ENACTS

ENHANCED NATIONAL CLIMATE SERVICES

El Niño-Southern Oscillation (ENSO) Temperature Probability Training

Training Module
Ethiopia
October 09, 2016
Version 1.0

International Research Institute for Climate and Society
EARTH INSTITUTE | COLUMBIA UNIVERSITY

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International Research Institute for Climate and Society (IRI), (2016). El Nino-Southern Oscillation (ENSO) Rainfall Probability Training - Ethiopia. October 09, Version 1.0. Palisades: IRI.

Acknowledgements

The ENACTS team, wishes to thank all the individuals and institutions that contributed in the many ways to the preparation of this manual. The shared technical knowledge, experiences, and perspectives have produced a training module that will have a significant positive impact on the capability of strengthening the ENACTS tools in various East African countries.

Special thanks are extended to the IRI staff members who collaborated in the preparation of the different manuals: Dr. Pietro Ceccato, Luz Cervantes, John delCorral, Dr. Tufa Dinku, Igor Khomyakov, Aisha Owusu, Yohana Tesfamariam Tekeste and Dr. Madeleine Thomson.

The preparation of this manual would not have been possible without the support provided by our donors WHO - Global Framework for Climate Services and UK DfID WISER ENACTS and we extend sincere appreciation to our donors.

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CHAPTER

ONE

EL NIÑO-SOUTHERN OSCILLATION (ENSO) TEMPERATURE PROBABILITY TRAINING - ETHIOPIA

1.1 El Niño-Southern Oscillation (ENSO) Impact in Africa

The climate impacts of El Niño (and its counterpart, La Niña) are not uniform across the world or within the African continent. The El Niño-Southern Oscillation (ENSO) phenomenon (both El Niño and La Niña) is today recognized as the most prominent mode of climate variability that operates on seasonal to yearly time scales (2-7 years) (Zebiak et al. 2014). Accounting for large swings in both oceanic and atmospheric conditions in the tropical Pacific region, it is closely associated with climate anomalies and related extremes, such as heat-waves, droughts and floods, throughout the globe (Figure 1.1). El Niño conditions in the Pacific typically prevail for 9-12 months or longer, starting around June and peaking between November and January. By the time El Niño (La Niña) has begun, there is a ramp up (down) of global temperatures, which are then slow to dissipate after the return to a neutral phase; because of this, the temperature response to ENSO phases is lagged by three months.

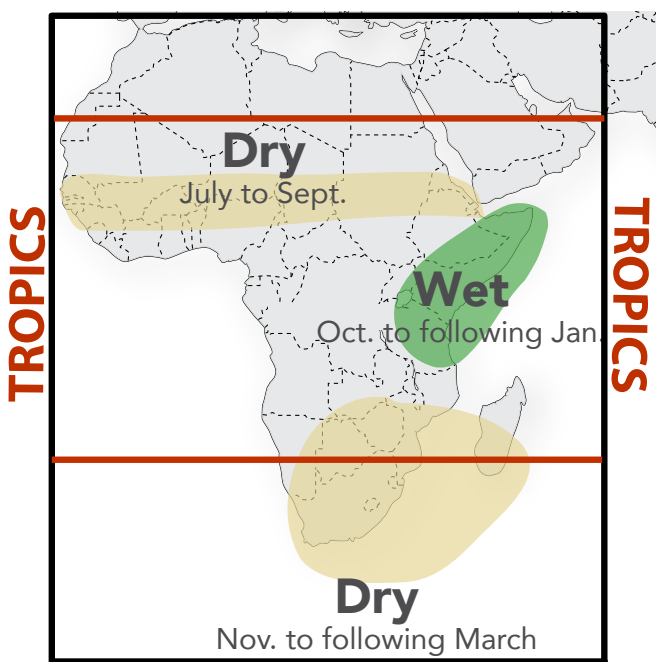


Fig. 1.1: El Niño and Temperature

The progress and strength of ENSO are routinely monitored through near-real-time ENSO observing systems, including satellite data and in situ measurements of atmospheric and oceanic temperatures (McPhaden et al. 1998). The local impact on temperature is, in part, determined by the rainfall response. In regions that experience unusually high

rainfall, minimum temperatures are likely to rise further (due to cloud cover) while the rise of maximum temperatures are moderated by heavy cloud cover during the daytime (Omumbo et al. 2011), refer to Figure 1.2.

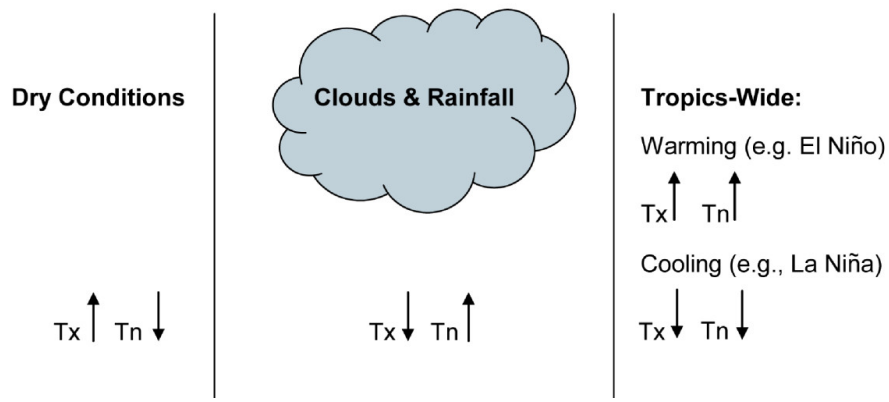


Fig. 1.2: Representation of the relationship between Tmax and Tmin with unusually dry conditions (left), rainy conditions (center) and in relation to tropics-wide warming or cooling associated with El Niño or La Niña (right).

At the local level, the impact of ENSO is best assessed using high quality historical data such as the temperature products available from the ENACTS database and Maprooms.

1.2 Overview

Why was it developed?

- The ENSO (El Niño and La Niña) Temperature Probability Mappages were initially created to help stakeholders identify whether or not temperature in their country, region, or district of interest was historically associated with ENSO. Where strong relationships exist, temperature is potentially predictable using ENSO informed seasonal climate forecasts in conjunction with climate analysis tools.

What can the ENSO Rainfall Probability Maproom be used for?

- Assessing the historical probability of temperature for a particular season and within a certain ENSO phase for a specific region or district
- Visualizing the spatial extent of ENSO climate impacts

What can the ENSO Temperature Probability Maproom NOT be used for?

- Providing information on the current ENSO event

1.3 Definition

ENSO temperature probability is calculated from the long-term average (1981-2010) of monthly rainfall from the ENACTS rainfall database, then and classified according to ENSO state (El Niño, La Niña, Neutral).

The ENSO state for each season is defined according to the Oceanic Niño Index (ONI). It is calculated using Sea Surface Temperature (SST) anomalies, based on the 1981-2010 normal, in the geographical box (170°W, 5°S, 120°W, 5°N). A season is considered El Niño (La Niña) if it is part of at least 5 consecutive overlapping 3-month long seasons where the ONI is above 0.45°C (below -0.45°C).

1.4 Interpretation

Figure 1.4 is an example of the historical probability (given in percentile) of seasonal average monthly monthly minimum or maximum temperature falling within the upper (hot), middle (normal), or bottom (cold) one-third ("tercile") of the 1981-2014 historical distribution in Ethiopia given the state of ENSO (El Niño, Neutral, La Niña) during the previous season (e.g. Jan-Mar temperature against Oct-Dec ENSO state). Please note that this is not a forecast.

And also please note that when interpreting the graph, each tick represents the beginning of the year (look at Figure 1.3).

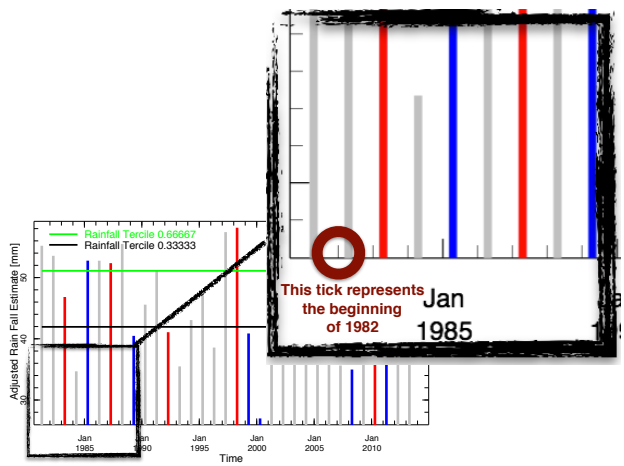


Fig. 1.3: Explanation on the ticks: Each tick on the time axis (x-axis), marks the beginning of the respective year

1.5 Access

The ENSO Rainfall Mapage can be accessed via the Climate Forecast Maproom. http://map.meteoRwanda.mg/maproom/Climatology/Climate_Forecast/ENSO_Prob_Precip.html

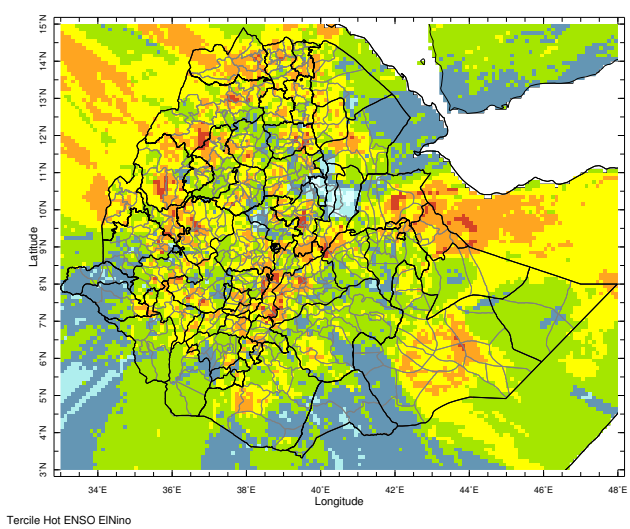


Fig. 1.4: Ethiopia ENSO Minimum Temperature Probability for MAM Season and El Niño

The Maproom allows you to create an analysis by 3-month period (e.g. Jan-Mar), ENSO state (El Niño, La Niña and Neutral), and temperature outcome/tercile (hot, normal, cold).

1.6 Case Study - Ethiopia

The Ethiopian climate is extremely variable and complex. The Ethiopian temperature is sensitive to global climate drivers as well as the regional complexity of its climate which is influenced both by regimes found in equatorial eastern African and those associated with the Sahel (Seleshi and Demaree 1995; Nicholson 1996; Korecha and Barnston 2007; Lyon 2014).

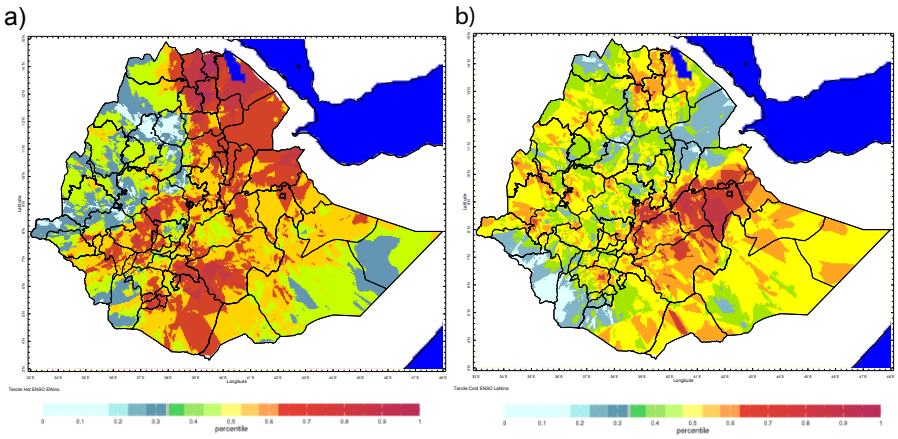


Fig. 1.5: Historical probability of seasonal monthly averages of minimum temperature conditioned on El Niño (a) and La Niña in Ethiopia (b). a) hot in Oct-Dec b) cold in Oct-Dec

The high resolution ENACTS temperature database has been used to help determine and associate where and when ENSO impacts temperature in Ethiopia, as seen in Figure 1.5. However, due to the relative short time series of 1981-2010 and the relatively few ENSO events, it should be noted that the relationships observed may not be statistically significant.

1.6.1 Examples

Figure 1.6 displays the historical impact of ENSO on minimum temperature via a bar graph product generated after setting the analysis criteria to the following: (1) Region: Ethiopia; (2) Variables: tmin (3) Spatially Average Over: Zone, South Wollo, Amhara, Ethiopia; (4) Season: Mar-May; (5) Tercile: hot; and (6) ENSO State: El Niño.

As can be seen, this zone has a strong historical tendency for below normal to normal minimum temperature during El Niño events (lower tercile/below normal is below black line) and a propensity for above normal minimum temperature during La Nina events (upper tercile/above normal is above green line). Also, in South Wollo it can be seen that the strong El Niño of 1997 was associated with a July-September drought due to below normal rainfall.

Figure 1.7 displays the historical impact of ENSO on rainfall via a bar graph product generated after setting the analysis criteria to the following: (1) Region: Ethiopia; (2) Variable: tmin; (3) Spatially Average Over: Zone,Borona, Oromia; (4) Season: Oct-Dec; (5) Tercile: Hot; and (6) ENSO State: El Niño.

As can be seen, this zone was heavily impacted by the 1997/8 El Niño with extreme, above-normal minimum temperature. Furthermore, Borena has a tendency to have above normal minimim temperature during many El Niño years. However, there are notable El Niño years when the minimum temperature was normal or below normal.

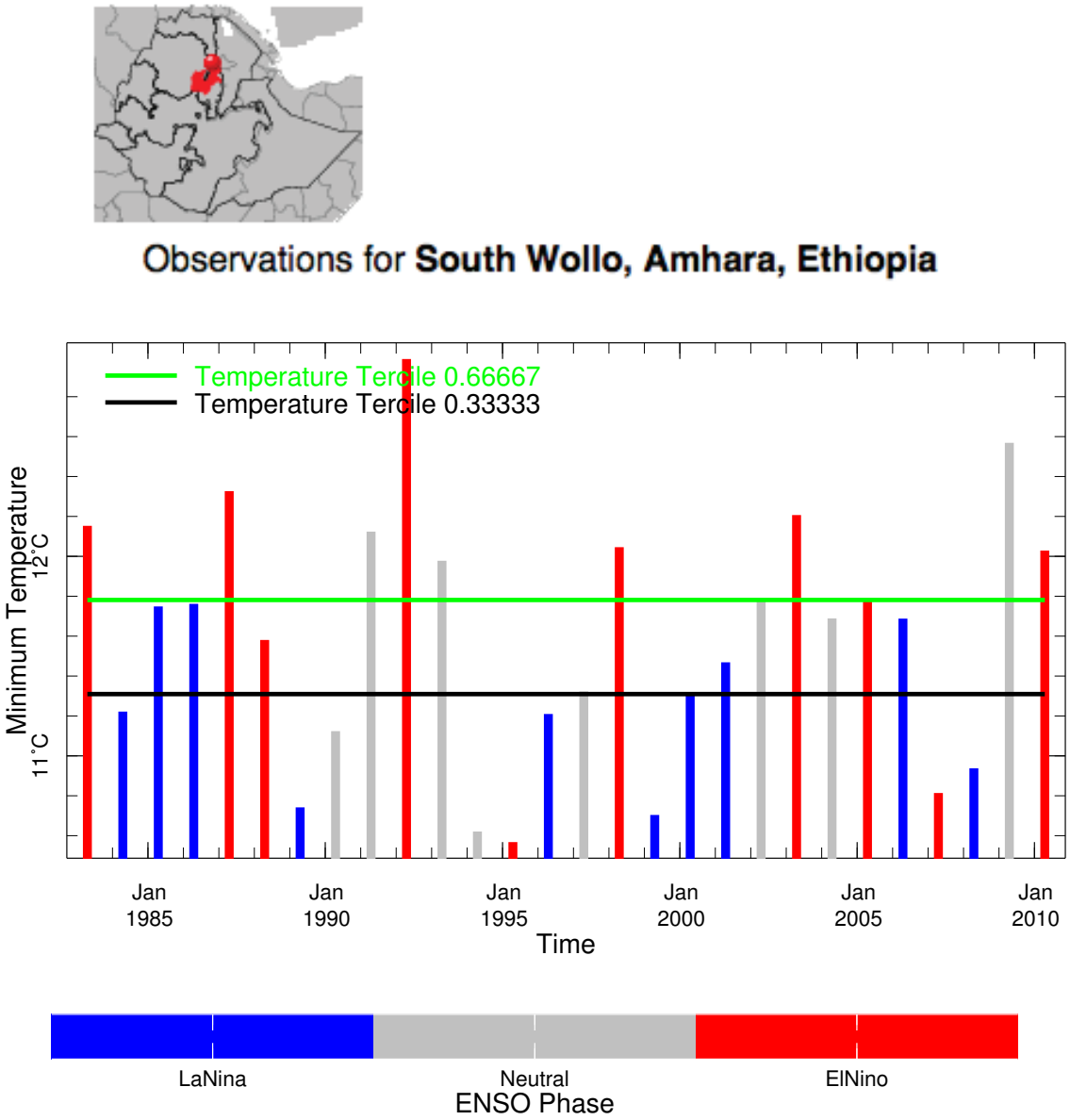


Fig. 1.6: March - May Minimum Temperature Conditioned on El Niño

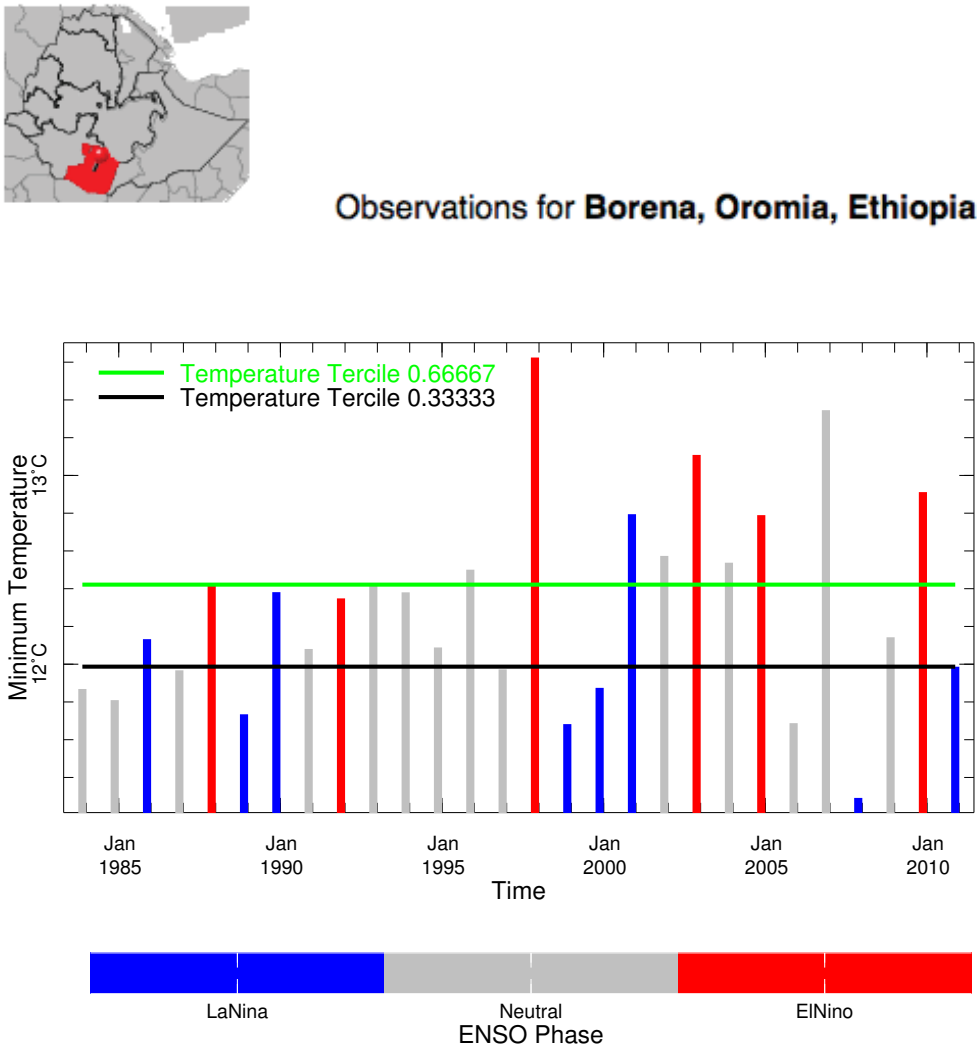


Fig. 1.7: October – December Minimum Temperature Conditioned on El Niño

1.6.2 Case Study Summary

In Ethiopia, the relationship between ENSO and temperature is significant and varies according to season and region. The unusually high temperatures that occur across the tropics during and immediately following an El Niño event pose a significant risk for malaria in Ethiopia.

Because ENSO has a strong impact on the magnitude and duration on temperature in some seasons and regions, there is the possibility to develop robust and skillful seasonal climate forecasts that may predict the extent of the temperature several months in advance. These forecasts may be able to help decision-makers in a number of sectors including agriculture, health, water, energy, disasters etc.

1.7 Exercise - Ethiopia

Ethiopia has five complex geographical regions: the west coast, the southwest, the central highlands, the Tsaratanana Massif, the central highlands, and the east coast. The highest elevations line the east coast.

Ethiopia has two seasons: (1) a warm, wet season from Nov-April, peaking Dec-Feb and (2) a cooler, dry season from May-Oct. There is, however, great variation in climate owing to elevation and position relative to dominant winds. The east coast has an equatorial climate; being most directly exposed to the trade winds it has the highest rainfall, averaging as high as 4,000 mm annually in some places depending on elevation.

Please perform the following exercises:

E1. Proceed to the ENSO Temperature Probability Mapage within Rwanda's Climate Forecast Maproom, and set the analysis tool bar to the categories in Figure 1.8. (1) Region: Ethiopia; (2) Variable: tmin (3) Spatially Average Over: Region; (4) Season: Oct - Dec; (5) Tercile: Hot; and (6) ENSO State: El Niño.

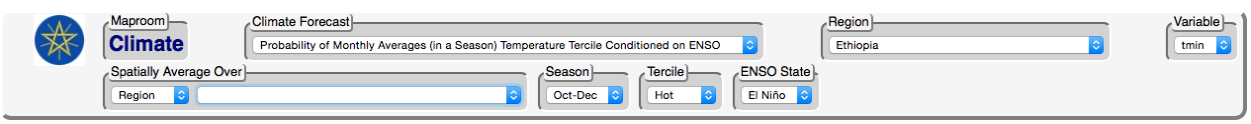


Fig. 1.8: Control Bar Settings for ENSO Temperature Probability

E2. Now, generate the time series, bar graph for the following Regions: (1)Afar, (2) Tigray , (3) Ormonia , (4) Amhara and (5) Somali .

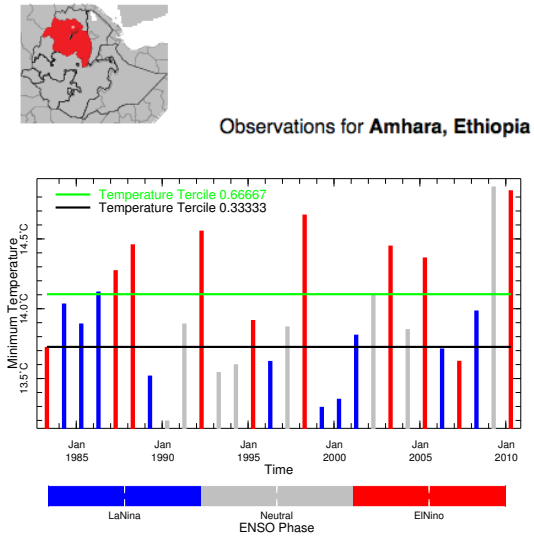
E3. For each region, indicate the number of years for the categories in the table below (Figure 1.9). Please note that in the below table and within the time series, bar graph, hot=above normal=above rainfall tercile 0.66667 (green) and cold=below normal=below temperature tercile 0.33333 (black).

Region	Above Normal	Normal	Below Normal
XXX			
El Nino			
Neutral			
La Nina			

Fig. 1.9: ENSO Phase and Tercile Category Table

1.7.1 Example - Amhara Region

See Figure 1.10 found on the next page.



Region	Above Normal	Normal	Below Normal
Amhara			
El Nino	7	2	1
Neutral	2	3	3
La Nina	1	4	5

Fig. 1.10: Time Series Bar Graph and Completed Table for Afar Region (Minimum Temperature variable and for OND season)

1.8 Quiz

Please answer the following questions using the ENSO Temperature Probability Mapage, and figures and tables generated in the previous exercise

Q1. In the Oromia Region of Ethiopia, which season has an increased possibility to have a minimum temperature in above normal conditions during an El Niño? (a) October - December (OND) (b) March - May (MAM)

Q2. What year(s) (if any) was consistently with highest minimum temperature, for all provinces examined for Oct-Dec (OND) and associated with El Niño?

Q3. Which province(s) had the highest, above-normal minimum temperature associated with El Niño for OND?

Q4. How is maximum temperature associated with El Niño events in Ethiopia OND and MAM as compared to minimum temperature? (a) It Increases as well (b) It Decreases (c) It is not affected by El Niño

1.8.1 Quiz - Answers

A1. October - December (OND)

A2. 1997

A3. Easter Province

A4. (a) It Increases as well

1.9 Summary

ENSO impacts the climate of Ethiopia during Nov-April rainy season and in regions which experience the peak in Dec-Feb. During El Niño the minimum and maximum temperature tend to increase whereas during La Nina they

decrease.

1.10 Reference(s)

- Kousky, V. E. and Higgins, R. W. (2007). An Alert Classification

System for Monitoring and Assessing the ENSO Cycle. Wea. Forecasting, 22, 353-371. doi: http://dx.doi.org/10.1175/WAF987.1