climate events are documented using

various weather and climate observation networks as well as information obtained from other reliable sources such as newspapers, media, and reports.

This report mainly focuses on seasonal and annual trends and temperature and rainfall anomalies for the year 2023. All maps and graphs presented in this report characterize the climate status observed in 2023 relative to the 1991–2021 baseline climatology. Moreover, the major drivers of weather and climatic events that have contributed to severe and extreme climate events are included in this report.

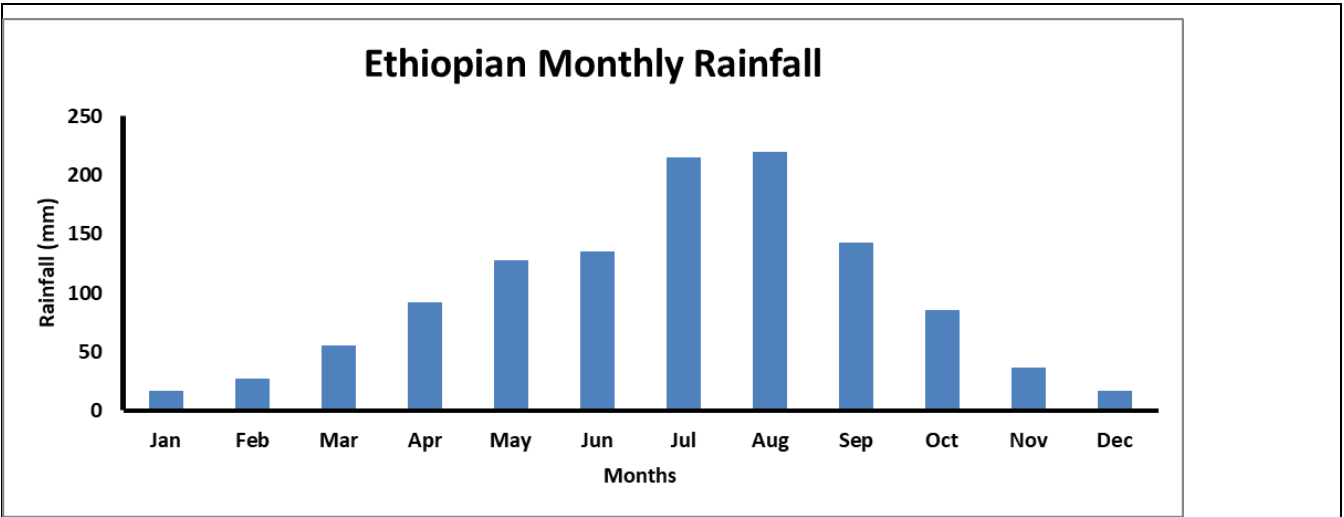


Figure 1: Monthly distributions of average rainfall over Ethiopia

1.2. Drivers of climate variability affecting the region

Seasonal rainfall in Ethiopia is driven mainly by the migration of the Inter-Tropical Convergence Zone (ITCZ). The exact position of the ITCZ changes over the course of the year, oscillating across the equator from its northern most position over northern Ethiopia in July and August, to its southern most position over southern Kenya in January and February. Most of Ethiopia experiences one main wet season (called ‘Kiremt’) from June to September, when the ITCZ is at its northern-most position. Parts of northern and central Ethiopia also have a secondary wet season of erratic, and considerably lesser, rainfall from February to May (called the ‘Belg’). The southern lowland regions of Ethiopia experience two distinct wet seasons which occur as the ITCZ passes through this more southern position. The March to May ‘Belg’ season is the main rainfall season followed by a lesser rainfall season in October to December called “Bega”. The movements of the ITCZ are sensitive to variations in Indian Ocean sea-surface temperatures and vary from year to year, hence the onset and duration of the rainfall seasons vary considerably inter- annually, causing frequent drought. The most well

documented cause of this variability is the El Niño Southern Oscillation (ENSO) and IOD. ENSO and IOD are oceanographic phenomena that occur in the tropical Pacific Ocean and Indian Ocean, due to the interaction between the sea and the atmosphere.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

Ethiopia is a landlocked country located in the Horn of Africa, situated in the eastern part of the continent of Africa. Here are key details about its geographical location and features: geographical coordination's of Ethiopia is approximately situated between latitudes 3° and 15° N and longitudes 33° and 48° E and Borders from North: Eritrea, East: Djibouti and Somalia, South: Kenya, West: South Sudan and Northwest: Sudan (Figure 2).

Ethiopia is also known for its diverse topography, which includes high plateaus, mountains, valleys, and lowland plains. The Ethiopian Highlands, often referred to as the "Roof of Africa," are one of the most prominent features, with the Simien Mountains and the Bale Mountains being notable ranges (Abbate et al., 2015).

The country has considerable altitude variation, with the central highlands averaging around 2,500 meters (8,200 feet) above sea level. The lowest point is the Danakil depression, which lies below sea level. Ethiopia's climate varies with altitude. The highlands typically have a temperate climate, while the lowland areas experience more tropical and arid conditions. The country has three main seasons: two wet season (June to September) and (February to May) and one dry season (October to January). The Blue Nile, one of the major tributaries of the Nile River, originates in Ethiopia. The country is also home to several lakes, including Lake Tana, the largest lake in Ethiopia, which is the source of the Blue Nile.

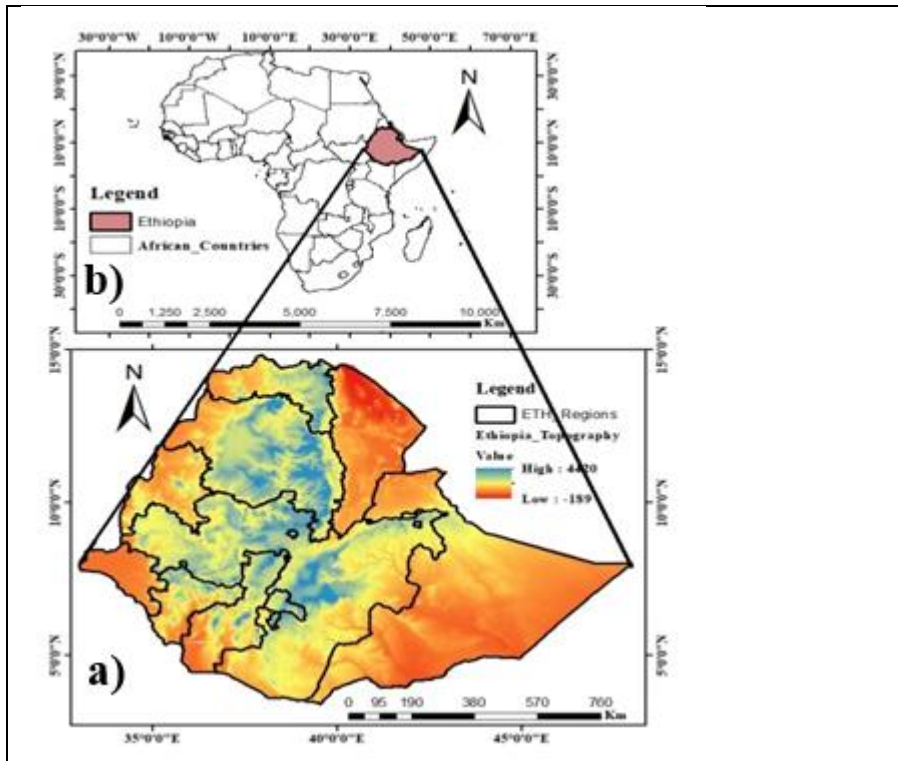


Figure 2: Maps for Ethiopian country and border countries.

2.2. Data Collection and Methodology

2.2.1. Data types and sources

To produce this climate report we used rainfall, maximum and minimum temperature data and the dataset are collected from the Ethiopian Meteorological Institute (EMI). The data spans from 1991 to 2023 and from this data 1991-2021 used for long term mean and 2023 used for present status of Ethiopian climate.

2.3. Methods

To produce this scientific annual climate report we reviewed different research papers, articles and reports in order to know the current status of global climate change. Moreover, we utilized various statistical methods to analyze temperature and rainfall data over Ethiopia. The techniques include trend analysis, anomaly detection (such as change-point detection tests), and graphical representations (like time series plots). The following equations are represents for:

Annual and seasonal total rainfall and Average temperature (minimum or maximum):

$$P_{rf} = \sum_{i=1}^n RF_i \text{-----Equation 1}$$

Where; P_{rf} represents total present rainfall, RF_i represents present rainfall for i^{th} time and n is number of data

$$P_{temp.} = \frac{1}{n} \sum_{i=1}^n Temp_i \text{-----Equation 2}$$

Where; $P_{temp.}$ represents average temperature, $Temp_i$ represents present temperature for i^{th} time and n is number of data

Annual and seasonal anomalies for both rainfall and temperature status:

$$Anom = P_{clim} - LTM \text{-----Equation 3}$$

Where; $Anom$ represents anomalies of present rainfall or temperature, P_{clim} represents present climate and LTM is long term mean

Percent of normal for rainfall parameters:

$$P_{nor} = \frac{P_{rf}}{LTM} * 100 \text{-----Equation 4}$$

Percent of deviation for temperature:

$$P_{dev.} = \frac{P_{temp} - LTM}{LTM} * 100 \text{-----Equation 5}$$

Where P_{nor} is percent of normal for rainfall and $P_{dev.}$ is Percent of deviation for temperature

After this process to employ tools like charts, graphs, and maps to effectively communicate the findings. Visualization helps in illustrating patterns, trends, and anomalies in climate data.

3. RESULT AND DISCUSSIONS

3.1. Global and regional current climate status

3.1.1. Current temperature status

Figure 3 shows that the global mean near-surface temperature in 2023 is significantly elevated, at 1.40 ± 0.12 °C above the 1850–1900 average. This year is projected to be the warmest on record since instrumental measurements began 174 years ago. Additionally, the past nine years (2015 to 2023) are identified as the warmest years recorded, with 2016 and 2020 being the previous joint warmest years at anomalies of 1.29 ± 0.12 °C and 1.27 ± 0.13 °C, respectively. This trend underscores ongoing concerns about climate change and its impacts on global temperatures.

The statement highlights two significant factors contributing to the long-term increase in global temperatures: the increased concentration of greenhouse gases and the recent climatic shift from La Niña to El Niño conditions. Greenhouse Gases: The long-term rise in global temperatures is primarily driven by increased levels of greenhouse gases, such as carbon dioxide and methane. These gases trap heat in the atmosphere, leading to a warming effect known as the greenhouse effect. La Niña to El Niño Transition: The transition from La Niña, a cooling phase of the El Niño-Southern Oscillation (ENSO), to El Niño, a warming phase, can significantly impact global temperatures (Provisional State of the Global Climate 2023, 2023). La Niña conditions typically lead to cooler global temperatures, while El Niño conditions often result in higher temperatures due to changes in ocean and atmospheric circulation patterns. The shift that occurred by September 2023 likely contributed to the observed rise in temperatures from 2022 to 2023, as El Niño can enhance the warming effects already in place due to climate change. Overall, this combination of human-induced greenhouse gas emissions and natural variability in climate patterns contributes to the fluctuations in global temperature, which are increasingly evident in recent years (Forster et al., 2024). For the year 2023 to date, most land areas were warmer than the 1991–2020 average. Unusual warmth was reported across large areas of the eastern U.S., Mexico, and Central America, as well as western and southern areas of South America. Western Europe and western parts of North Africa, western Eurasia, areas of Central and Southeast Asia, and Japan, were also unusually warm (Figure 4).

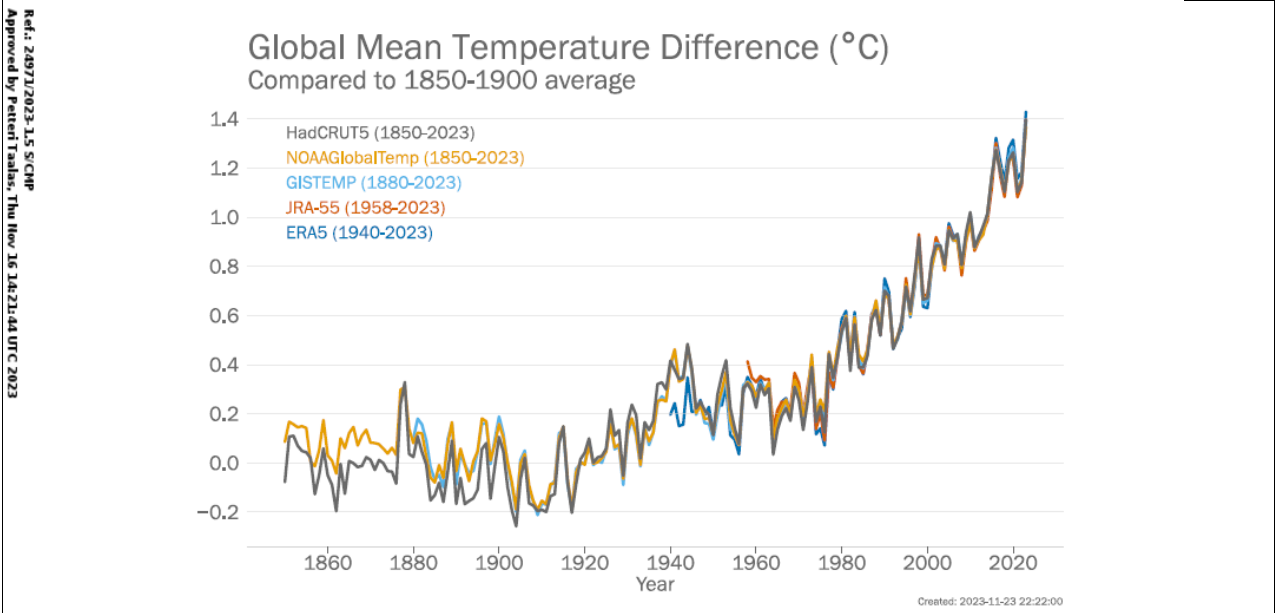


Figure 3: Annual global mean temperature anomalies (relative to 1850–1900) from 1850 to 2023.

Image source from (Provisional State of the Global Climate 2023, 2023)

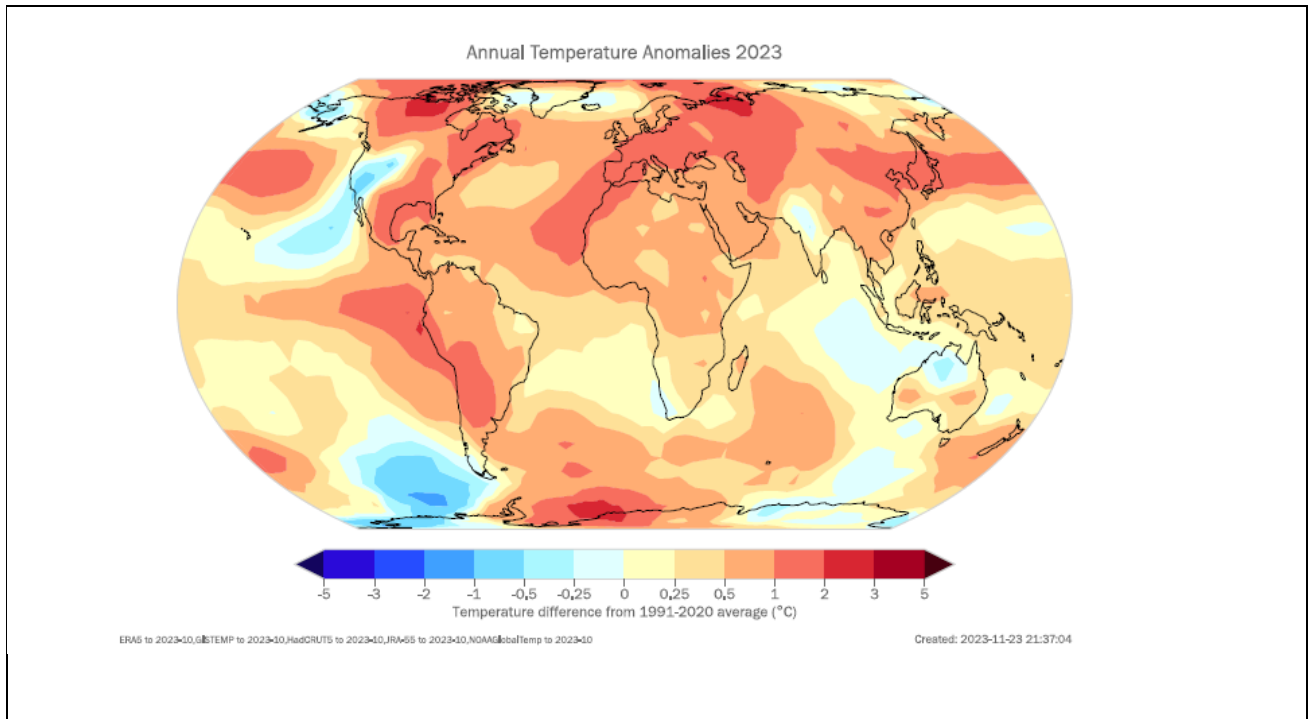


Figure 4: Mean near-surface temperature anomalies (difference from the 1991–2020 average) for 2023

Image source from (Provisional State of the Global Climate 2023, 2023)

3.1.2. Current Rainfall status

Figure 5 shows changes in rainfall patterns from the 2011-2020 decade compared to the 1951-2000 reference period. It highlights the prevalence of long-term drought conditions in various subtropical regions, where decadal average rainfall fell more than 10% below the levels recorded during the earlier reference period. The regions specifically mentioned as experiencing these significant decreases in rainfall including South-western United States, Western Mediterranean, Eastern Australia (south of the tropics), Southern Africa and Central Chile. This information underscores the impact of climate variability and change on global precipitation patterns, particularly in subtropical areas.

The strong El Niño episode of 2015-2016 resulted in strong precipitation anomalies in various parts of the world. From 2011 to 2020 some years was wet in the northern hemisphere section of the African monsoon region specifically in 2018, 2019 and 2020 all about 10% above average. Significant flooding ensued, particularly in 2020. The Greater Horn of Africa saw very large anomalies in both directions. The 12-month period ending in June 2011 was extremely dry, contributing to significant famine later in 2011 and 2012, and also had severe drought in the 2016 - 2017 and the 2018-2019 periods. However, in late 2019, and, to a lesser extent, early 2020, conditions became extremely wet (The Global Climate 2011-2020, 2020).

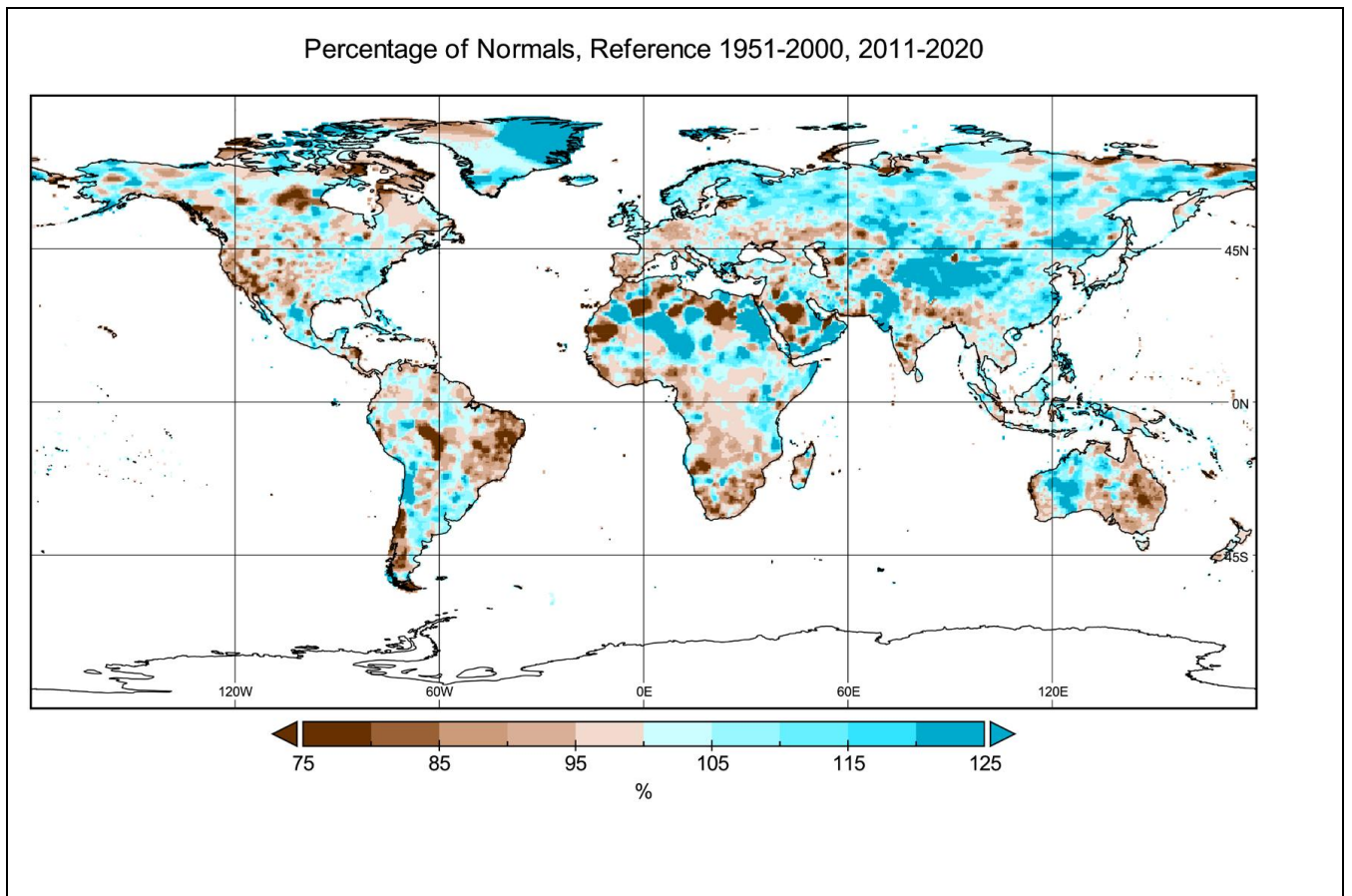


Figure 5: Mean annual rainfall over the decade 2011-2020, expressed as a percentage of the mean for the 1951-2000 reference periods.

Image source from (*The Global Climate 2011-2020*, 2020)

3.2. Temperature

3.2.1. Annual maximum temperature

The annual mean monthly maximum temperature for the year 2023 using well distributed meteorological stations were computed across the nation with relative to their climatology (1991-2021). In this year north eastern and eastern low land areas of the country annual maximum temperature recorded from 29 to 33.7°C. The annual mean monthly maximum temperature were slightly warmer than long term average over most parts of the country, between 0.1 and 1.9°C except for few locations over central highland areas. on the other hands some areas like bale highlands of annual maximum temperature was recorded below normal and temperature anomalies were below

average in the range of 0.1 and 0.27 °C. The observed higher temperature anomalies were mainly in areas surrounding northeastern lowlands and some pocket areas of central highlands (Figure 6).

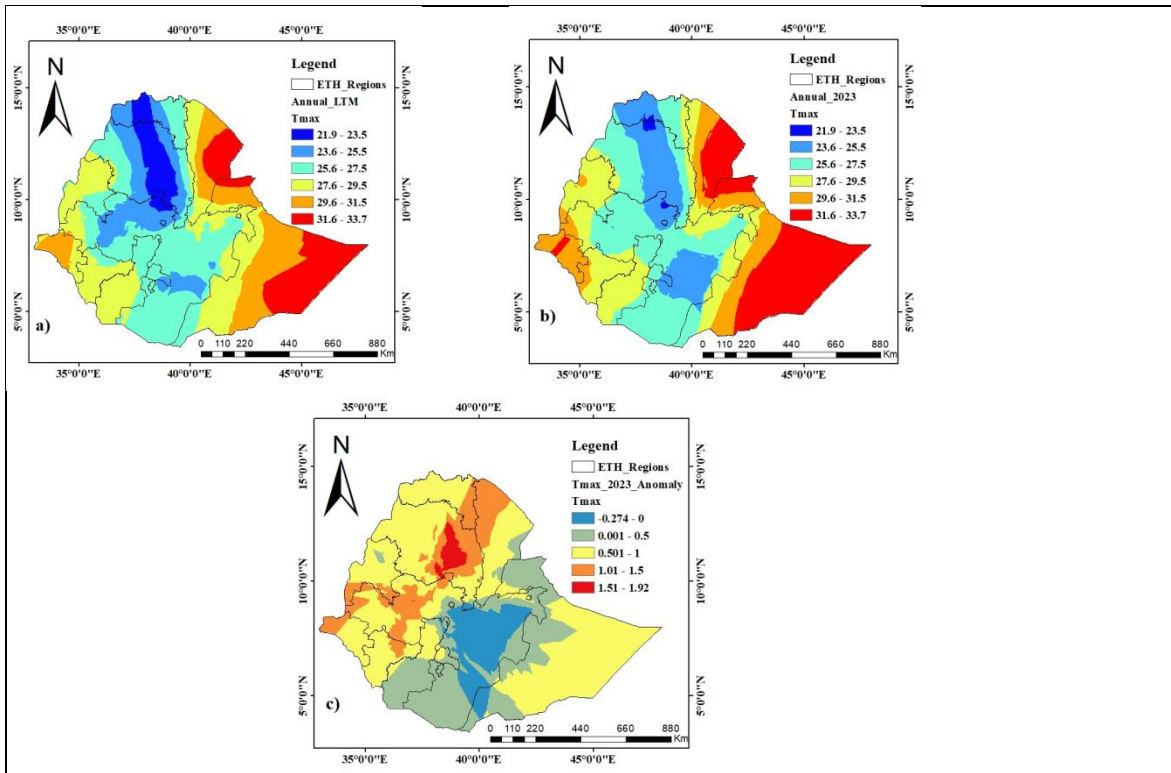


Figure 6: Spatial distributions of maximum temperature in 2023: a) represents long term mean annual maximum temperature, b) 2023 annual maximum temperature and c) anomalies of maximum temperature for 2023

3.2.2. Bega (ONDJ) Seasonal maximum temperature trend

Historically most of eastern and Bale highlands, central and northern high land areas of the country the maximum temperature during Bega season depicts colder relatively to the other seasons and the maximum temperature ranges between 21 to 26°C. Whereas, north eastern and eastern low land areas of the country were relatively hotter than the other areas and the temperature varies between 29 to 33°C). Nevertheless areas like southern, western and some parts of eastern middle altitudes of the country were experienced from 26-29°C (Figure 7a).

The result of Bega 2023, maximum temperature revealed that increasing trend compared with climatology 1991 to 2021. North eastern, Eastern and South eastern parts of the country mostly dominated by 29-33°C of average maximum temperature and area coverage's of this value was larger

than climatology. In general except bale highland some central and northern highland parts most of the country of maximum temperature was slightly increasing relative to climatology 1991-2021 (Figure 7b). Anomalies of maximum temperature in this season were highly increasing over some parts of northern highlands, north eastern lowlands and some pocket areas of central parts of the country from 2 to 3°C. While the rest most areas were increasing from 0.1 to 2°C. In general there in no decreasing anomalies in 2023 bega season over the country (Figure 7c).

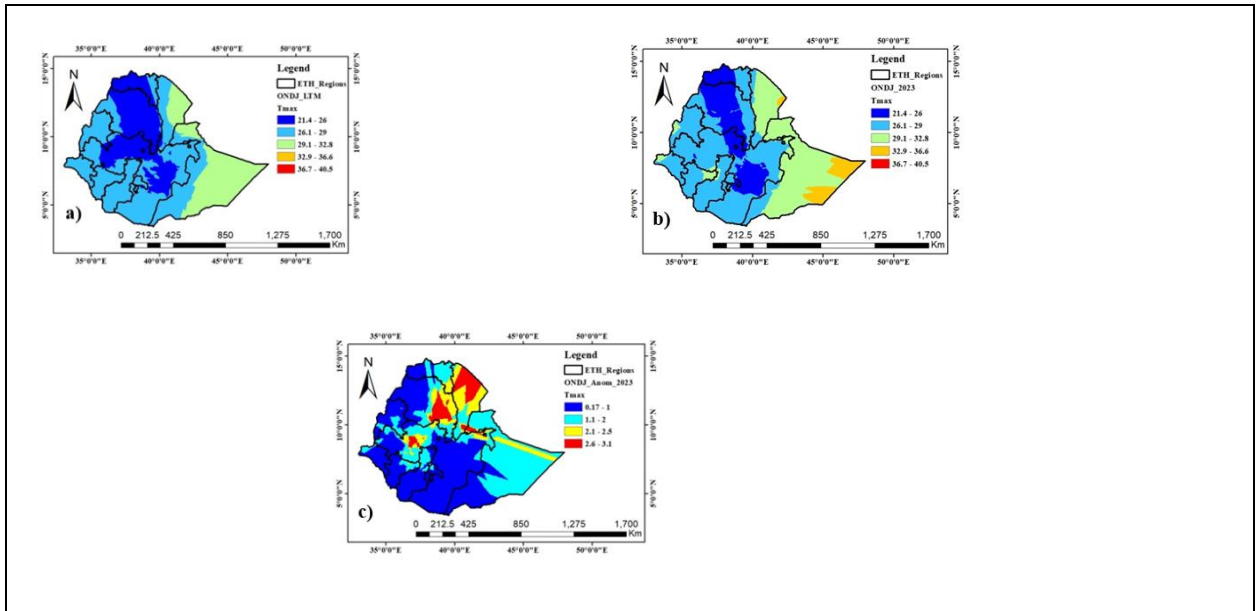


Figure 7: Spatial distributions of maximum temperature in 2023: a) represents long term bega mean maximum temperature, b) 2023 bega maximum temperature and c) bega anomalies of maximum temperature for 2023

3.2.3. Belg (FMAM) Season maximum temperature trends

Climatologically, Belg season in Ethiopia is known as hottest season compared with the other seasons. From the Belg season, the months of April and May the maximum temperature will reach maximum and in few place the daily maximum temperature exceeds $>40^{\circ}\text{C}$ (Figure 8a).

In 2023, Belg season north eastern and south eastern parts of the country were dominated high temperature values in between 30 to 35°C . Whereas eastern and western middle altitude areas of the country experienced between 27 to 30°C and the rest and most of highland parts of the country was dominated from 22 to 27°C (Figure 8b).

Figure 8c shows that maximum temperature anomaly of belg 2023. In this season south eastern pocket areas of Somali region was experienced relatively high increasing maximum temperature from 0.5 to 0.75°C. except northern, pocket areas of southern and south eastern tip areas most parts of the country was decreasing maximum temperature anomalies from 0.1 to 2.2°C.

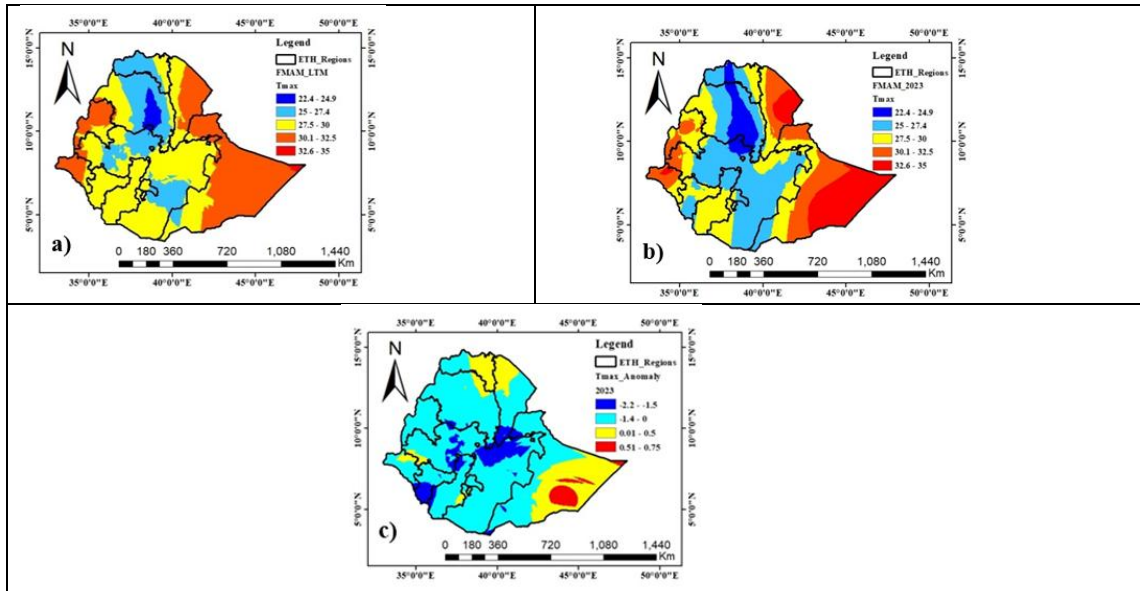


Figure 8: Spatial distributions of maximum temperature in 2023: a) represents long term belg mean maximum temperature, b) 2023 belg maximum temperature and c) belg anomalies of maximum temperature for 2023

3.2.4. Kiremt (JJAS) Season maximum temperature trends

Kiremt season is the second next to belg hottest time in Ethiopia. Specifically the first month like June month is hottest month compared to the rest months of the season especially over north eastern parts. Historically from 1991 to 2021 the status of maximum temperature shows north eastern, eastern and south eastern areas are experienced high temperature from 29 to 40.5°C. Whereas, the most parts of the country dominated moderate temperature values in between 21 to 29°C compared to lowland areas (Figure 9a).

In kiremt 2023 maximum temperature in most lowland areas such as some pocket areas of western parts, north eastern, eastern and south eastern areas dominated from 29 to 40.5°C. While most of highland and middle altitudes of the country were experienced from 21 to 29°C (Figure 9b).

Figure 9c shows anomalies of maximum temperature in kiremt 2023 season. North western parts were highly increasing maximum temperature from 2 to 3°C and north eastern and eastern parts of the country were relatively slightly increase from 0.1 to 1°C. In general kiremt 2023 season was increased maximum temperature all over the country compared with climatology of 1991 to 2021.

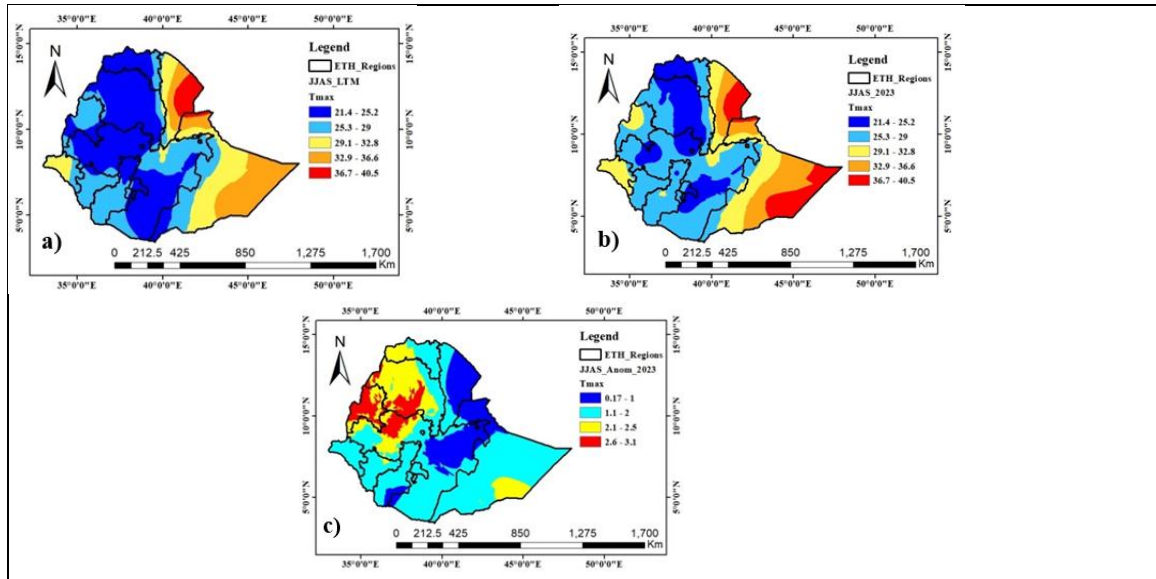


Figure 9: Spatial distributions of maximum temperature in 2023: a) represents long term kiremt mean maximum temperature, b) 2023 kiremt maximum temperature and c) kiremt anomalies of maximum temperature for 2023

3.2.5. Annual minimum temperature

In 2023, annual minimum temperature over northern half highland areas recorded ranging between 9 to 14°C and the rest parts of the country were recorded above 14°C. comparing with long term mean slightly increasing over northern half and highly increase over southern half specially over most parts of south western Ethiopia, western Ethiopia southern oromia and Somali regions. In addition, anomalies of minimum temperature shows that annual mean monthly minimum temperature, were slightly lower than the long-term means across some stations in northeastern, Eastern areas and pocket areas of the country, particularly Afar, eastern Tigray, eastern amhara and northern Somali (0.1 to 3.76°C) but in most of the country slightly higher than the long-term means at a lots of stations across Western, central and southern parts (0.1 to 1.5°C) (Figure 10).

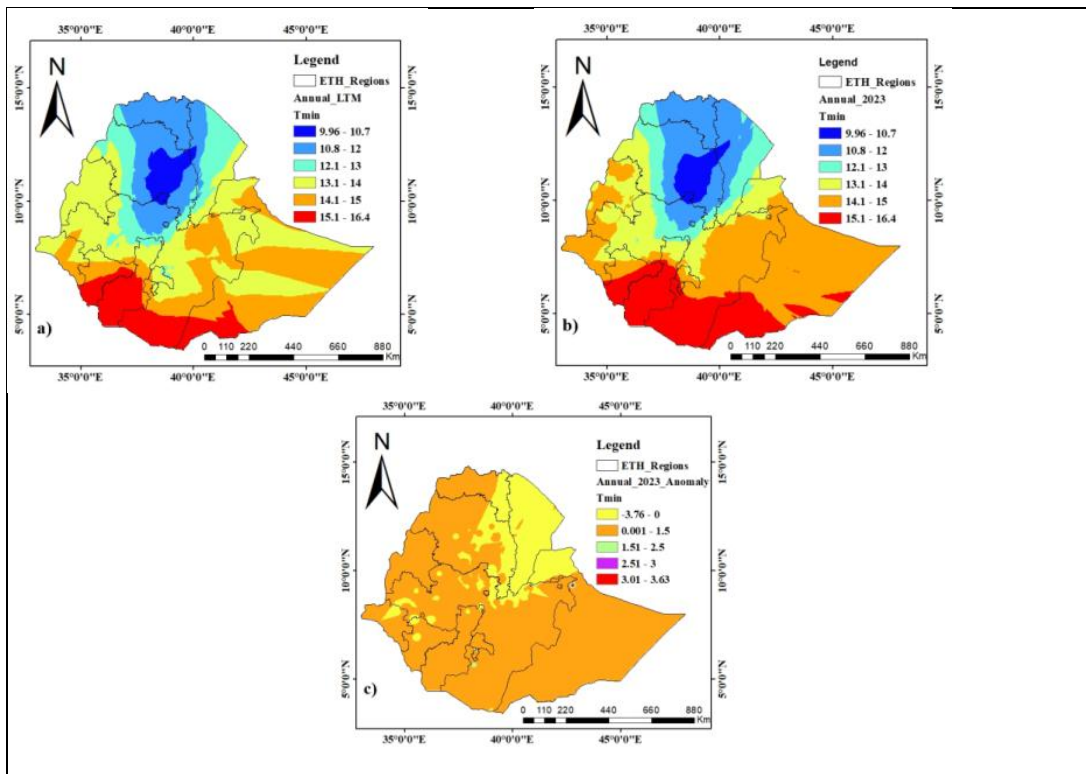


Figure 10: Spatial distributions of minimum temperature in 2023: a) represents long term mean annual minimum temperature, b) 2023 annual minimum temperature and c) anomalies of minimum temperature for 2023

3.2.6. Bega (ONDJ) season minimum temperature trends

Minimum temperature for bega 2023 were experienced the range from 14 to 18.2°C over most parts of the country such as north eastern, eastern, south eastern and southern areas. Whereas northern, north western, western and central areas of the country were dominated the ranges 8 to 14°C.

Anomalies of minimum temperature in this season were highly increasing over some central and eastern parts of the country from 1.5 to 2.6°C and the rest parts of the country were slightly increase ranging from 0.3 to 1.4°C. In general bega 2023 minimum temperature was increased all over the country compared with long term climatology 1991-2021(Figure 11).

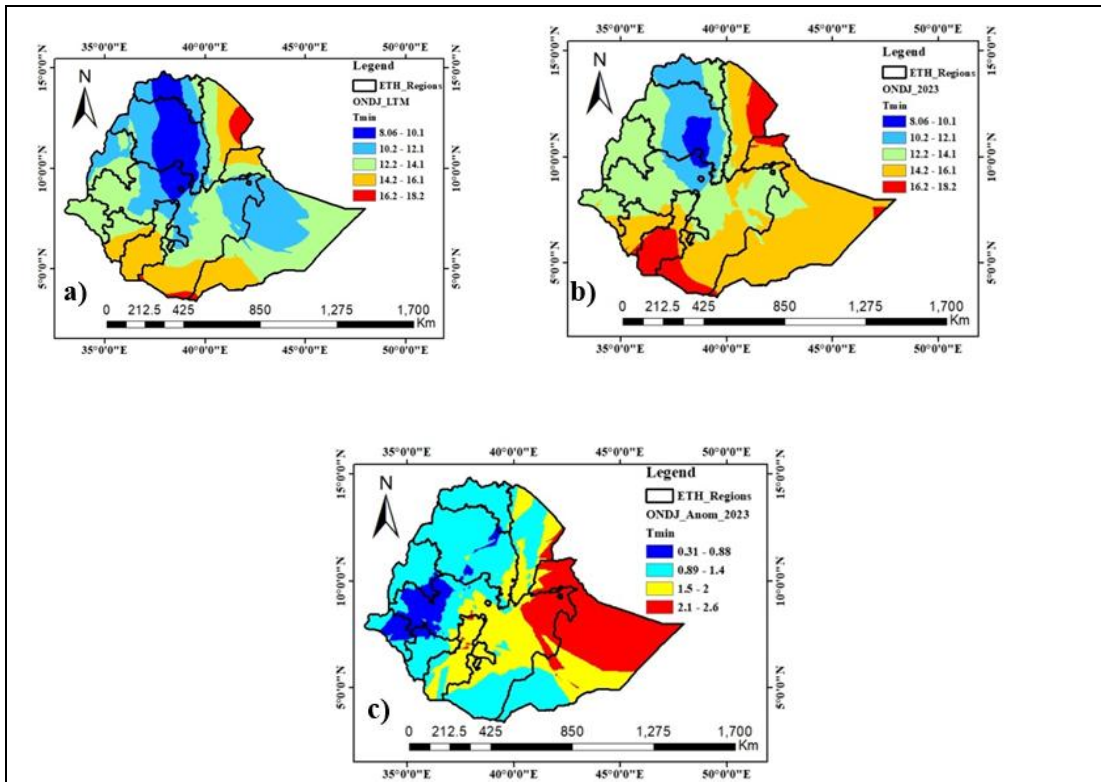


Figure 11: Spatial distributions of minimum temperature in 2023: a) represents long term bega mean minimum temperature, b) 2023 bega minimum temperature and c) bega anomalies of minimum temperature for 2023

3.2.7. Belg (FMAM) season minimum temperature trends

Figure 12 shows belg 2023 minimum temperature status. Comparing with climatology over central and northern high land areas of the country was slightly decreasing minimum temperature in this season. Whereas most of the country was all most similar status with long term mean (1991-2021).

Anomalies of minimum temperature relative to 1991-2021, most of the country was decreasing status from 0.1 to 2.2°C and pocket areas of southern and south eastern parts was increasing status ranging from 0.1 to 0.7°C

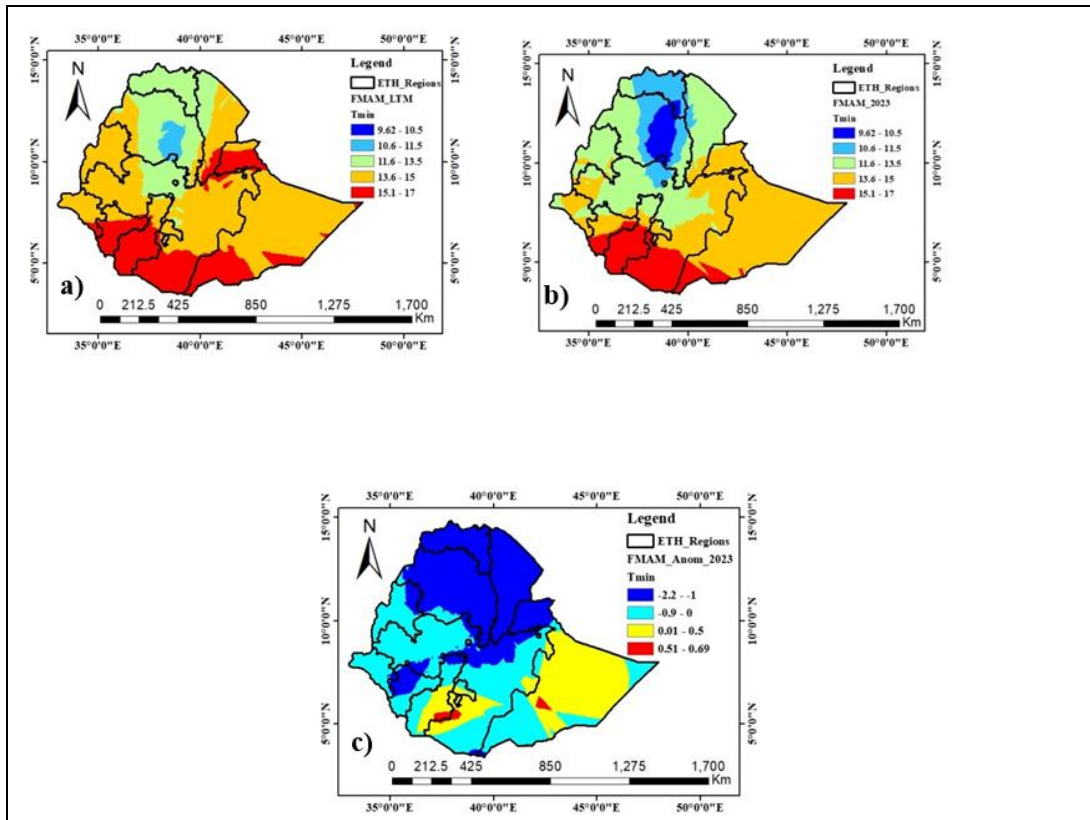


Figure 12: Spatial distributions of minimum temperature in 2023: a) represents long term belg mean minimum temperature, b) 2023 belg minimum temperature and c) belg anomalies of minimum temperature for 2023

3.2.8. Kiremt (JJAS) season minimum temperature performance

Kiremt 2023 was experienced from 13 to 18°C over most parts of the country and from 10.5 to 13°C over central and northern highland areas of the country. This status shows this season was highly hottest season compared with long term climatology 1991-2021.

Kiremt 2023 minimum temperature anomalies indicates that north eastern lowland areas was slightly decreasing condition from 0.1 to 1.7°C whereas the rest parts of the country was increasing status from 0.1 to 3.5°C (Figure 13).

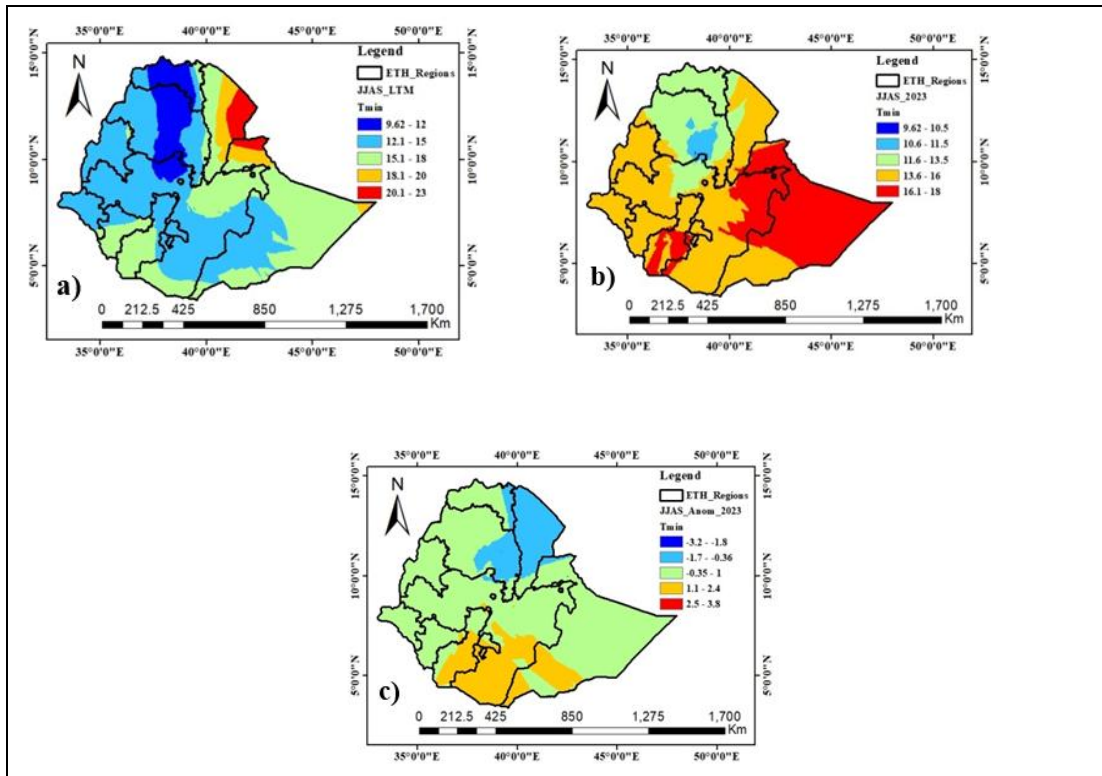


Figure 13: Spatial distributions of minimum temperature in 2023: a) represents long term kiremt mean minimum temperature, b) 2023 kiremt minimum temperature and c) kiremt anomalies of minimum temperature for 2023

3.3. Rainfall

Rainfall is a key climate parameter, closely related to essential resources for human activities, such as water for drinking, domestic purposes, agriculture and hydropower. It also drives major climatic events such as droughts and floods. Annual rainfall follows a bimodal seasonal pattern with rains, commonly referred to as the “long rains” season occurring from June to September (JJAS) across most parts of the country and the “short rains” in February, March, April and May (locally name, belg) across southern lowlands and eastern half of Ethiopia. The October, November and December (bega) is the dry, cold and windy climate across most portions of the country, while it is the second rainy season for southern lowlands.

3.3.1. Annual rainfall trends

The annual rainfall for the year 2023 using well distributed meteorological stations were computed across the nation with relative to their climatology (1991-2021). The annual rainfall for the year 2023

has the rainfall normal, with reference to the 1991–2021. Near normal rainfall were observed along the northern half, central, eastern, southwestern parts of Ethiopia. Abnormally high annual rainfall totals were detected in western, central and southwestern. The lowest recorded rainfall in 2023 was across Southwestern Somalia low land areas, which is 6.91 mm below the climatology (Figure 14).

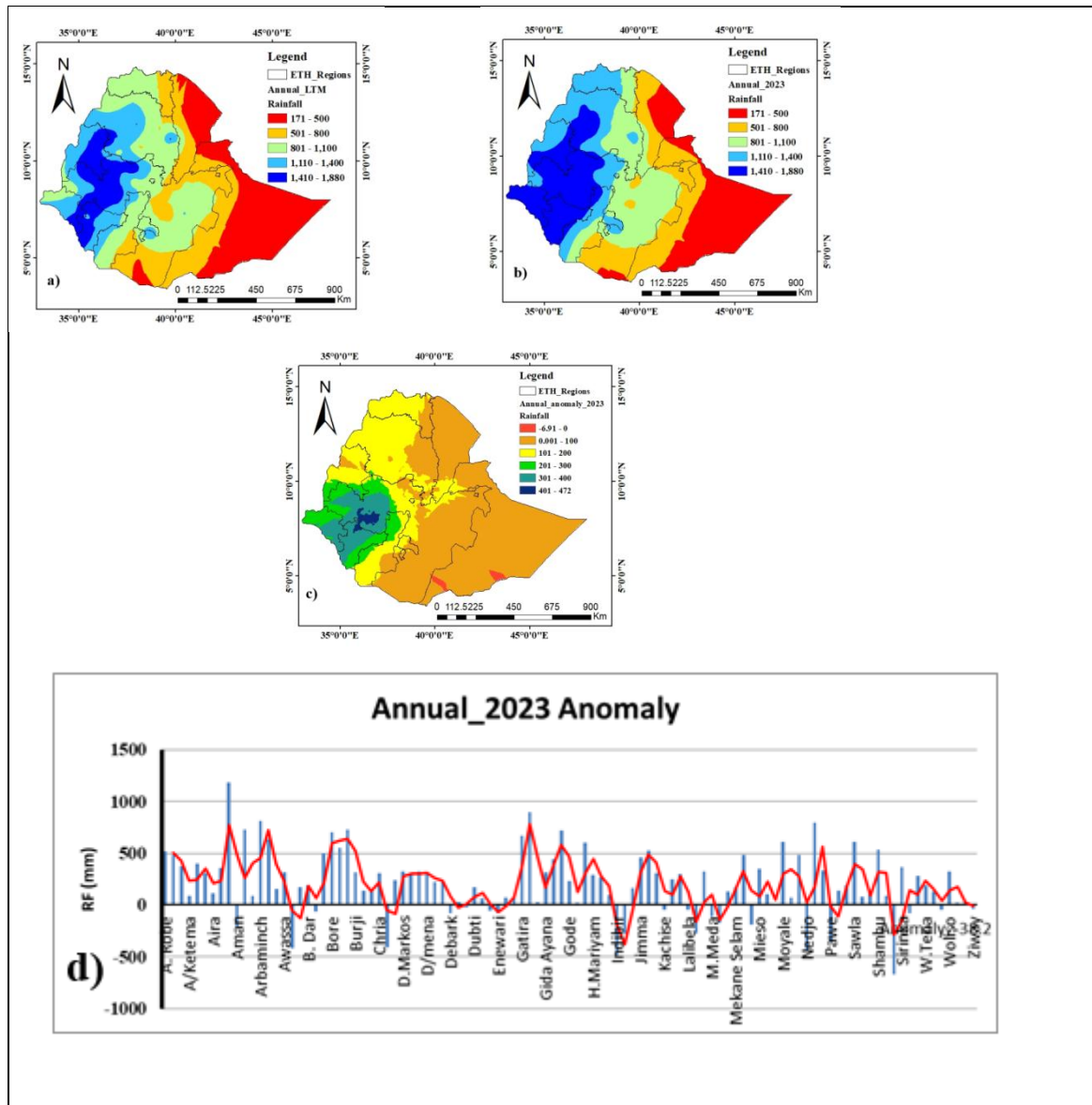


Figure 14: Spatial distributions of rainfall in 2023: a) represents long term mean annual rainfall, b) 2023 annual rainfall c) spatial distribution annual rainfall anomalies for 2023 and d) graph for anomalies of annual rainfall for selected station in 2023

3.3.2. Bega (ONDJ) season rainfall trends

An assessment of the recorded rainfall during ONDJ 2023 indicates that the rainfall performance was normal and above normal over most parts of the seasonal rain benefiting regions due to El Nino and positive IOD condition prevailed in this season (Figure 15).

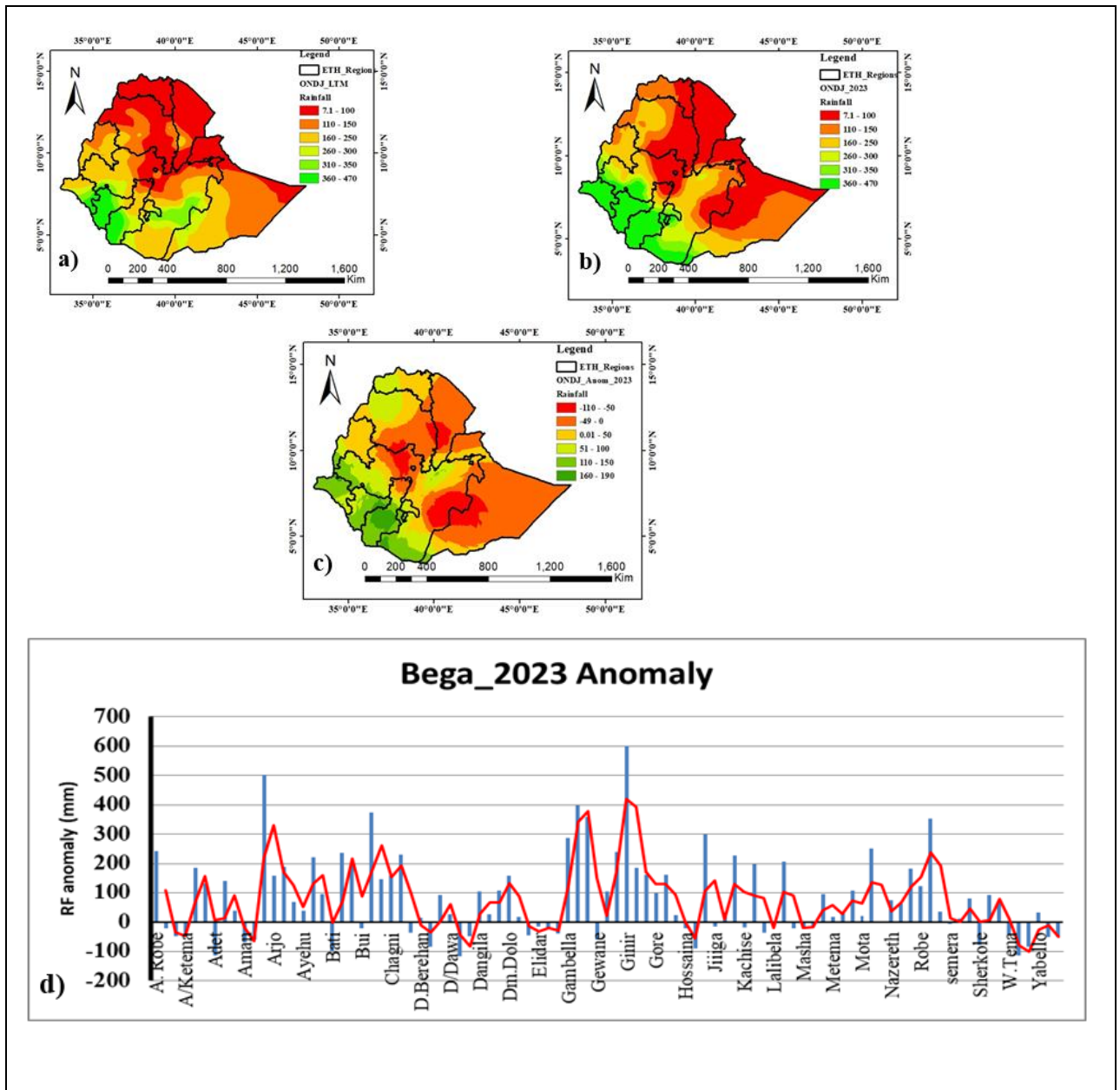


Figure 15: Spatial distributions of rainfall in 2023: a) represents long term bega mean rainfall, b) 2023 bega rainfall c) spatial distribution bega rainfall anomalies for 2023 and d) graph for anomalies of bega rainfall for selected station in 2023

3.3.3. Belg (FMAM) season rainfall trends

During FMAM 2023 Normal to Above normal rainfall observed over most of the North-western, western and South-western parts and Normal to above normal rainfall was observed over most of Southern and Southeastern Ethiopia by the cause of ENSO-neutral and Neutral IOD observed in this season (Figure 16).

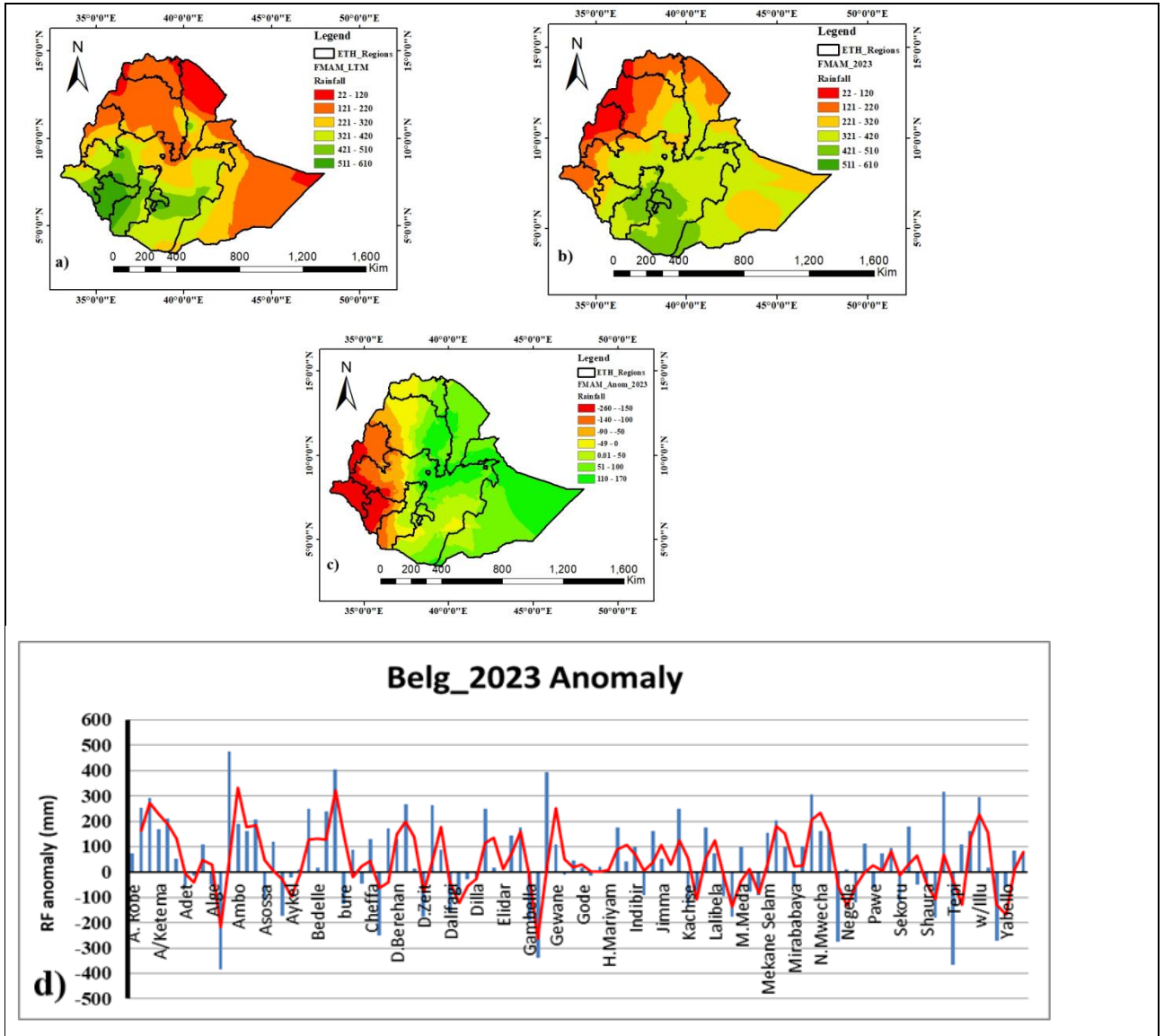


Figure 16: Spatial distributions of rainfall in 2023: a) represents long term belg mean rainfall, b) 2023 belg rainfall c) spatial distribution belg rainfall anomalies for 2023 and d) graph for anomalies of belg rainfall for selected station in 2023

3.3.4. Kiremt (JJAS) season rainfall trends

The JJAS 2023 rainfall analysis indicates that the rainfall performance was Normal to below normal rainfall observed over northeast, east and central parts and Normal to above normal rainfall observed few parts of the North-western, western and South-western parts of the country. . Several meteorological stations in the country recorded rainfall that was lower than 75% of their seasonal Long-Term Means (LTMs). This condition comes due to EL NINO and IOD Positive observed in this season (Figure 17).

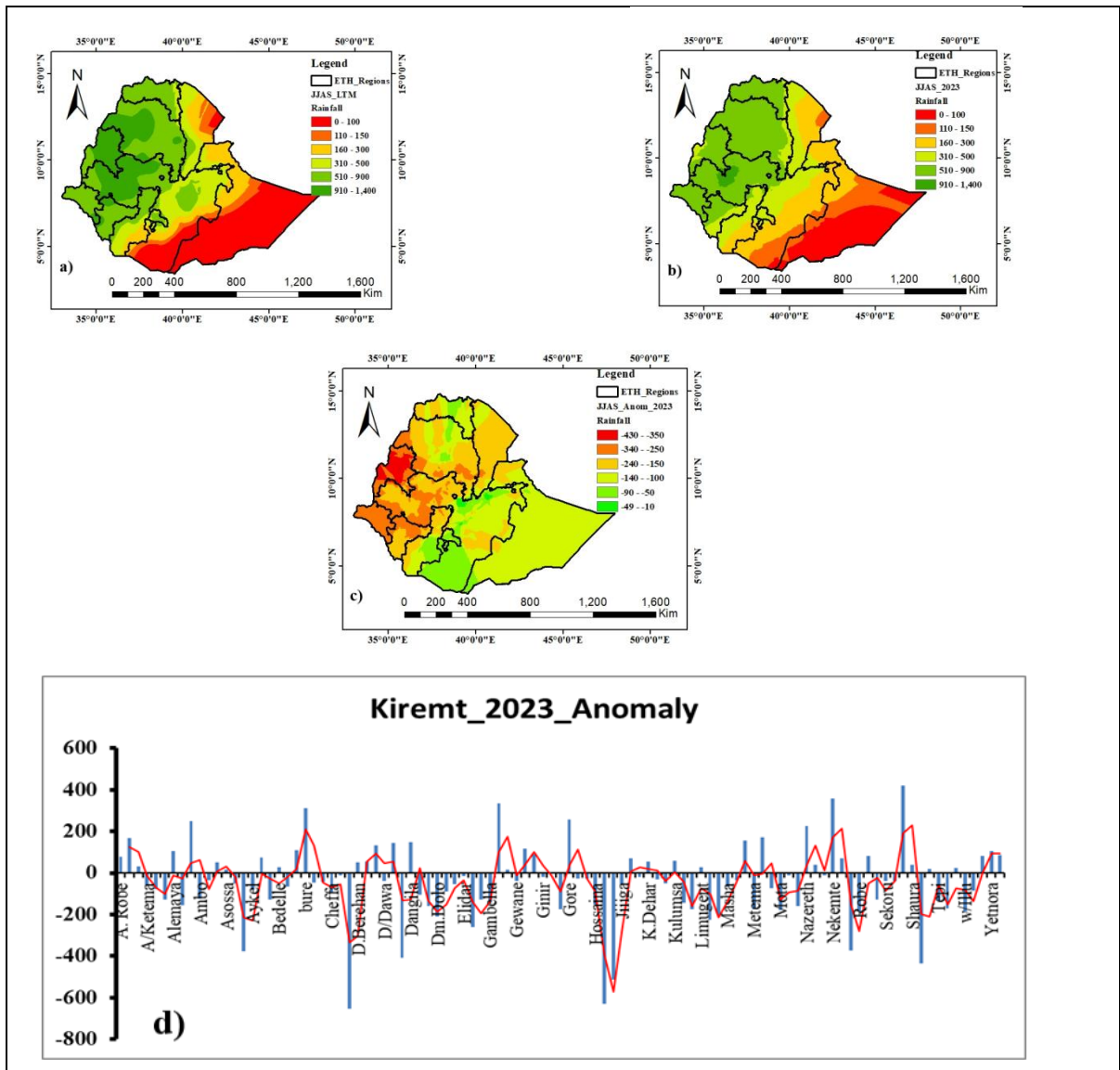


Figure 17: Spatial distributions of rainfall in 2023: a) represents long term kiremt mean rainfall, b) 2023 kiremt rainfall c) spatial distribution kiremt rainfall anomalies for 2023 and d) graph for anomalies of kiremt rainfall for selected station in 2023

3.4. Major Drivers of Weather and Climate Events in 2023

In 2023, the El Niño phase conditions are present and Positive IOD prevailed in bega (ONDJ) season. Due to this case most areas of south and south east areas of the country was recorded above normal rainfall, Normal to Above normal rainfall was observed over most of the North-western, western and South-western parts of the country as anticipated. And much of the northern, north-eastern, eastern and central Ethiopia received above normal rainfall (unseasonal rainfall). ENSO-neutral and Neutral IOD observed in belg (FMAM) season. Related to this Normal to Above normal rainfall observed over most of the North-western, western and South-western parts and Normal to Above normal rainfall was observed over most of Southern and Southeastern Ethiopia. EL NINO and IOD Positive observed in kiremt (JJAS) Season. Then Normal to below normal rainfall observed over northeast, east and central parts and Normal to above normal rainfall observed few parts of the North-western, western and South-western parts of the country.

While the impacts of the ENSO and IOD conditions on the East African rains are well established, these conditions cannot fully explain variation in rainfall across the country. Other drivers, such as synoptic systems and their movements and local factors, are responsible for variations in day-to-day weather conditions observed like the Madden Julian Oscillations (MJO), the near equatorial trough and surface convergence associated with the presence of the Inter-tropical Convergence Zone (ITCZ) also brought significant weather conditions over different parts of the country.

3.5. Extreme Weather and Climatic events

Recurrent extreme drought and flood in Ethiopia lead to more economic loss (Teshome & Zhang, 2019). the year 2023 was mainly dominated by wet conditions, especially for regions receiving two rainy seasons. However, extreme weather events, particularly heavy rains, localized thunderstorms with rain, and high temperatures were reported in different parts of the country. These events have had impacts on people's livelihoods, including the loss of lives and properties, and destruction of infrastructure.

In 2023, unusual heavy rains were observed in bega season over the northern parts of the country. In general, a considerable number of heavy rains and flooding events were reported in different parts of the country with in three seasons. Table 1 presents some of the extreme rainfall events in the view that they were exceptional from historical perspectives and they caused significant impacts.

Table 1: extreme rainfall events from historical perspectives in 2023

Station	Highest Rainfall (mm)	Date of Recorded
Arba Minch	106.7	19-Oct
Jinka	81.2	20-Oct
Ginnir	80	02-Nov
Bule Hora	107.4	07-Nov
Limu Genet	72	04-Nov
Masha	80.6	18-Nov
Bore	75	4-Aprl
Chifra	40	3-Aprl
Nifas Mewecha	70	7-Aprl
Jinka	72.8	29-Aprl
Kibre Dehar	<u>230</u>	29-Aprl
Chifra	104.5 and 42	13,15 and 16-Mar
Kebri Dehar	44.3	17 and 19-Mar
Dalifagi	107.4	25-Mar

In 2023, a large number of hot days with Tmax exceeding 35 °C were mostly recorded in northeastern and western low land parts of the country during from February to May. The highest daily temperatures in 2023 were 35.4 °C, 35.5 °C recorded at Mille, Gewane, Awash Arba, Abobo, Dubti, Gambela, Gode and Fugnudi meteorological stations on belg season 2023, respectively.

In contrast, the country was cool during bega season 2023, especially over the northern and central highlands, where cold nights with temperatures lower than 10 °C were recorded.

3.6. Climate impacts over Ethiopia in 2023

In 2023, Ethiopia experienced severe flooding primarily due to heavy rainfall, which significantly impacted communities, particularly in the pastoral south. Reports have indicated that around 240,000 people were affected by these floods, with at least 29 fatalities recorded. The ongoing flooding complicated recovery efforts from previous droughts and has created further humanitarian challenges in the region.

Example in November 2023, heavy rainfall affected southern and eastern Ethiopia, in particular the Somali Region, causing floods, flash floods and the overflow of some rivers. Overall, the devastating El Niño induced floods have impacted 1.5 million individuals.

The drought situation in Ethiopia in 2023 has worsened significantly, particularly affecting parts of northern, southern, and southeastern regions. Continued deteriorating conditions are expected unless substantial aid is provided. Humanitarian reports indicate a challenging situation requiring urgent intervention to alleviate the impacts of the drought on the affected populations. Communities in southern and north-eastern parts of Ethiopia are suffering from a devastating drought following four consecutive failed rainy seasons since late 2020. This is the worst drought in forty years.

4. Conclusion

The country's average air temperature for 2023 was slightly warmer than the long term average for all months except bega season. On average, April, May and June were the warmest months of the year, while October and November 2023 was cooler than the long term average. In terms of rainfall, the year 2023 Rainfall deficiency was experienced during the JJAS rainy seasons, especially over the northern and northeastern parts of the country.

The existence of the observed SSTs over the global oceans had a large contribution to the weather and climate conditions that were observed over different parts of the country. The existence of EL NINO and Positive IOD in kiremt season largely associated with the rainfall deficit that was observed over the country, especially over the northern and north eastern parts of the country.

Moreover, extreme weather events, especially heavy rainfall accompanied by strong winds, were observed over many parts of the country during the year 2023. These events had significant impacts on the community.

Among others, it includes the loss of lives and properties, destructions to infrastructure, people's settlements, and the destruction of farm fields.

The impacts of extreme weather events that were experienced in different parts of the country could have been much reduced if the weather and climate forecasts, advisories, and warnings issued by EMI were closely followed and used by the public and different government sectors for decision-making in their day-today socio-economic activities.

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