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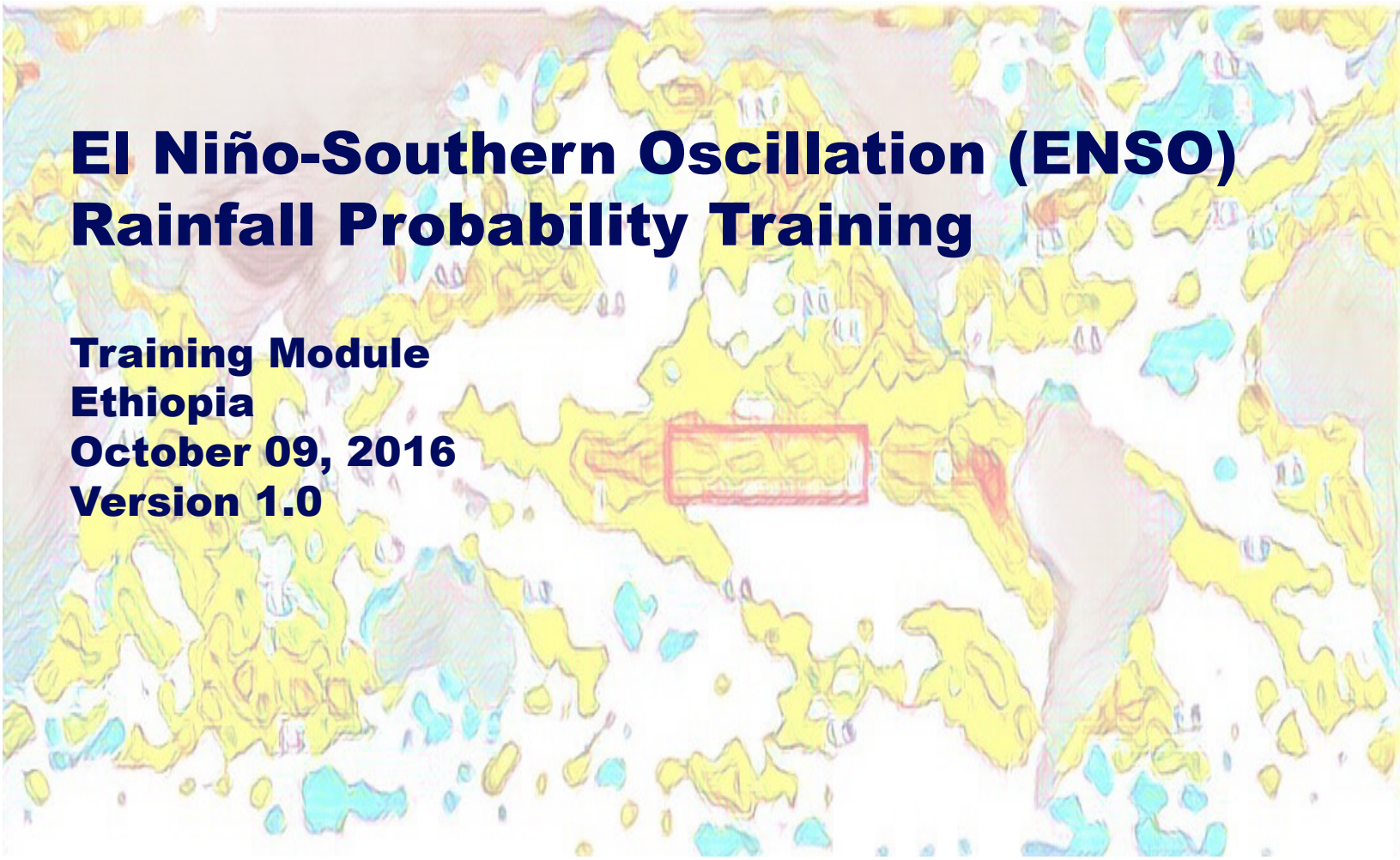

El Niño-Southern Oscillation (ENSO) Rainfall Probability Training

Training Module
Ethiopia
October 09, 2016
Version 1.0

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

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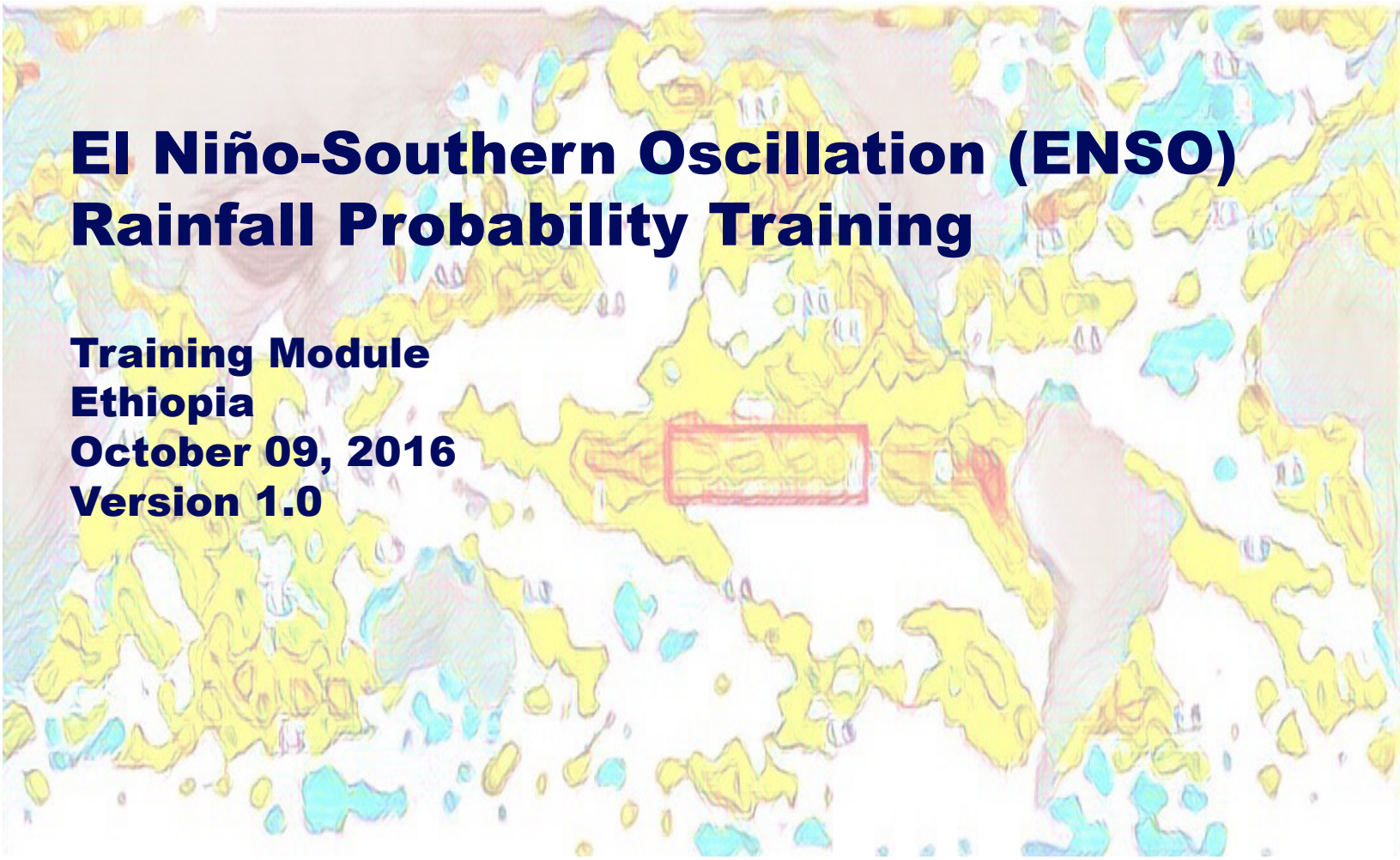

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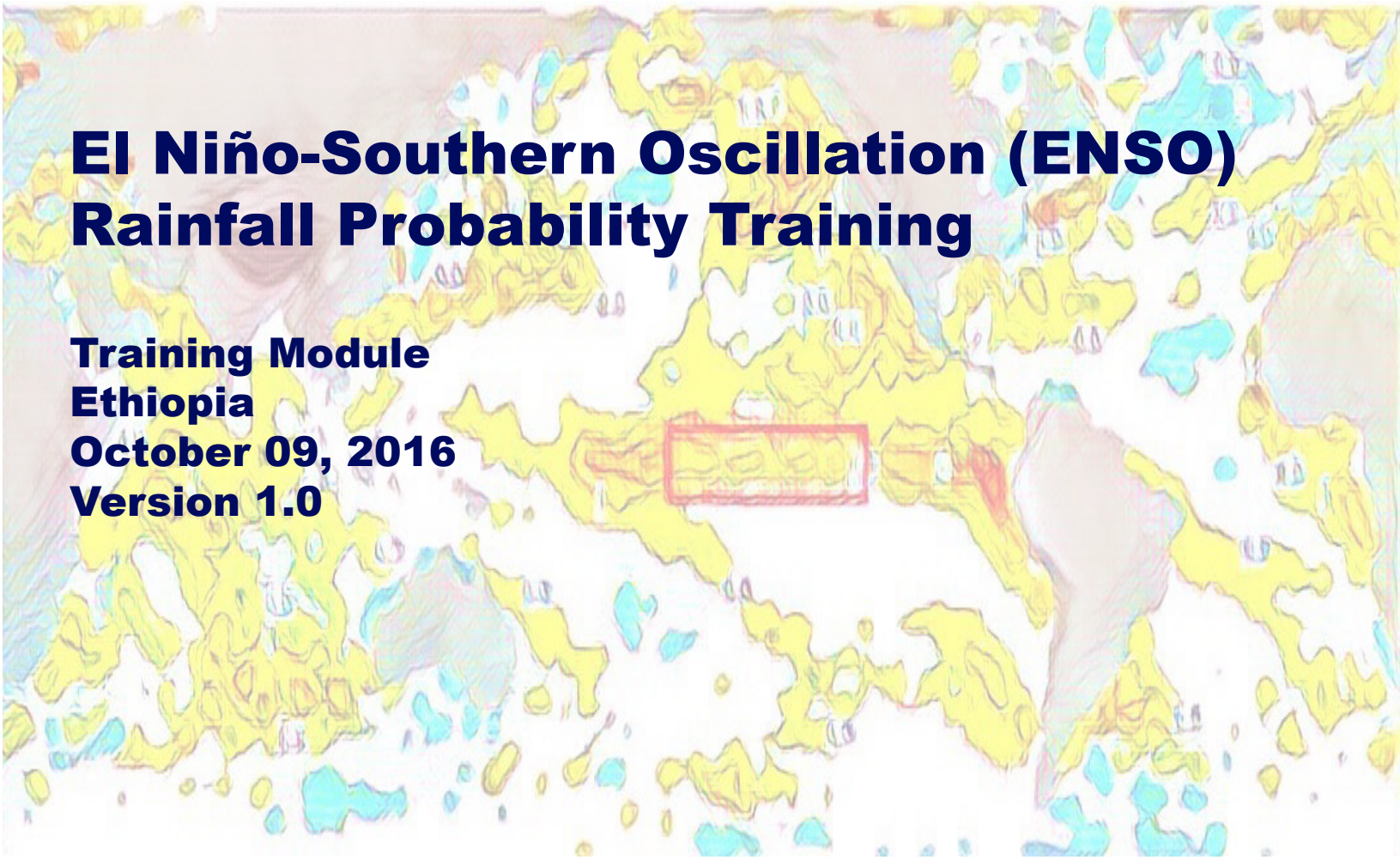

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Acknowledgements

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.

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CHAPTER

ONE

EL NIÑO-SOUTHERN OSCILLATION (ENSO) RAINFALL 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. And similar to other parts of the world, the impacts of El Niño or La Niña on rainfall in Africa also vary according to location and season (please refer to Figures 1.1 and 1.2). When sea surface temperatures in the Niño 3.4 region of the equatorial Pacific are unusually high, Southern and Western Africa have a tendency to be anomalously dry during the primary rainy season of November - February. Additionally, Northeastern Africa generally becomes anomalously dry during its primary and longer rainy season of June - September. The converse is true in these regions during La Niña years.

However, Eastern Africa is different. When an El Niño is underway in this region, the climate has a substantially increased probability of being unusually wet during the secondary and shorter rainy season of October - December, whereas the region's primary and longer rainy season, March - May, is largely unaffected.

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

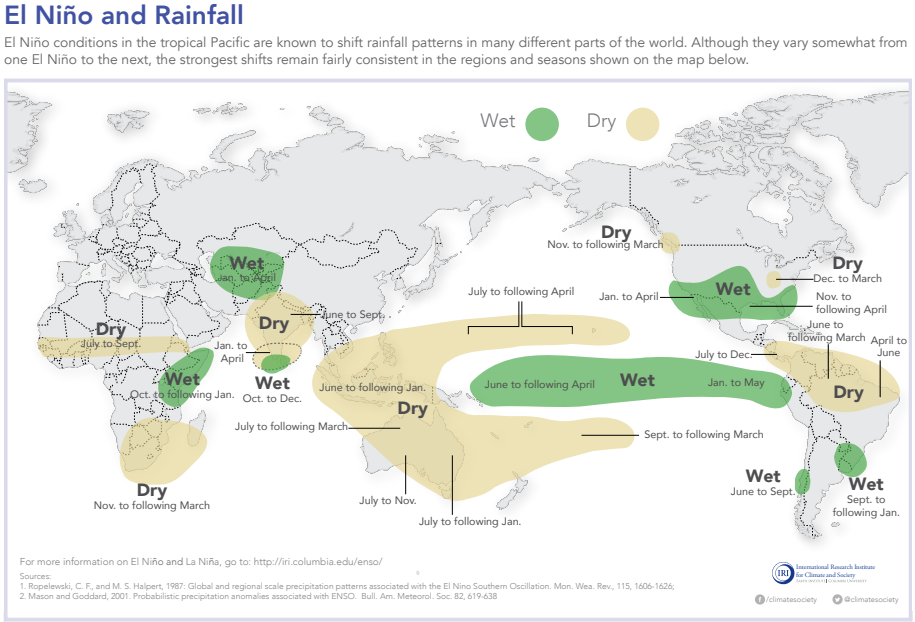


Fig. 1.1: El Niño and Rainfall

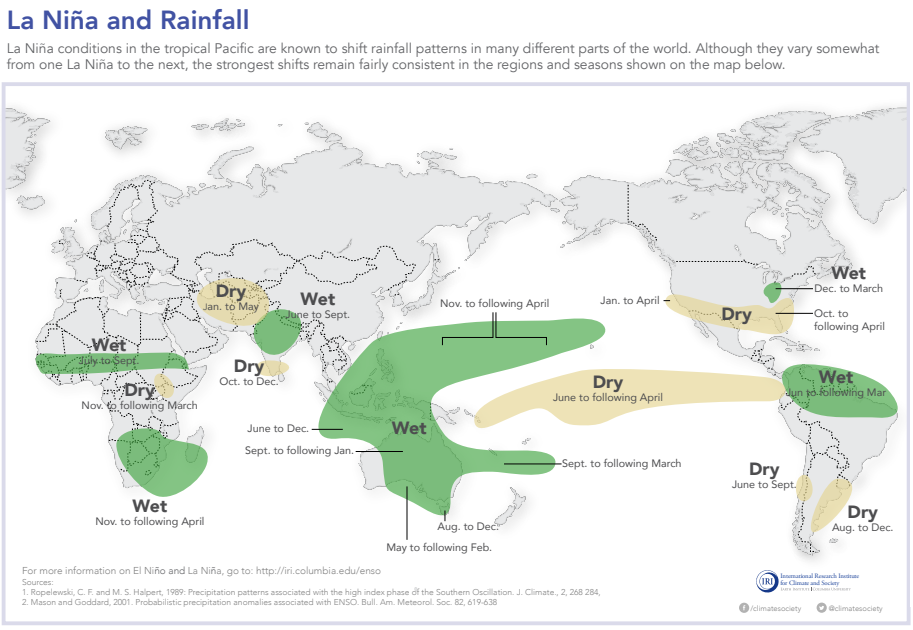


Fig. 1.2: La Niña and Rainfall

1.2 Overview

Why was it developed?

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

What can the ENSO Rainfall Probability Maproom be used for?

- Assessing the historical probability of rainfall 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 Rainfall Probability Maproom NOT be used for?

- Providing information on the current ENSO event although, curent events may have the characteristics of past events

1.3 Definition

ENSO rainfall 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 of seasonal average monthly rainfall product conditioned on El Niño during the July-August-September season, and falling within the upper (wet) one-third ("tercile") of the 1983-2010 historical distribution in rainfall for Ethiopia. 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).

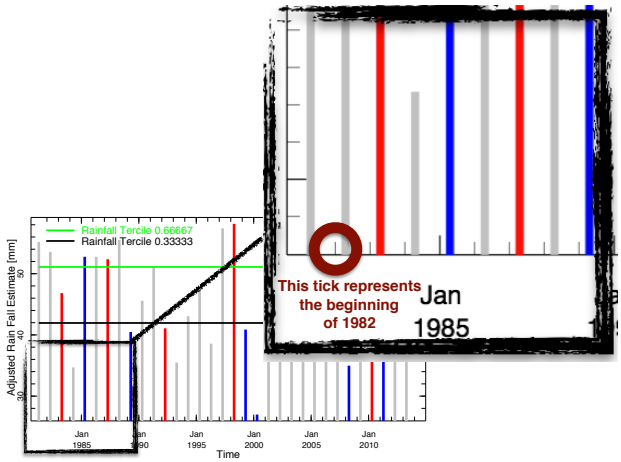


Fig. 1.3: Explanation on the ticks: Each tick on the time axis (x-axis), marks the beginning of the respective year

1.5 Access

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

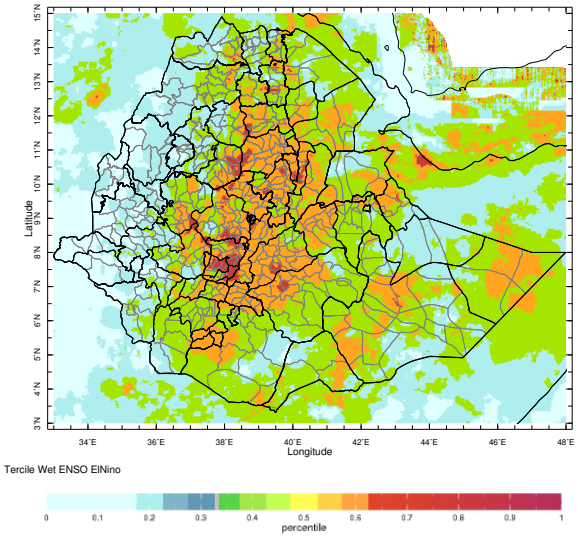


Fig. 1.4: Ethiopia ENSO Rainfall Forecast Maproom for March April May (MAM) season

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 rainfall outcome/tercile (wet, normal or dry).

1.6 Case Study - Ethiopia

The Ethiopian climate is extremely variable and complex. Annual rainfall characteristics of Ethiopia are classified into three distinct rainy seasons: (1) the longer, primary season (Jun–Sep: JJAS); (2) the shorter, secondary season (Feb–May FMAM); and (3) the dry season (Oct–Jan: ONDJ). The first season corresponds with the Sahelian rainy season (JAS); whereas, the last two seasons correspond with the main East African seasons (MAM and OND). The seasons are locally defined as Kiremt, Belg, and Bega and respectively. Because Ethiopia's climate is the most complex topography on the African continent, precise delineation of distinct regions and rainy seasons are difficult as the climate varies significantly within a short distance.

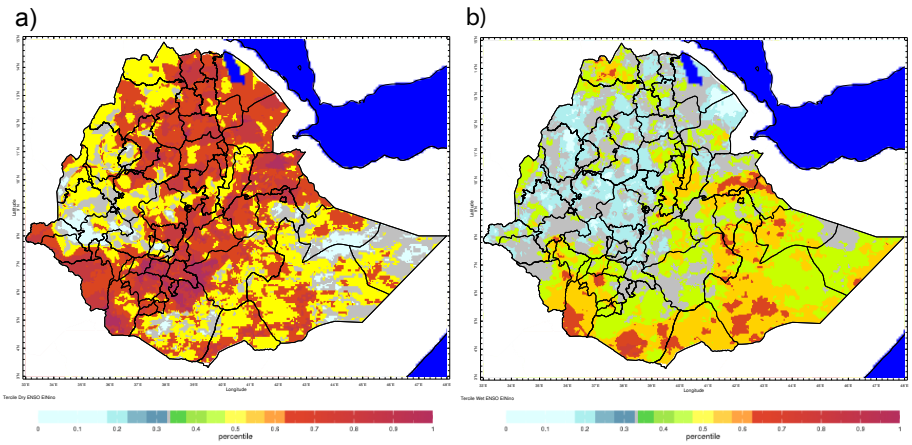


Fig. 1.5: Historical probability of seasonal monthly averages of rainfall conditioned on El Niño in Ethiopia a) low and dry in Jul-Sep (b) high and wet in Oct-Dec

The high resolution ENACTS rainfall database has been used to help determine and associate where and when ENSO impacts rainfall in Ethiopia, as seen in Figure 1.5. However, due to the relative short time series of 1983-2010 and the relatively few ENSO events, it should be noted that the relationships observed may not always be statistically significant.

1.6.1 Examples

Figure 1.6 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) Spatially Average Over: Zone, South Wollo, Amhara, Ethiopia; (3) Season: Jul-Sept; (4)Tercile: Dry; and (5)ENSO State: El Niño.

As can be seen, this zone has a strong historical tendency for below normal to normal rainfall during El Niño events (lower tercile/below normal is below black line) and a propensity for above normal rainfall 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 severe July-September drought.

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) Spatially Average Over: Zone, Borena, Oromia, Ethiopia; (3) Season: Oct-Dec; (4) Tercile: Wet; and (5) ENSO State: El Niño.

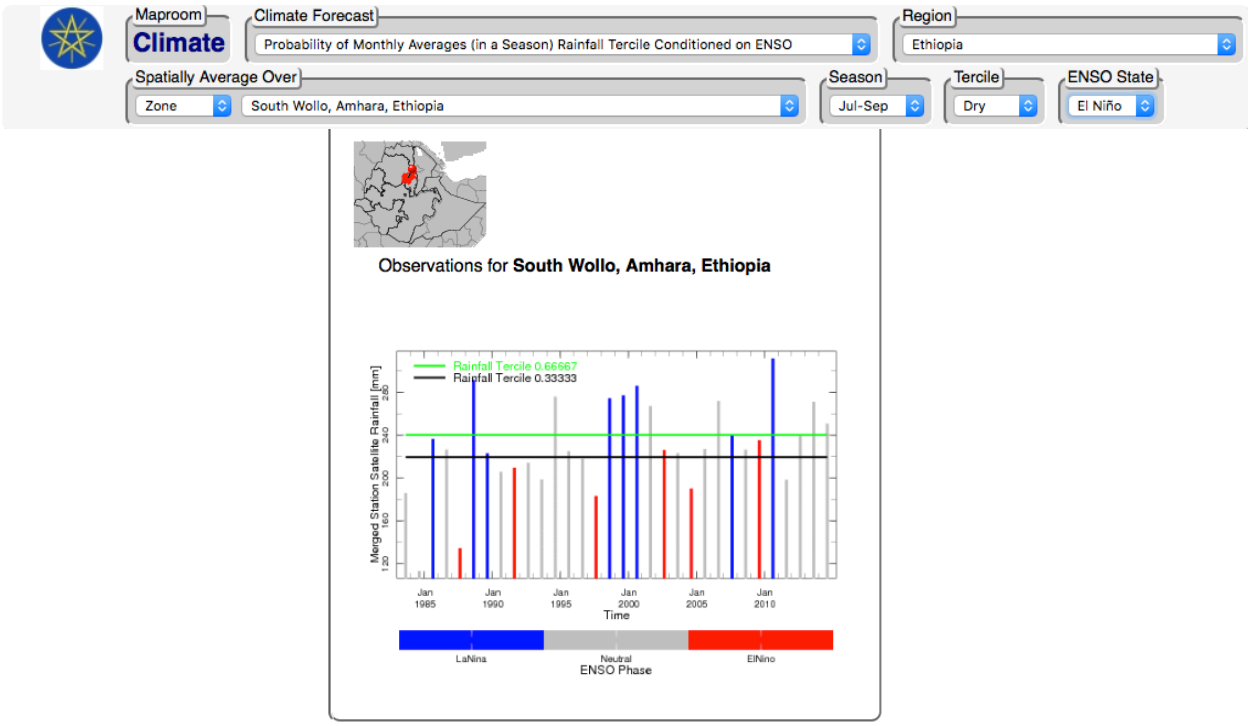


Fig. 1.6: July – September Rainfall Conditioned on El Niño

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

1.6.2 Case Study Summary

In Ethiopia, the relationship between ENSO and rainfall is significant and varies according to season and region. El Niño years are often associated with major droughts during the July-September primary, rainy season across the central and northern regions of the country, often resulting in food insecurity.

These droughts may then be followed by unseasonal and above normal rains in the southern part of the country that are associated with El Niño impacts on the shorter rainy season of Eastern Africa.

Because ENSO has a strong impact on the magnitude and duration on rains in some seasons and regions, there is the possibility to develop robust and skillful seasonal climate forecasts that may predict the extent of the rains 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. Because rain clouds discharge much

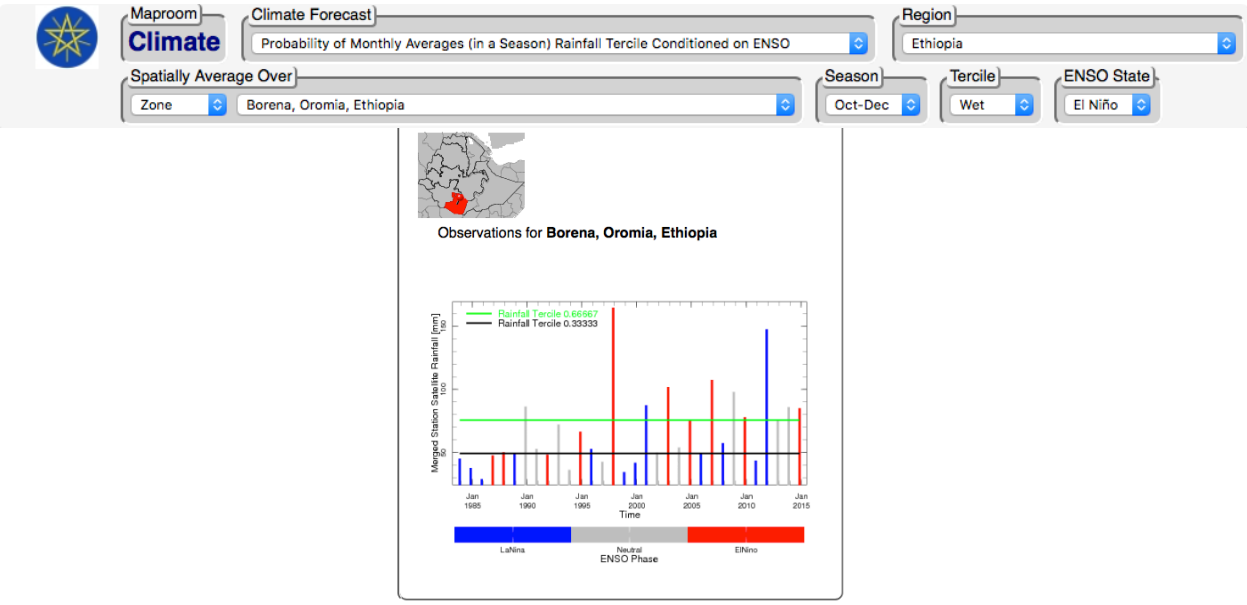


Fig. 1.7: October – December Rainfall Conditioned on El Niño

of their moisture east of the highest elevations on the island, the central highlands are drier and, owing to the altitude, also cooler.

Please perform the following exercises:

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

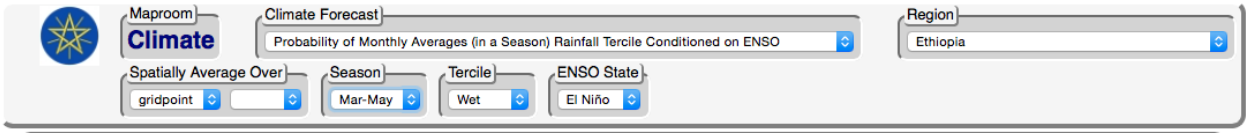


Fig. 1.8: Control Bar Settings for ENSO Rainfall Probability

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

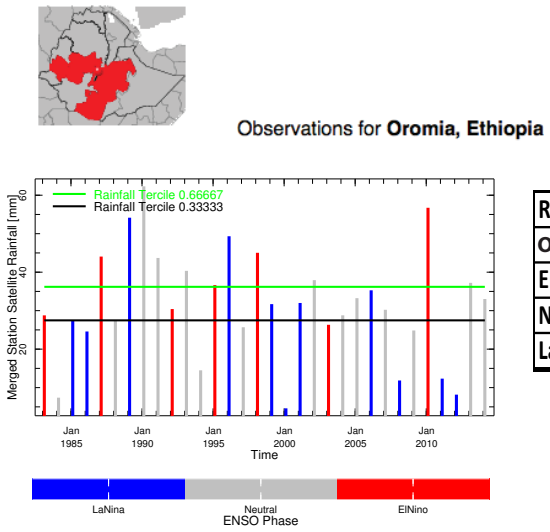
E3. For each region, indicate the number of years for the categories in the table below (Figure 1.9). Please note that in the below table and within the time series, bar graph, wet=above normal=above rainfall tercile 0.66667 (green) and dry=below normal=below rainfall tercile 0.33333 (black).

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 - Oromia Region

See Figure 1.10 found on the next page.



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

Fig. 1.10: Time Series Bar Graph and Completed Table for Oromia Region

1.8 Quiz

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

Q1. Which rainy season has an increased possibility to be wetter than normal during an El Niño? (a) October-December (b) March-May

Q2. What year(s) (if any) was consistently the wettest for all regions examined for Oct-Dec (OND) and associated with El Niño?

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

1.8.1 Quiz - Answers

A1. October-December

A2. 1998, 2003, 2007 and 2015

A3. Somali region

1.9 Summary

ENSO impacts the climate of Ethiopia during the Nov-April rainy season and in regions which experience the peak rains in Dec-Feb, especially within the north/northeastern region. During El Niño the rains tend to increase whereas

during La Nina they decrease. Temperatures are also affected by El Niño and La Niña.

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