ENACTS

ENHANCED NATIONAL CLIMATE SERVICES

Indian Ocean Dipole (IOD) Rainfall Probability Training

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

Tanzania Meteorological Agency
Mamlaka ya Hali ya Hewa Tanzania

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CHAPTER

ONE

INDIAN OCEAN DIPOLE (IOD) RAINFALL PROBABILITY TRAINING - TANZANIA

1.1 Indian Ocean Dipole (IOD) Impact in Eastern Africa

Across much of Eastern Africa, the annual cycle of rainfall tends to bi-modal, with rainy seasons in Oct-Dec (the short rains) and Mar-May (the long rains). Year-to-year variability of the short rains is frequently associated with ENSO (Mason and Goddard 2001) but this connection depends critically on sea surface temperatures in the Indian Ocean, not just the Pacific. El Niño is typically associated with wetter than average conditions while La Nina is frequently associated with drought in short (October, November December; OND) rainy season. An Indian Ocean dipole (IOD; its positive phase manifest as warmer than average SSTs in the west tropical Indian Ocean and cooler than average SSTs in the east tropical Indian Ocean) is also associated with enhanced short rains; its opposite phase with drier than average conditions. The IOD has been associated with changes in malaria risk in Kenya (Masahiro Hashizume. et al. 2009) but its occurrence is often (although not always) linked to ENSO. Variability of the long rains (MAM) does not exhibit any consistent and robust relationship to either ENSO or the IOD on the seasonal time scale (Lyon and DeWitt 2012). Thus it is observed that the two rainy seasons in East Africa act independently and there is no statistically significant temporal correlation between rainfall totals in these two seasons (Lyon 2014).

1.2 Overview

Why was it developed?

- The (IOD) Indian Ocean Dipole 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 IOD. Where strong relationships exist, rainfall is potentially predictable using IOD informed seasonal climate forecasts.

What can the IOD Rainfall Probability Maproom be used for?

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

What can the IOD Rainfall Probability Maproom NOT be used for?

- Providing information on the current IOD event

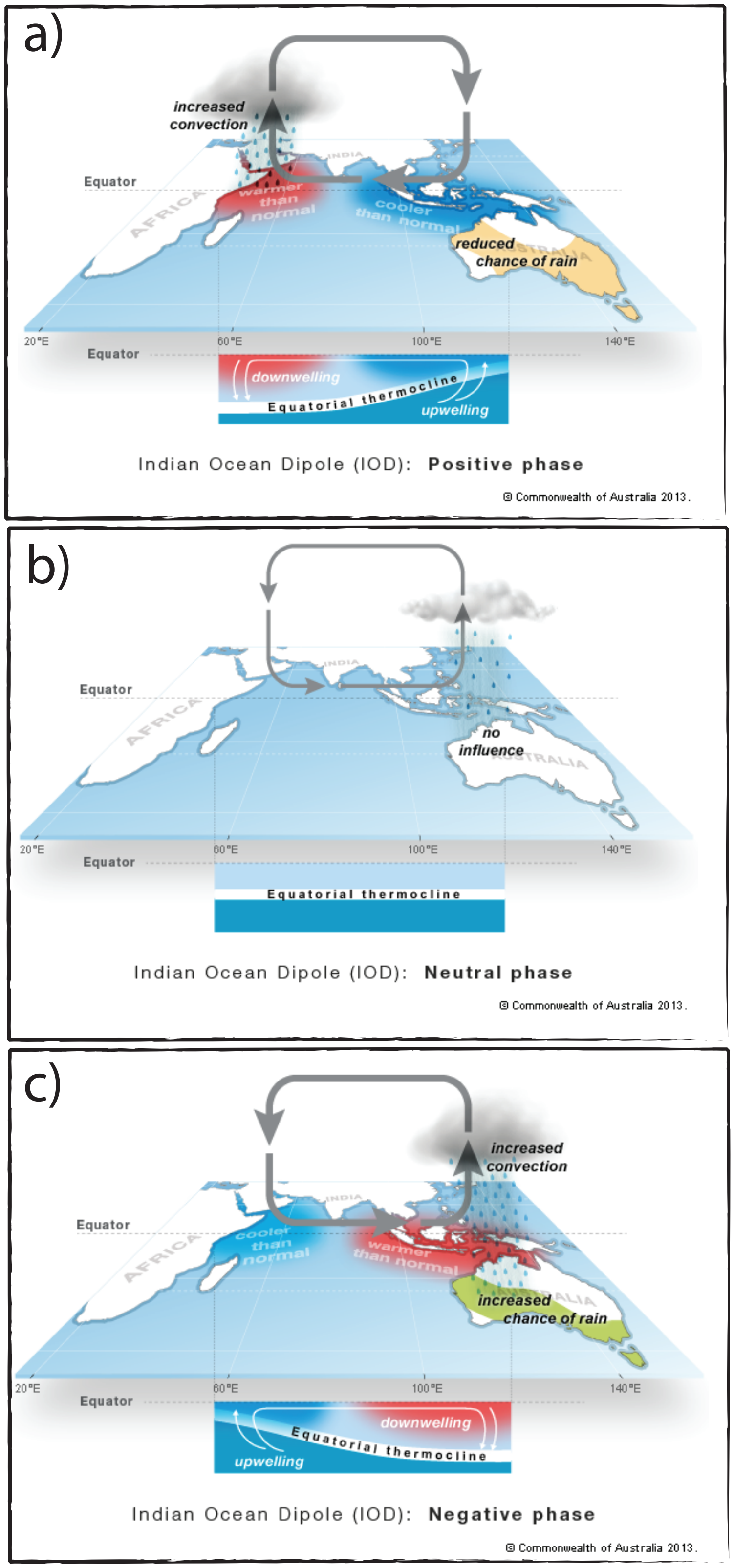


Fig. 1.1: Positive IOD (a), Neutral IOD (b) and Negative IOD (c) [1]

1.3 Definition

The IOD is defined as the difference between SST anomalies of a West box average (50E-70E, 10S-10N) and an East box average (90E-110E, 10S-0N). Anomalies are computed for and with respect to the period of rainfall data availability (1983-2014). The IOD is categorized in 3 Tercile classes and the positive tercile indicates warmer SST conditions in the West compared to the East.

Clicking on the map will then display, for the selected point, yearly seasonal rainfall averages time series. The colors of the bars depict what IOD Tercile it was that year, and the horizontal lines show the historical terciles limits. This allows to quickly picture what years fell into what IOD Tercile and into what Rainfall Tercile category.

While the IOD is often referred to as a distinct feature of climate variability, a similar pattern of sea surface temperature variations on the Indian Ocean often occurs as a response to ENSO in the Pacific Ocean. That is, the two phenomena are often related. As a result, one should expect similar impacts of El Niño (La Niña) phase and Positive (Negative) IOD to climate in Eastern and Southern Africa. Therefore, this Maproom doesn't exhibit an independent feature that comes on top of the information that is displayed by the ENSO Maprooms, but rather complementary information that can help intricate the delicate cases when ENSO and IOD could be out of sync at some critical seasons.

1.4 Interpretation

Figure 1.3 is an example of the historical probability of seasonal average monthly rainfall product conditioned on Positive IOD Tercile during the July-August-September season, and falling within the upper (wet) one-third ("tercile") of the 1983-2014 historical distribution in rainfall for Tanzania. 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).

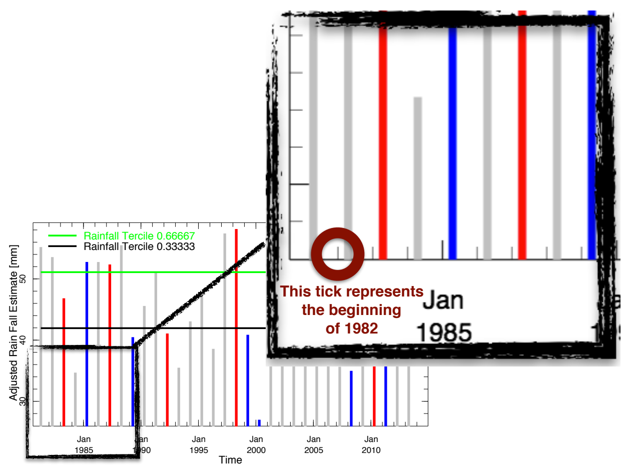


Fig. 1.2: Explanation on the ticks: Each tick on the time axis (x-axis), marks the beginning of the respective year

1.5 Access

The IOD Rainfall Mapage can be accessed via the Climate Forecast Maproom. http://maproom.meteo.go.tz/maproom/Climatology/Climate_Forecast/IOD_Prob_Precip.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 rainfall outcome/tercile (wet, normal or dry).

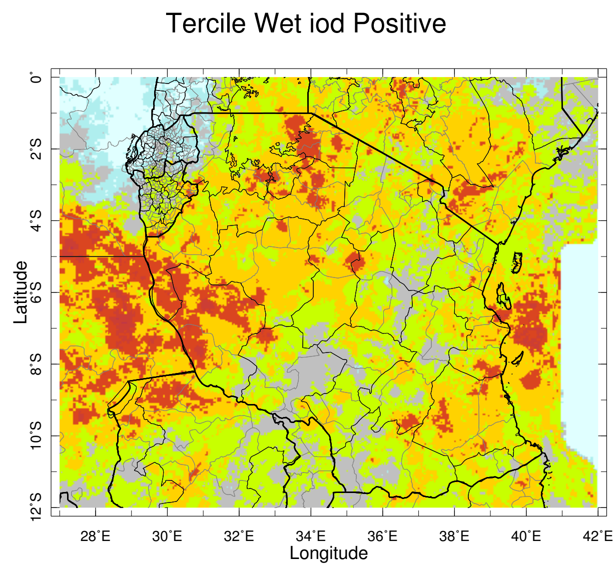


Fig. 1.3: Tanzania IOD Rainfall Forecast Maproom for the OND (Oct-Dec) season

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.

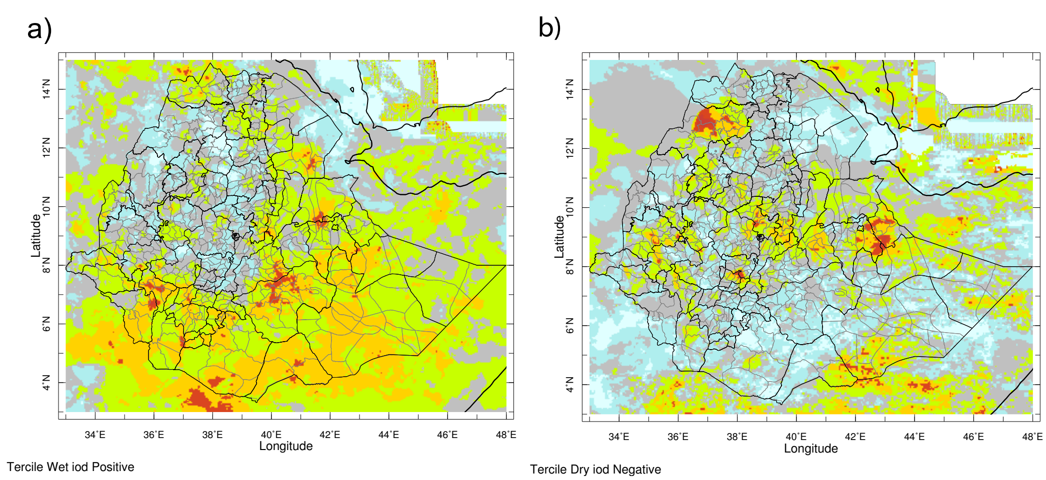


Fig. 1.4: Historical probability of seasonal monthly averages of rainfall conditioned on Positive IOD in Ethiopia a) negative and dry in Jul-Sep (b) positive and wet in Oct-Dec

The high resolution ENACTS rainfall database has been used to help determine and associate where and when IOD impacts rainfall in Ethiopia, as seen in Figure 1.4. However, due to the relative short time series of 1983-2010 and the relatively few IOD events, it should be noted that the relationships observed may not be statistically significant.

1.6.1 Examples

Figure 1.5 displays the historical impact of IOD 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) IOD Tercile: Positive.

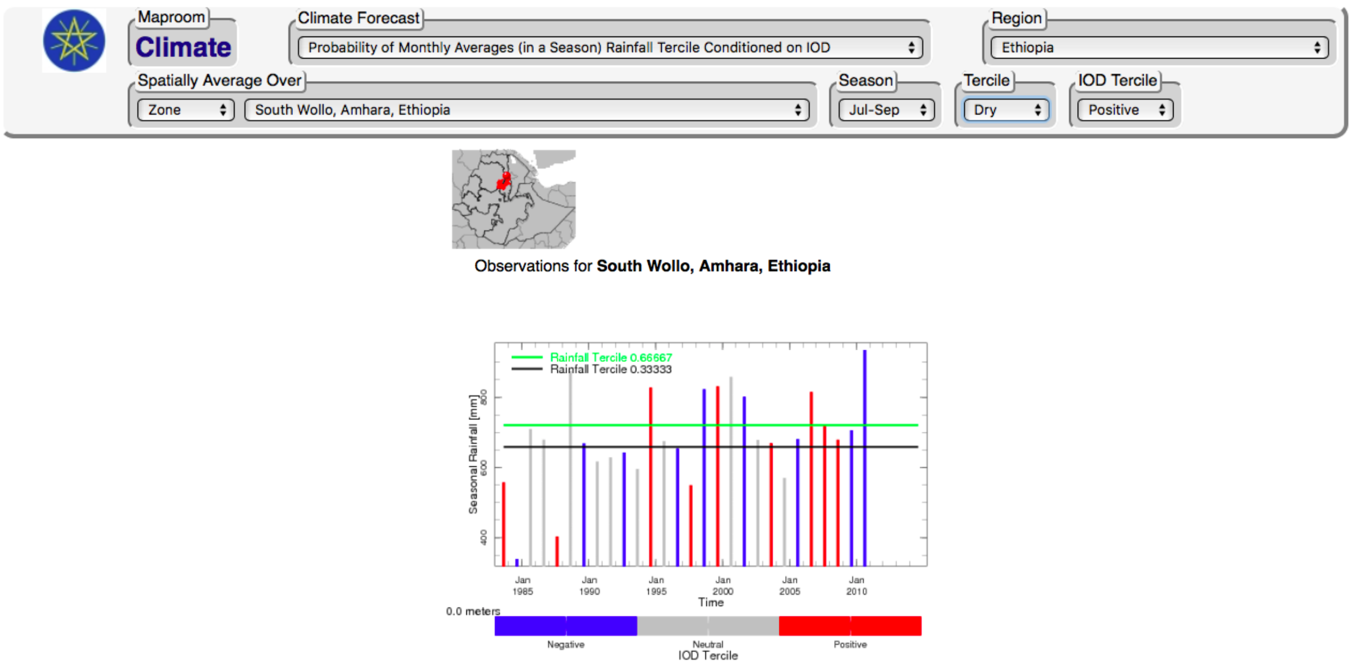


Fig. 1.5: July – September Rainfall Conditioned on Positive Dry IOD

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, Borena, Oromia, Ethiopia; (3) Season: Oct-Dec; (4) Tercile: Wet; and (5) IOD Tercile: Positive.

As can be seen, this zone was heavily impacted by the 1998 positive IOD which was also an El Niño year with an extreme, above-normal rainfall. Furthermore, Borena has a tendency to have above normal rainfall during many positive IOD years. However, there are notable positive IOD years when rainfall was normal or below normal.

1.6.2 Case Study Summary

In Ethiopia, the relationship between IOD and rainfall is significant and varies according to season and region.

1.7 Exercise - Tanzania

Tanzania has a tropical climate but has regional variations due to topography. Seasonal rainfall is driven mainly by the migration of the Intertropical Convergence Zone. It migrates southwards through Tanzania in October to December, reaching the south of the country in January and February, and returning northwards in March, April, and May. This causes the north and east of Tanzania to experience two distinct rainy seasons – (1) the short rains (Vuli") from

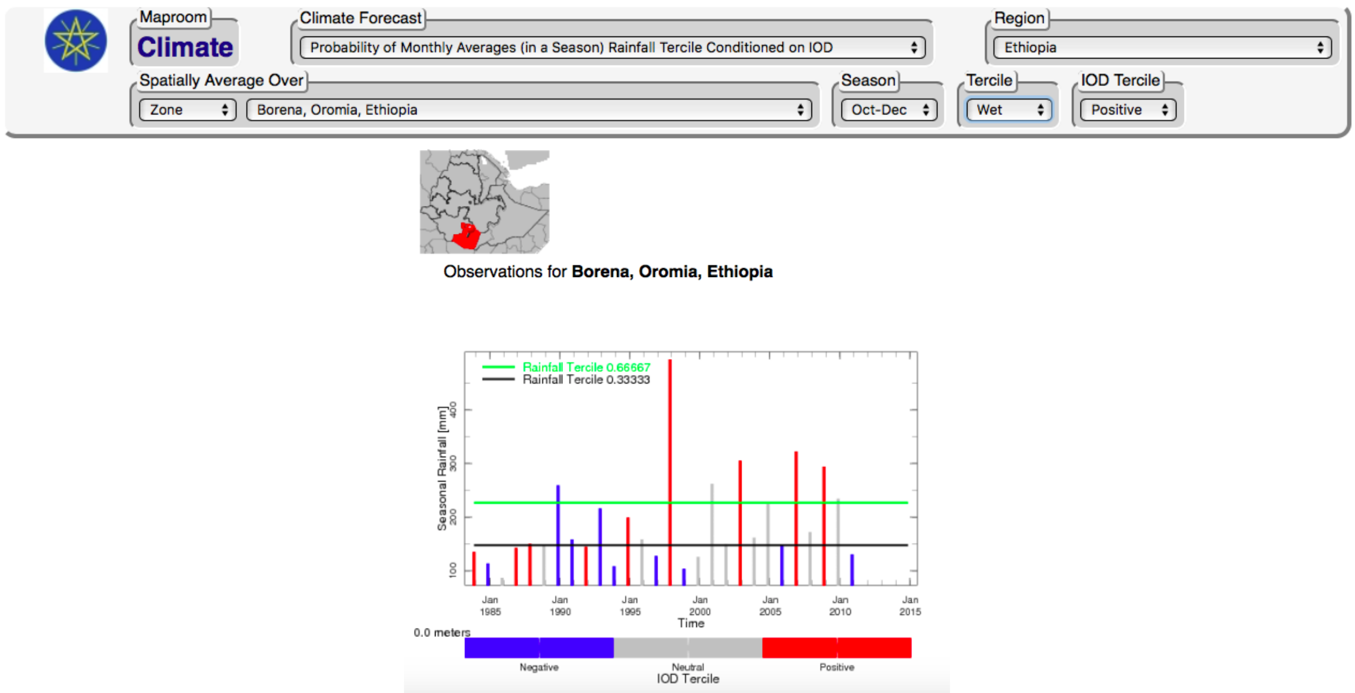


Fig. 1.6: October – December Rainfall Conditioned on Positive, Wet IOD

October-December and (2) the long rains (Masika) from March-May. However, the southern, western, and central parts of the country typically only experience one rainy season that continues October-April/May.

Please perform the following exercises:

E1. Proceed to the IOD Rainfall Probability Mapage within Tanzania's Climate Forecast Maproom, and set the analysis tool bar to the categories in Figure 1.8. (1) Region: Tanzania; (2) Spatially Average Over: TBC (do not select anything for now); (3) Season: March-May; (4) Tercile: Wet; and (5) IOD Tercile: Positive.

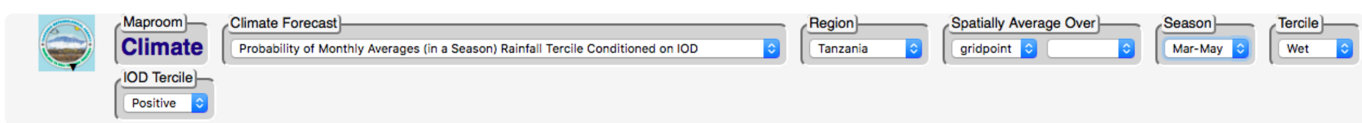


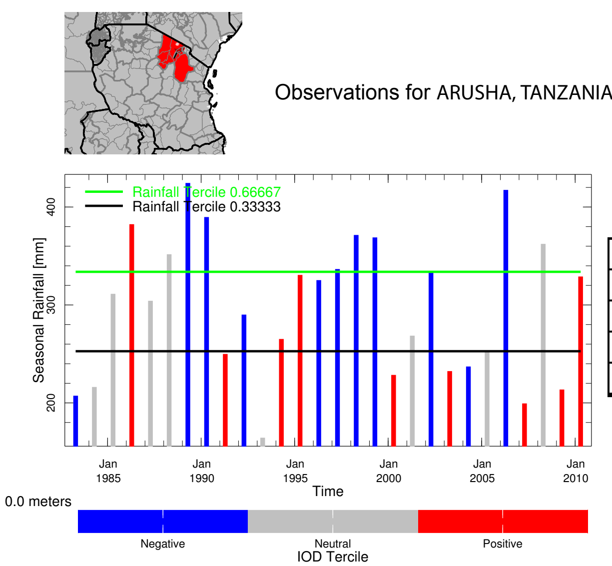
Fig. 1.7: Control Bar Settings for IOD Rainfall Probability

E2. Now, generate the time series, bar graph for the following provinces: (1) Kasena Nankana East, (2) Central Tongu, (3) Ho West, Volta, (4) and (5) Ruvuma.

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			
Positive			
Neutral			
Negative			

Fig. 1.8: ENSO Phase and Tercile Category Table



Province	Above Normal	Normal	Below Normal
Arusha			
Positive	1	3	5
Neutral	2	4	2
Negative	7	2	2

Fig. 1.9: Time Series Bar Graph and Completed Table for the Arusha Region

1.7.1 Example - Kasena Nankana East District (Figure 1.9)

1.8 Quiz

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

Q1. In north and east of Tanzania, which rainy season has an increased possibility to be wetter than normal during a positive IOD? (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 Positive IOD

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

Q4. How do the magnitudes of rainfall associated with Positive IOD events in Tanzania OND compare with that of Ethiopia OND? (a) Weaker (b) Same (c) Stronger

1.8.1 Quiz - Answers

A1. October-December

A2. 1986, 1997, 2006

A3. Rukwa, Tabora, Lindi, Mtwara provinces.

A4. (b) Stronger

1.9 Summary

IOD impacts the climate of Tanzania during the primary rainy season of October-December, especially within the northern and western regions.

1.10 Reference(s)

- Ihara, Chie, Yochanan Kushnir, and Mark A. Cane. "Warming trend of the Indian Ocean SST and Indian Ocean dipole from 1880 to 2004." Journal of Climate 21.10 (2008): 2035-2046.

Images

- http://www.bom.gov.au/climate/iod/ [1]