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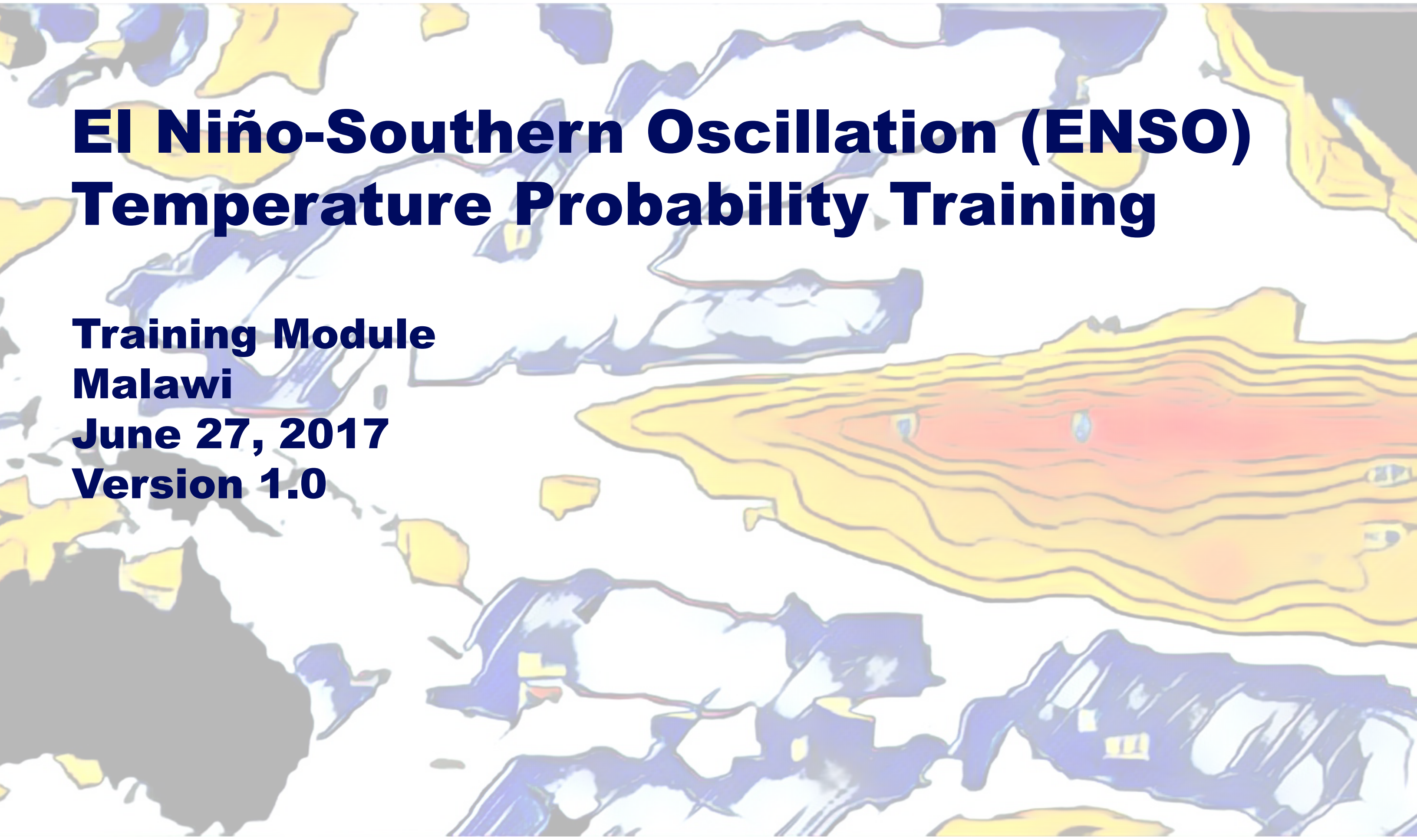

El Niño-Southern Oscillation (ENSO) Temperature Probability Training

Training Module
Malawi
June 27, 2017
Version 1.0

International Research Institute for Climate and Society
Earth Institute | Columbia University

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CHAPTER

ONE

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

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. 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.

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.

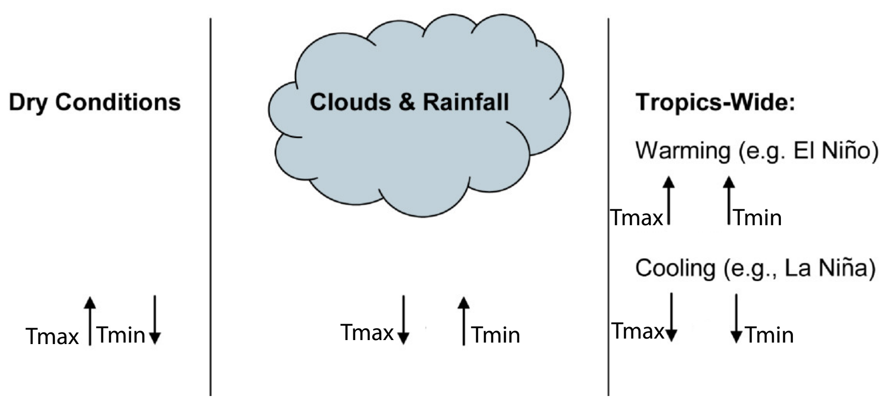


Fig. 1.1: Representation of the relationship between Tmax and Tmin with unusually dry conditions (left), rainy conditions (center) and in relation to tropics-wide warming or cooling associated with El Niño or La Niña (right).

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 Temperature 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 (2003-2015) of monthly temperature from the global products' temperature 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 2003-2015 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 2003-2015 historical distribution in Malawi 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).

1.5 Access

The ENSO Rainfall Mapage can be accessed via the Climate Forecast Maproom. http://datalib.metmalawi.com:8091/maproom/Climatology/Climate_Forecast/ENSO_Prob_Temp.html

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).

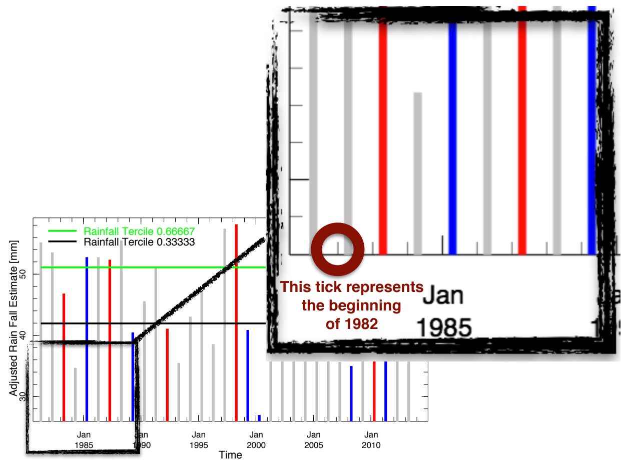


Fig. 1.2: Explanation on the ticks: Each tick on the time axis (x-axis), marks the beginning of the respective year

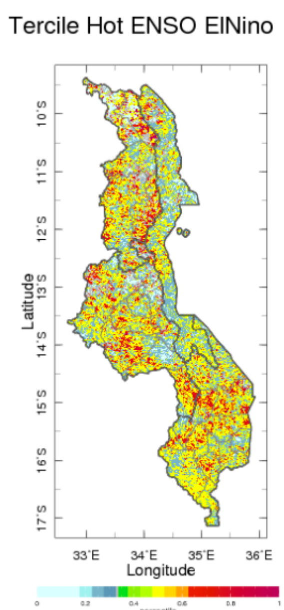


Fig. 1.3: Malawi ENSO Minimum Temperature Probability for DJF season and El Niño

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).

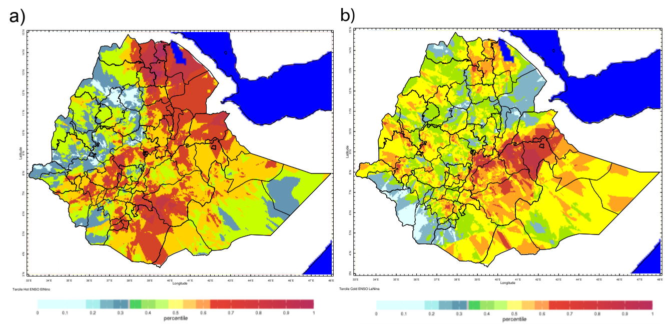


Fig. 1.4: Historical probability of seasonal monthly averages of minimum temperature conditioned on El Niño (a) and La Niña in Ethiopia (b). a) hot in Oct-Dec b) cold in Oct-Dec

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: ; (4) Season: Dec-Feb; (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: Chitipa district; (4) Season: Jul-Sep; (5) Tercile: Hot; and (6) ENSO State: 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.

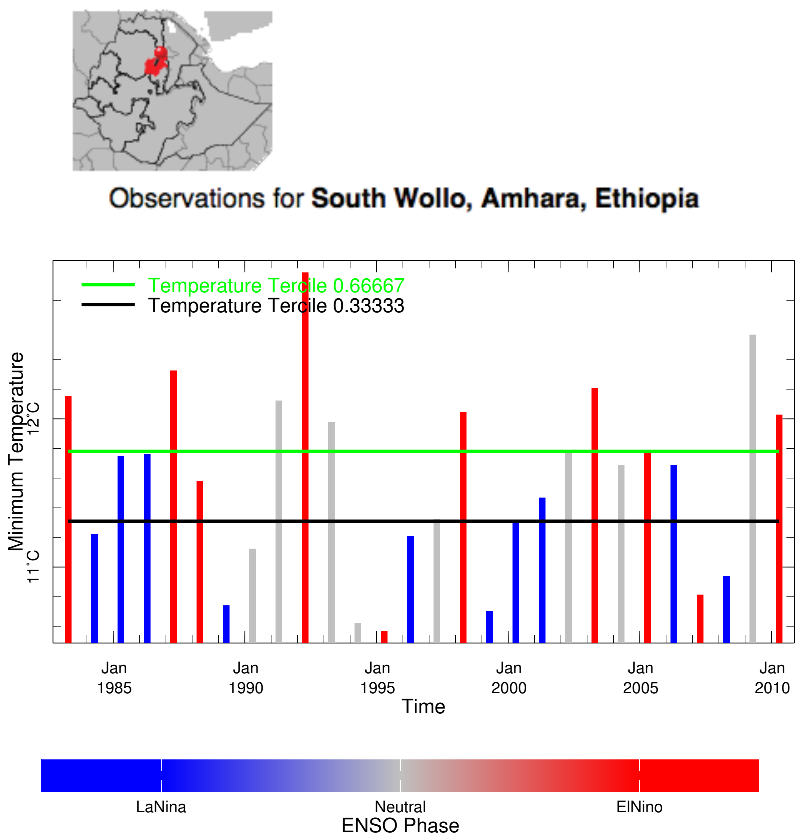


Fig. 1.5: March - May Minimum Temperature Conditioned on El Niño

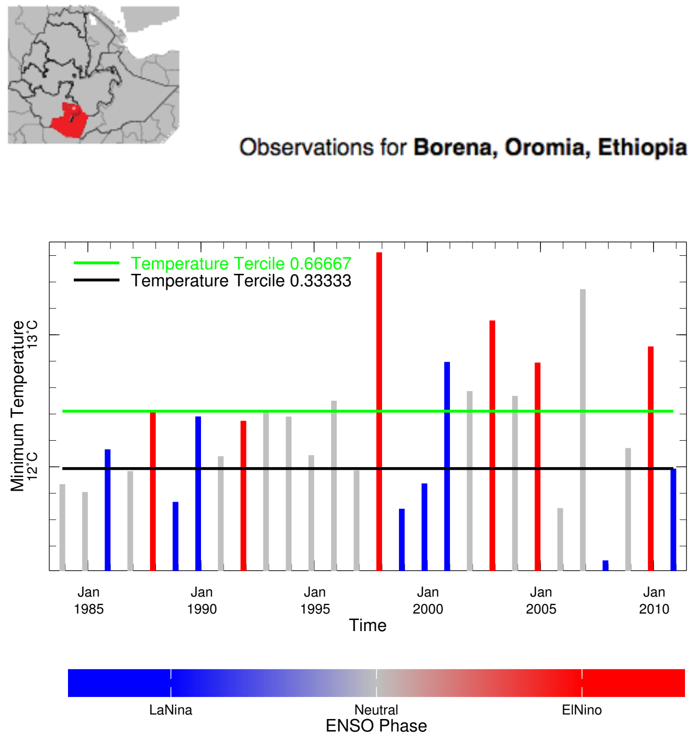


Fig. 1.6: July - August Minimum Temperature Conditioned on El Niño

1.7 Exercise - Malawi

Malawi has a sub-tropical climate, which makes it relatively dry as well as strongly seasonal. The warm-wet season takes place from November to April, it is in this time that 95% of the annual precipitation takes place.

Please perform the following exercises:

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

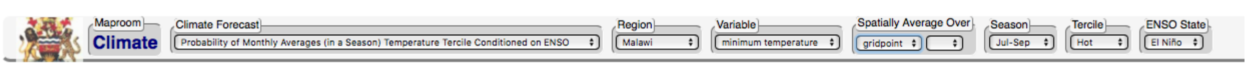


Fig. 1.7: Control Bar Settings for ENSO Temperature Probability

E2. Now, generate the time series, bar graph for the following Districts: (1) Chitipa, (2) Karonga , (3) Balaka , (4) Dowa and (5) Area Under National Administration

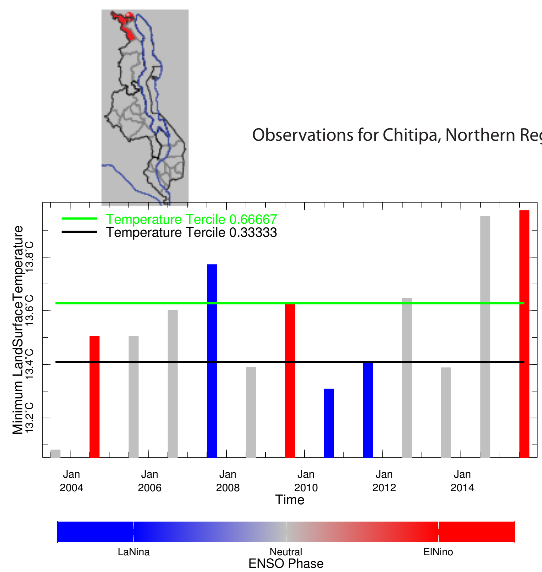
E3. For each region, indicate the number of years for the categories in the table below (Figure 1.9). Please note that in the below table and within the time series, bar graph, hot=above normal=above rainfall tercile 0.66667 (green) and cold=below normal=below temperature tercile 0.33333 (black).

1.7.1 Example - Chitipa Region

See Figure 1.10 found on the next page.

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

Fig. 1.8: ENSO Phase and Tercile Category Table



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

Fig. 1.9: Time Series Bar Graph and Completed Table for Chitipa District (Minimum Temperature variable and for JAS 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 Chitipa District of Malawi, which season has an increased possibility to have a minimum temperature in above normal conditions during an El Niño? (a) Jul-Sep (JAS) (b) Nov-Jan (NDJ)

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

Q3. Which district(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. 2015

A3. It is hard to conclude due to the limited amount of data available (from 2003 to 2015)

A4. (a) It Increases as well

1.9 Summary

ENSO impacts the climate of Malawi mainly during the JAS season but due to the limited data it is hard to make any conclusions. 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