AFRICAN CENTRE OF METEOROLOGICAL APPLICATIONS FOR DEVELOPMENT (ACMAD)

WORLD METEOROLOGICAL ORGANIZATION

NOR CAP — NORWEGIAN CAPACITY — OPERATED BY NRC

Workshop on Reviewing and Exploring Products Supporting Improvements on the Annual State of Climate Report for Africa.

Date: 11-13 July 2023.

Venue: Hotel Angehill

Place: Accra-Ghana

https://rcc.acmad.org/longerangebulletin.php
https://rcc.acmad.org

Presented by :
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ClimSA — INTRA-ACP CLIMATE SERVICES AND RELATED APPLICATIONS PROGRAMME

An initiative of the Organisation of African, Caribbean and Pacific States funded by the European Union

Presentation Outline

Major drivers of interannual climate variability in Africa

1. The State of the Ocean Climate: Pacific Ocean

2. The State of the Ocean Climate: Atlantic Ocean

3. The State of the Ocean Climate: Indian Ocean

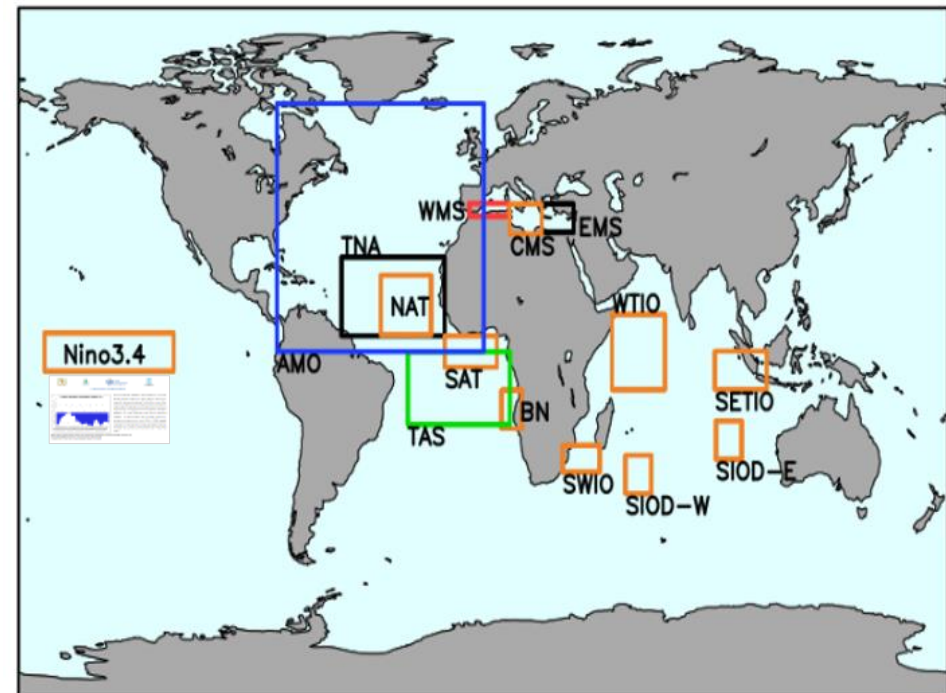**The State of the ocean climate: Major Drivers of Interannual Climate Variability In Africa**

Figure Major Oceans of the World. Source:
https://stateoftheocean.osmc.noaa.gov/sur/

Teleconnection analysis

- To understand the weather development in Africa insight is required on the status of the Sea Surface Temperature around the globe.
- Up to 16 major areas in the ocean are identified as being relevant for the development of rainfall in African areas
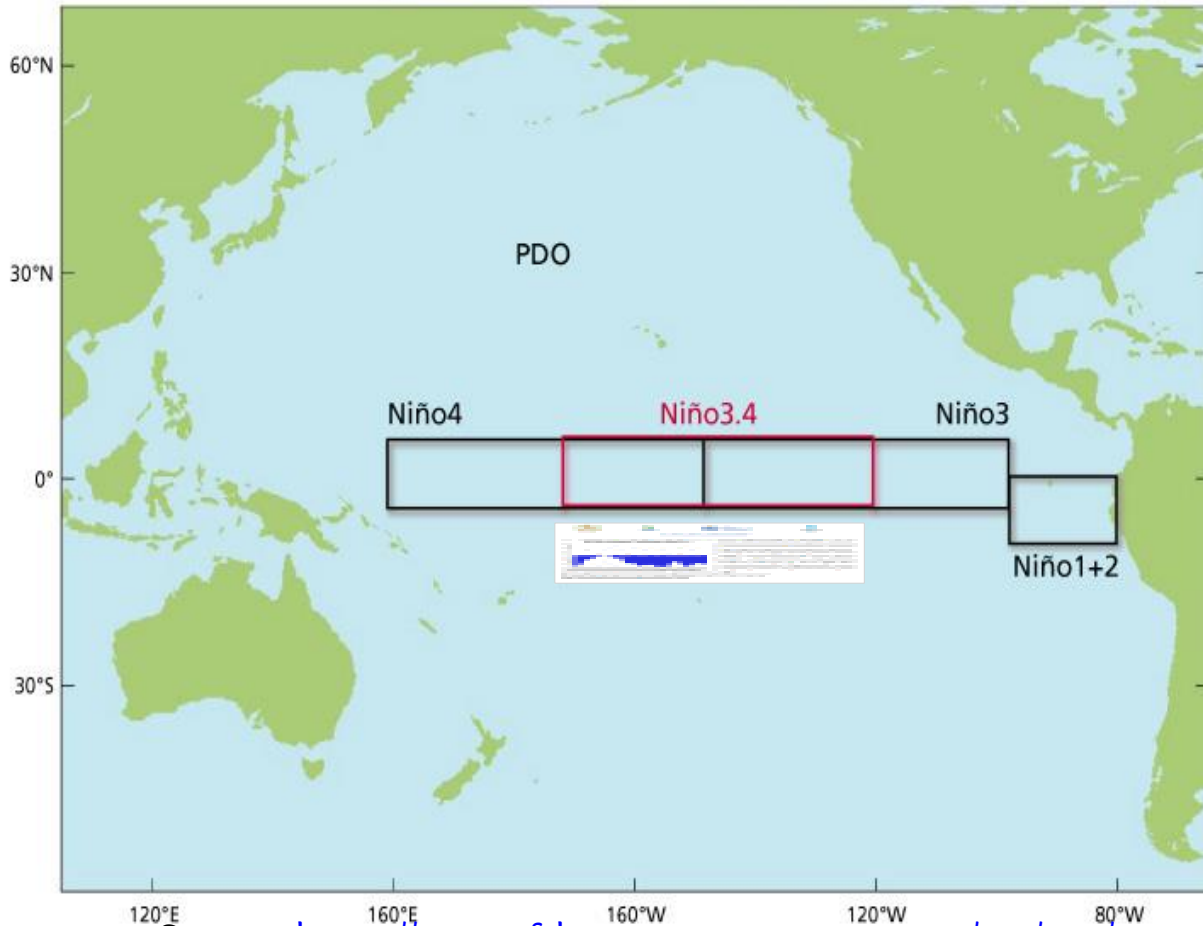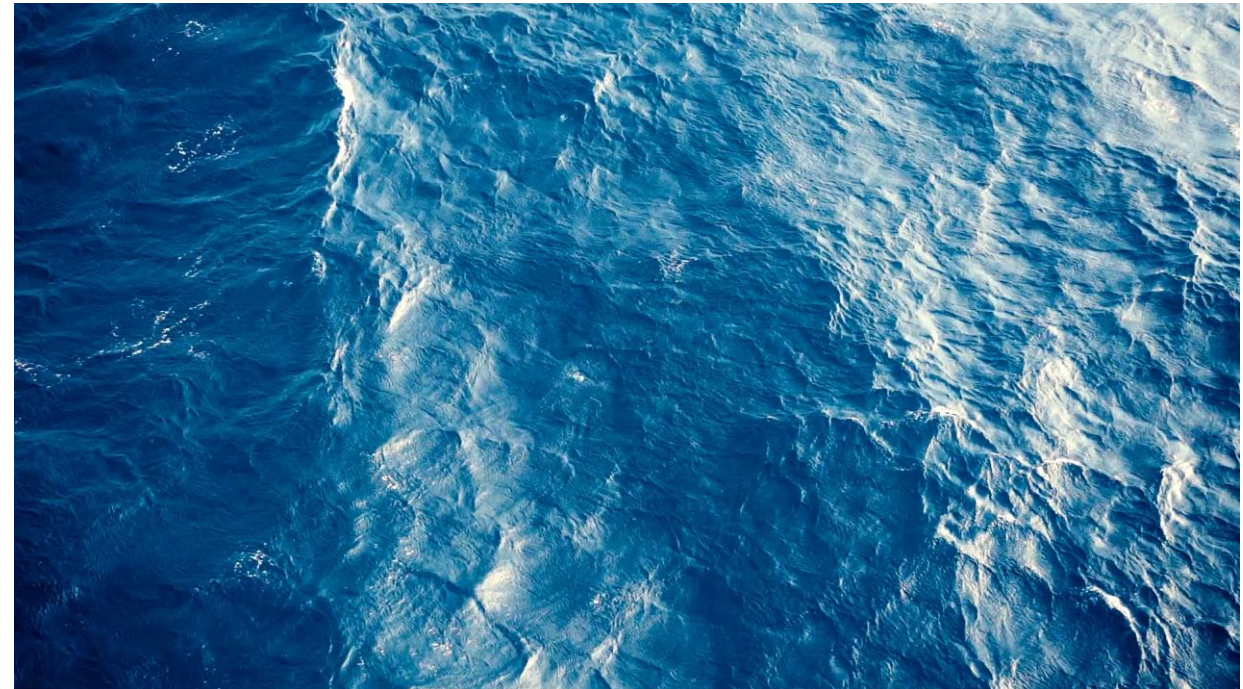
Major drivers of interannual climate variability in Africa: The state of the Pacific Ocean climate: Pacific Ocean

Source: https://stateoftheocean.osmc.noaa.gov/sur/pac/

Niño3.4

The Niño3.4 SST anomaly index is an indicator of central tropical Pacific El Niño conditions. It is calculated with SSTs in the box 170°W - 120°W, 5°S - 5°N.
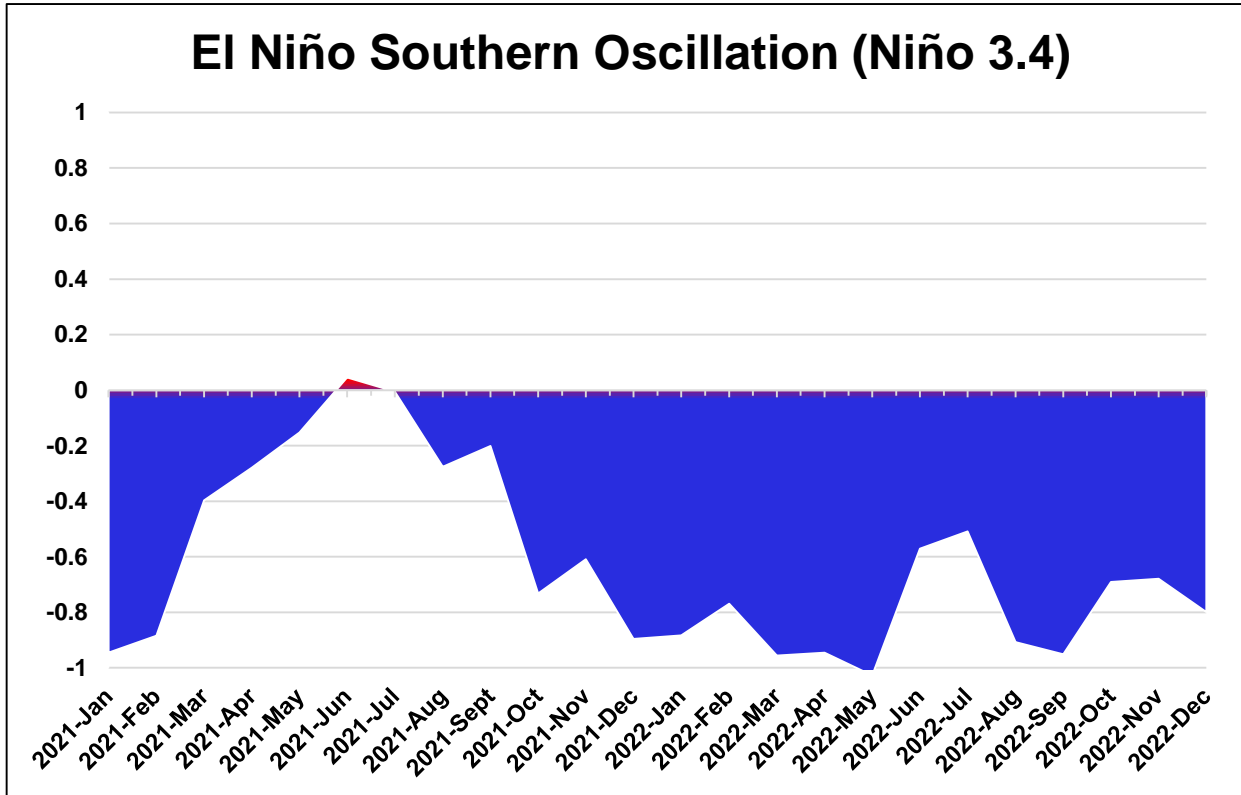
EL Niño Southern Oscillation (ENSO)

## El Niño Southern Oscillation (Niño 3.4)

These are large-scale changes in the atmosphere or ocean that influence climate conditions over many regions in the world on seasonal to interannual timescales. The links that connect these large changes with regional or localized hazards are referred to as teleconnections. At the global level, El Nino Southern Oscillation (ENSO) is one of the best-known major driver of interannual variability. In Africa, strong El Nino is usually connected to droughts over southern Africa (e.g 2015/16). ENSO negative anomalies dominated the Nino 3.4 region during 2022 s has been translated into a number of consecutive failed rain in East African region

Observed SST anomaly time series from the Ocean Observations Panel for Climate. Data source:
https://stateoftheocean.osmc.noaa.gov/sur/pac/nino34.php

The state of the ocean climate: Atlantic Ocean
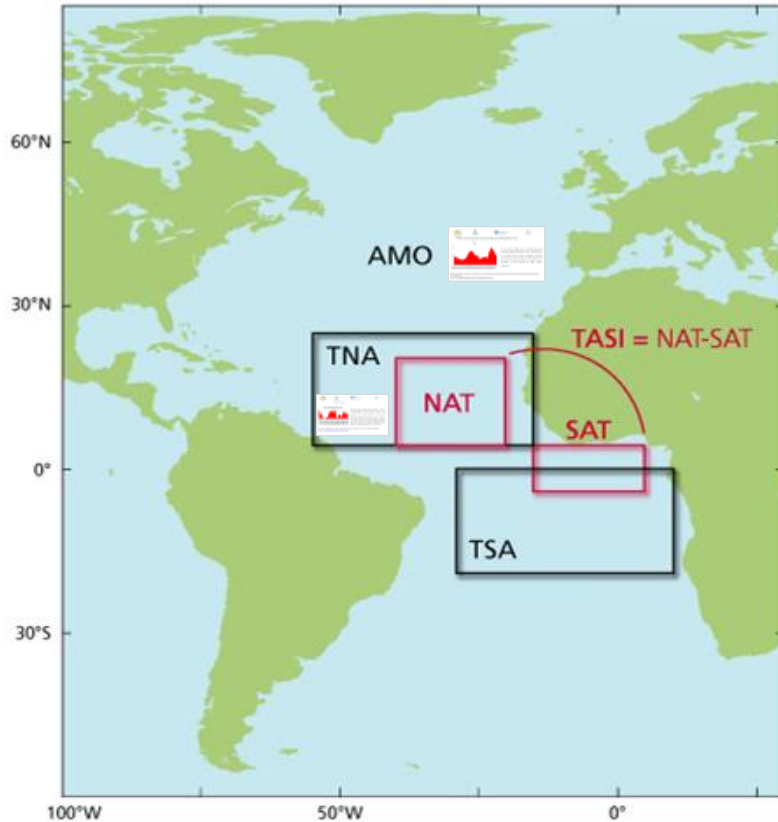
The state of the ocean climate: Atlantic Ocean

Source: https://stateoftheocean.osmc.noaa.gov/sur/atl/

Atlantic Multidecadal Oscillation (AMO)
The Atlantic Multidecadal Oscillation (AMO) index reflects an argued 50-80 years pattern of North Atlantic coupled ocean-atmosphere variability. It is associated with changes in rainfall over North America and Europe, the frequency of North American droughts, and the intensity of North Atlantic hurricanes

Tropical Northern Atlantic Index (TNA)
The TNA SST anomaly index is an indicator of the surface temperatures in the eastern tropical North Atlantic Ocean. It is calculated with SSTs in the box 55°W - 15°W, 5°N - 25°N

**North Atlantic Tropical (NAT) SST index**
The NAT SST anomaly index is an indicator of the surface temperatures in a broad swath of the tropical North Atlantic Ocean. It is calculated with SSTs in the box 40°W - 20°W, 5°N - 20°N.

Tropical Atlantic (TASI) SST index
The TASI SST anomaly index is an indicator of the meridional surface temperature gradient in the tropical Atlantic Ocean. It is calculated as the difference of the NAT and SAT indices

South Atlantic Tropical (SAT) SST index
The SAT SST anomaly index is an indicator of the surface temperatures in a broad swath of the tropical South Atlantic Ocean. It is calculated with SSTs in the box 15°W - 5°E, 20°S - 5°S.

Tropical Southern Atlantic Index (TSA)

The TSA SST anomaly index is an indicator of the surface temperatures in the Gulf of Guinea, the eastern tropical South Atlantic Ocean. It is calculated with SSTs in the box 30°W - 10°E, 20°S - 0°.

Monthly sea surface temperature of the Atlantic Multidecadal Oscillation(AMO) anomalies

AMO
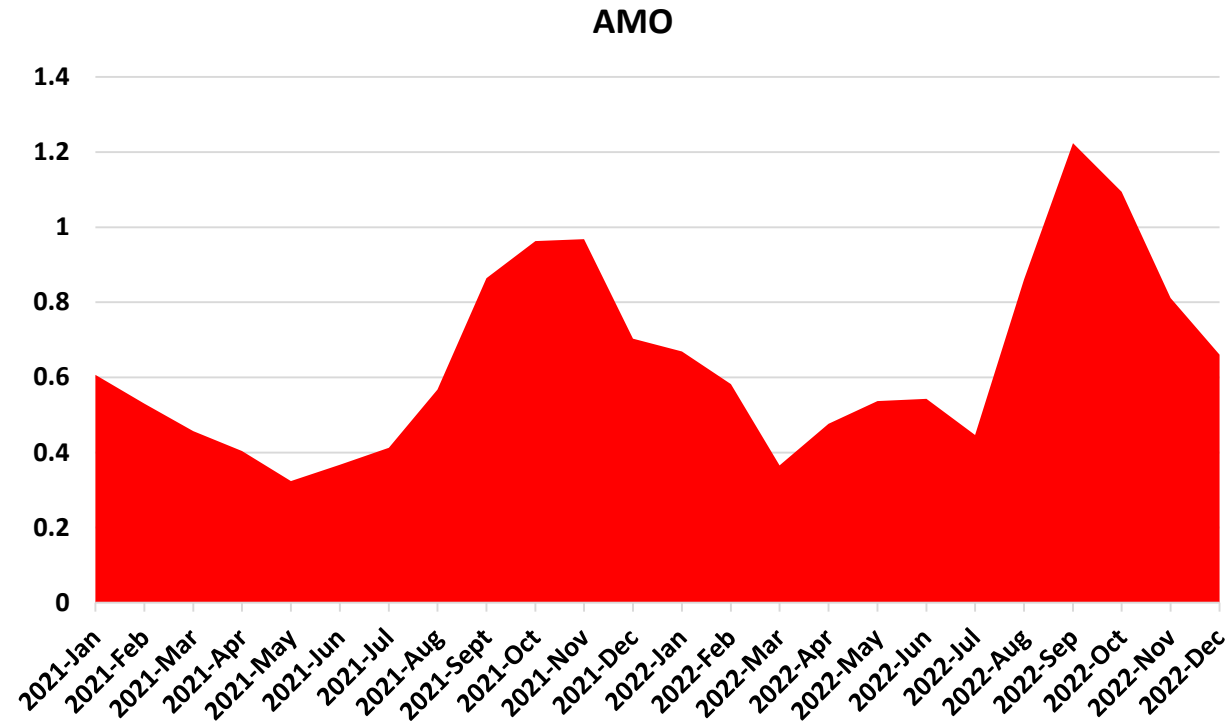
The sea surface temperature of the AMO anomalies have been positive since January 2022 and this pattern is associated with changes in rainfall over North America and Europe, the frequency of North American droughts, and the intensity of North Atlantic hurricanes.

Observed monthly sea surface temperature of the Atlantic Multidecadal Oscillation anomalies time series from the Ocean Observations Panel for Climate.
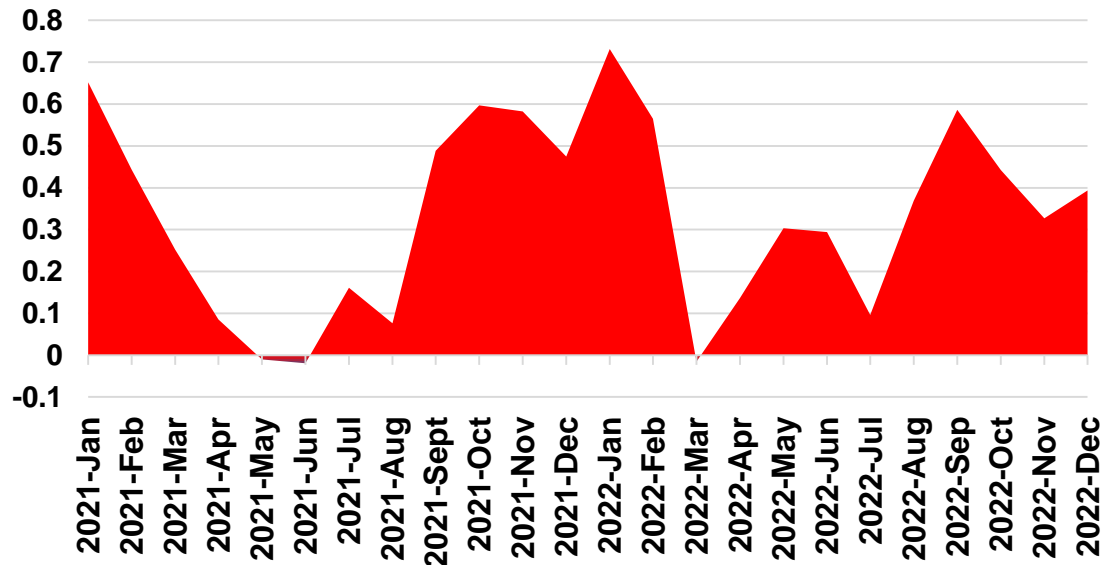Data source: https://stateoftheocean.osmc.noaa.gov/atm/amo.php

Tropical North Atlantic

## Tropical Northern Atlantic (TNA) Index

The Tropical North Atlantic (TNA) variability is related to monsoon rainfall over the Sahel. Positive TNA is usually favorable for active monsoon rainfall over the Sahel and particularly its westernmost part during summer. This pattern was mostly dominated by positive anomalies throughout 2022, This explains the precipitation variability patterns observed during monsoon season over the Sahel region.

Observed Tropical North Atlantic sea surface temperature (SST) anomaly time series from the Ocean Observations Panel for Climate.
Data source: https://stateoftheocean.osmc.noaa.gov/sur/atl/tna.php

North Atlantic Tropical (NAT) SST index
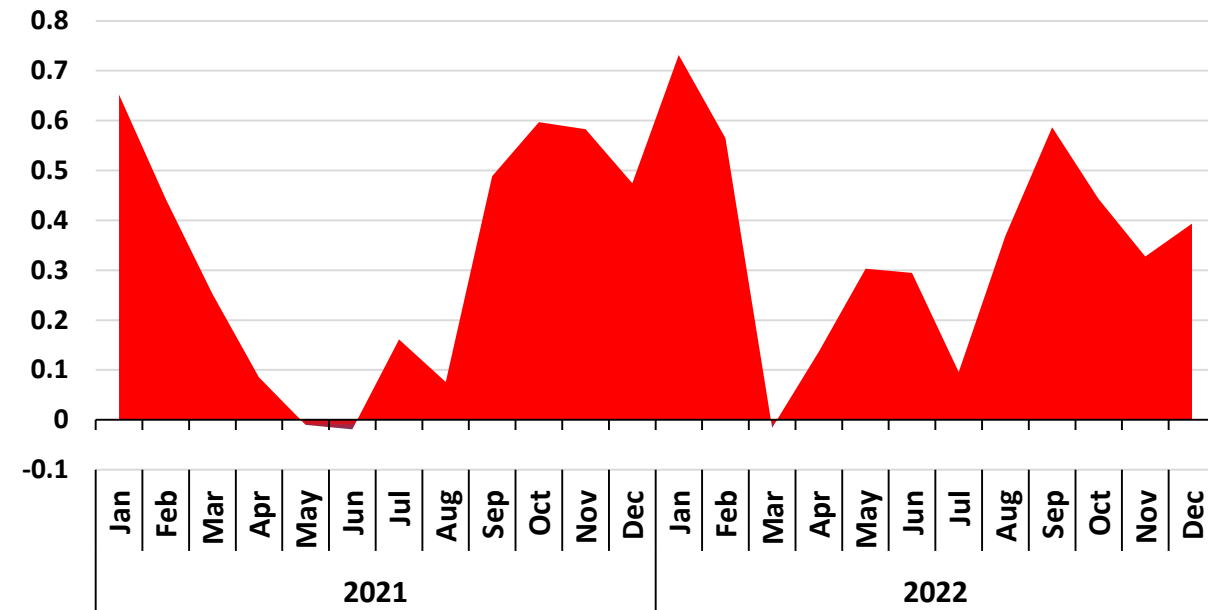
The NAT SST anomaly index is an indicator of the surface temperatures in a broad swath of the tropical North Atlantic Ocean and is associated with a potential decadal 'dipole' mode of coupled variability in the tropical Atlantic (Chang, Ji, and Li (*Nature*, 1997), this study can be found on the Journal *Nature's* Web site)

It is calculated with SSTs in the box 40°W - 20°W, 5°N - 20°N.

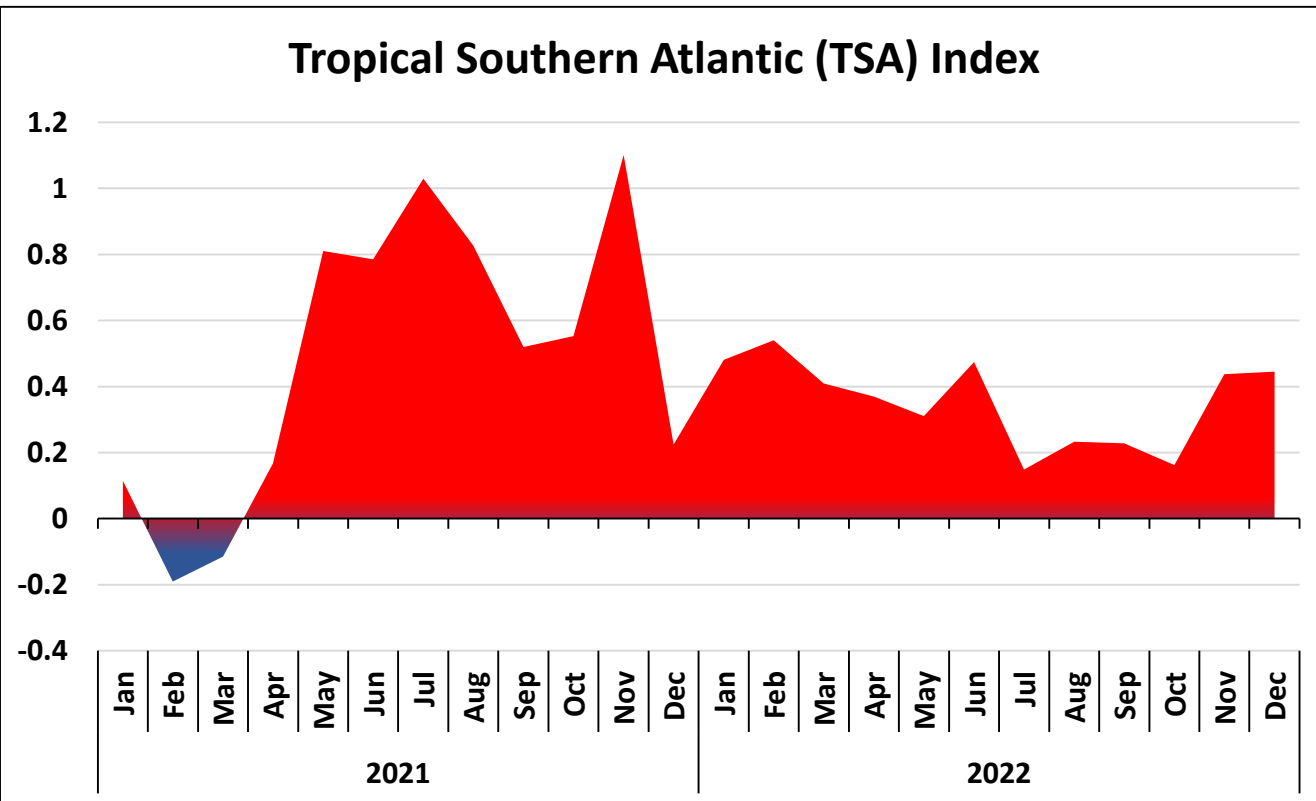The year 2022 was dominated by positive anomalies, except for the month of March.

North Atlantic Tropical (NAT) SST index
Source: https://stateoftheocean.osmc.noaa.gov/sur/atl/nat.php

Tropical South Atlantic

Tropical Southern Atlantic (TSA) Index

The Tropical South Atlantic (TSA) SST variability affects the Sahel, the Gulf of Guinea and the tropical eastern Atlantic coasts of Africa.

This explains the well to well above precipitation recorded over south Mauritania, the central part of Mali, Southeast Niger, most parts of Senegal, central Ivory cost, Guinea, Sierra Leone and most parts of Nigeria while below to well below average was observed over west Guinea Bissau.

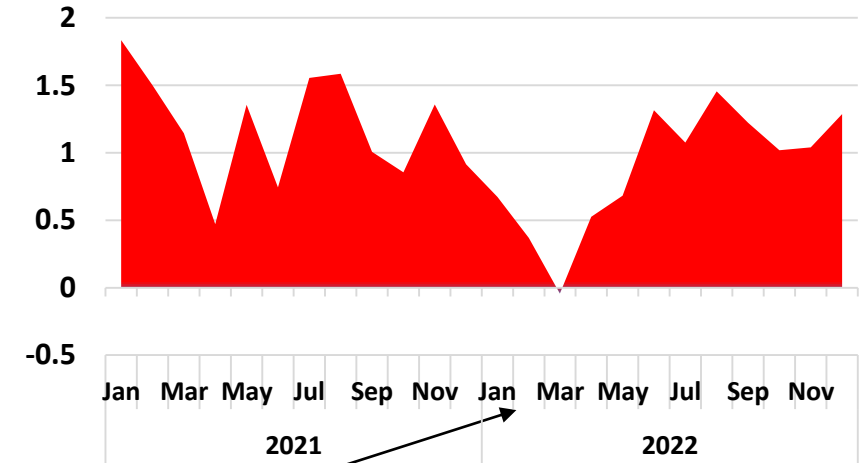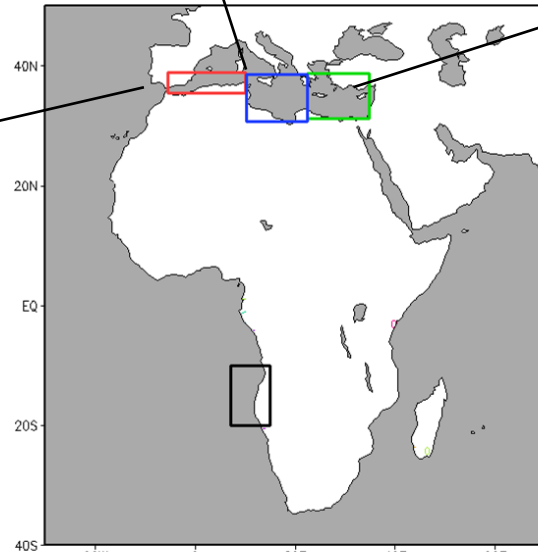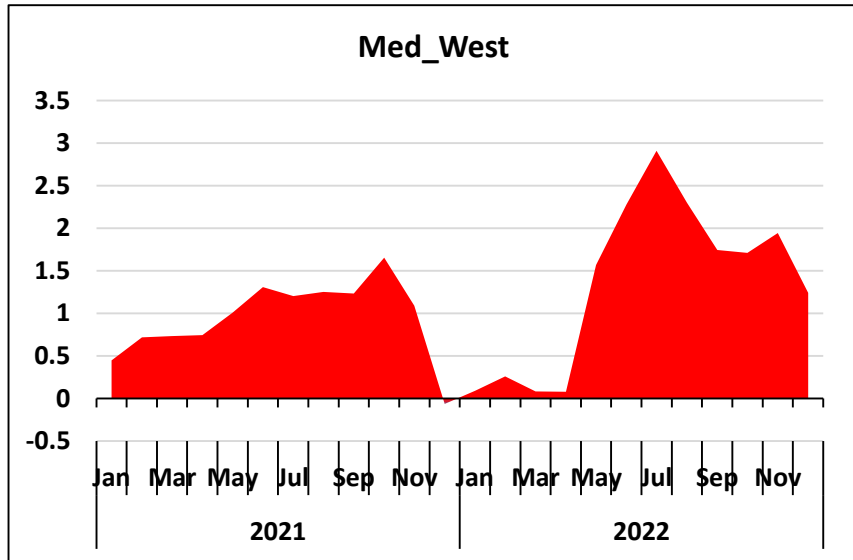Observed Tropical South Atlantic SST anomaly time series from the Ocean Observations Panel for Climate. Data source: https://stateoftheocean.osmc.noaa.gov/sur/atl/tsa.php

Mediterranean SST Index

Med_Central

Med-East
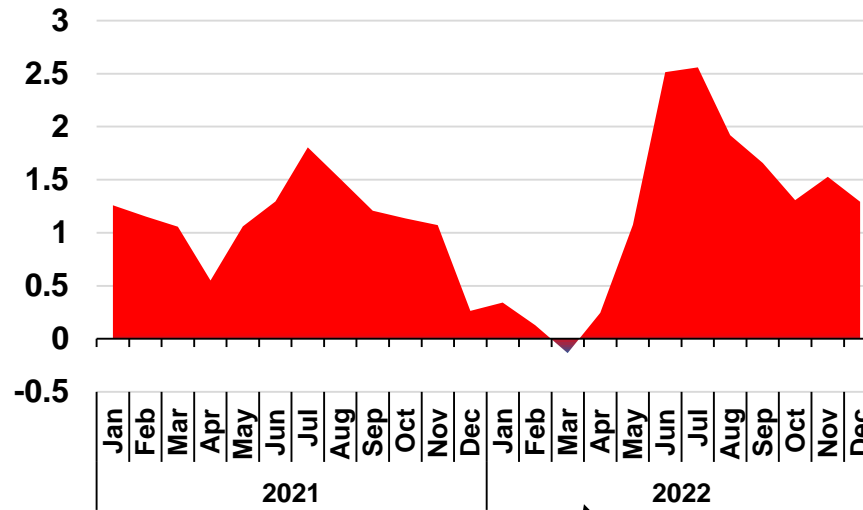
Med_West

Mediterranean SST Index

Sea surface temperature in the Mediterranean sea has experienced positive anomalies since the year 2022 to 2022.

Benguela Nino : lat [-20,-10] / lon [7,15]
East Med. Sea : lat [31.29,38.71] / lon [22.52,34.89]
West Med. Sea : lat [35.53,38.9] / lon [-5.46,10.09]
Cent Med. Sea : lat [30.81,38.67] / lon [10.14,22.51]

Benguela Nino index

Benguela Niños are generated by specific wind stress events in the west-central equatorial Atlantic, and progress from there as subsurface temperature anomalies that eventually outcropped only at the south-west African coast(Florenchie et al 2003) .

SST of Benguela has been characterised by positive anomalies throughout the year since 2022. A negative anomaly has been observed during the months of April and May 2022. This signal shifted to positive for the months of Jun to Dec 2022.
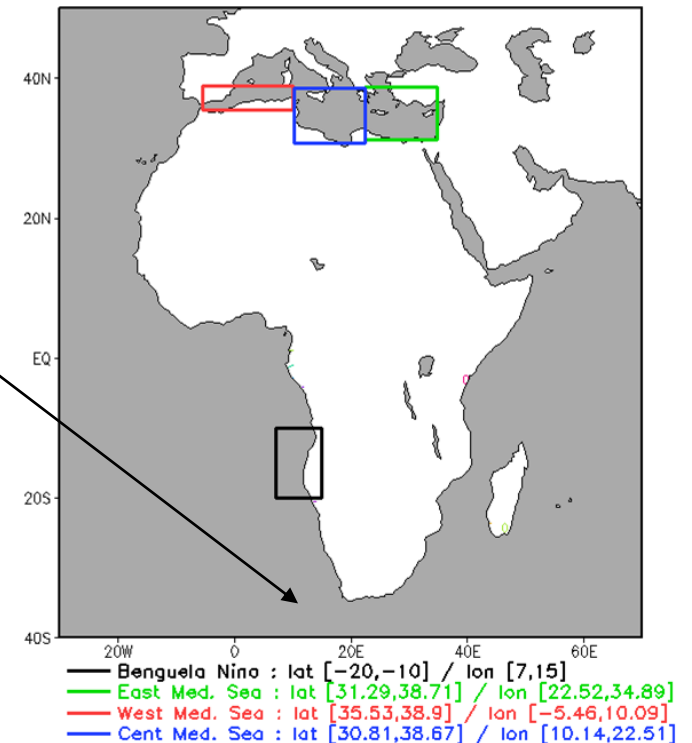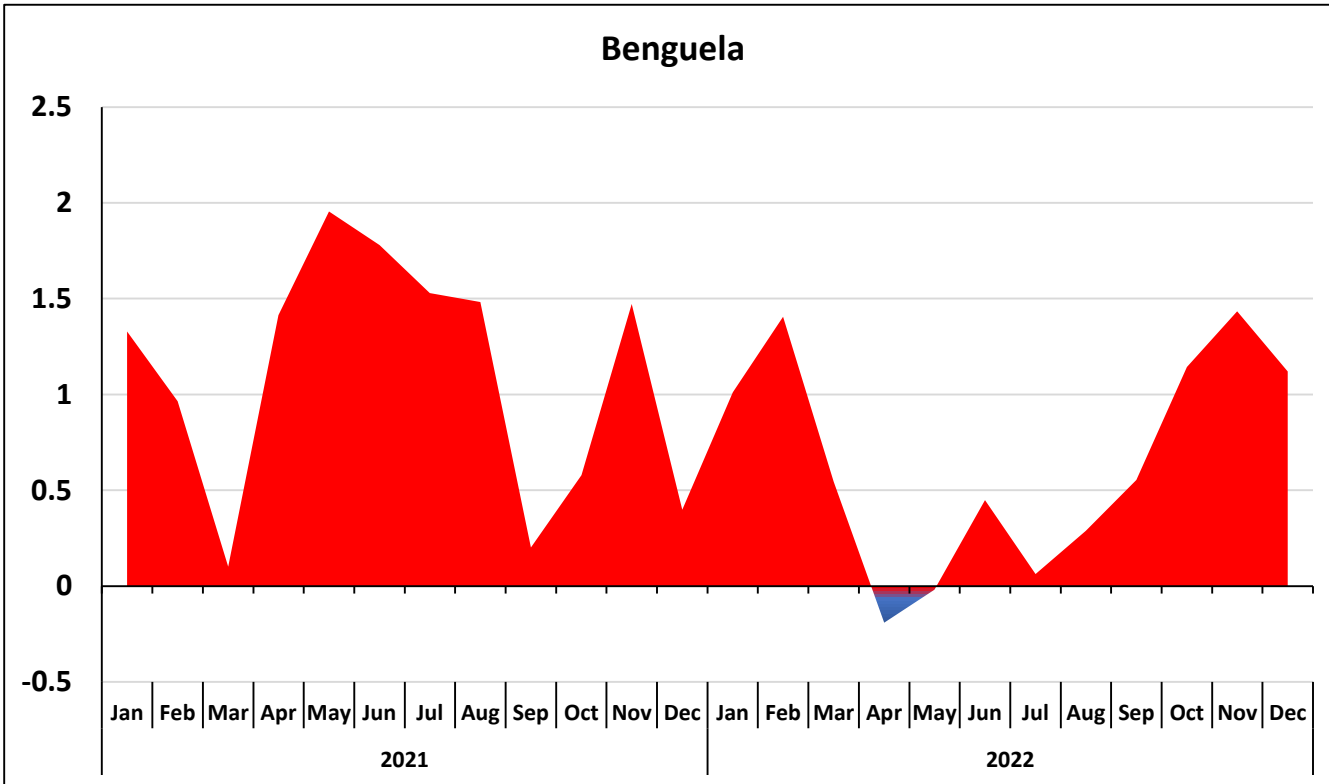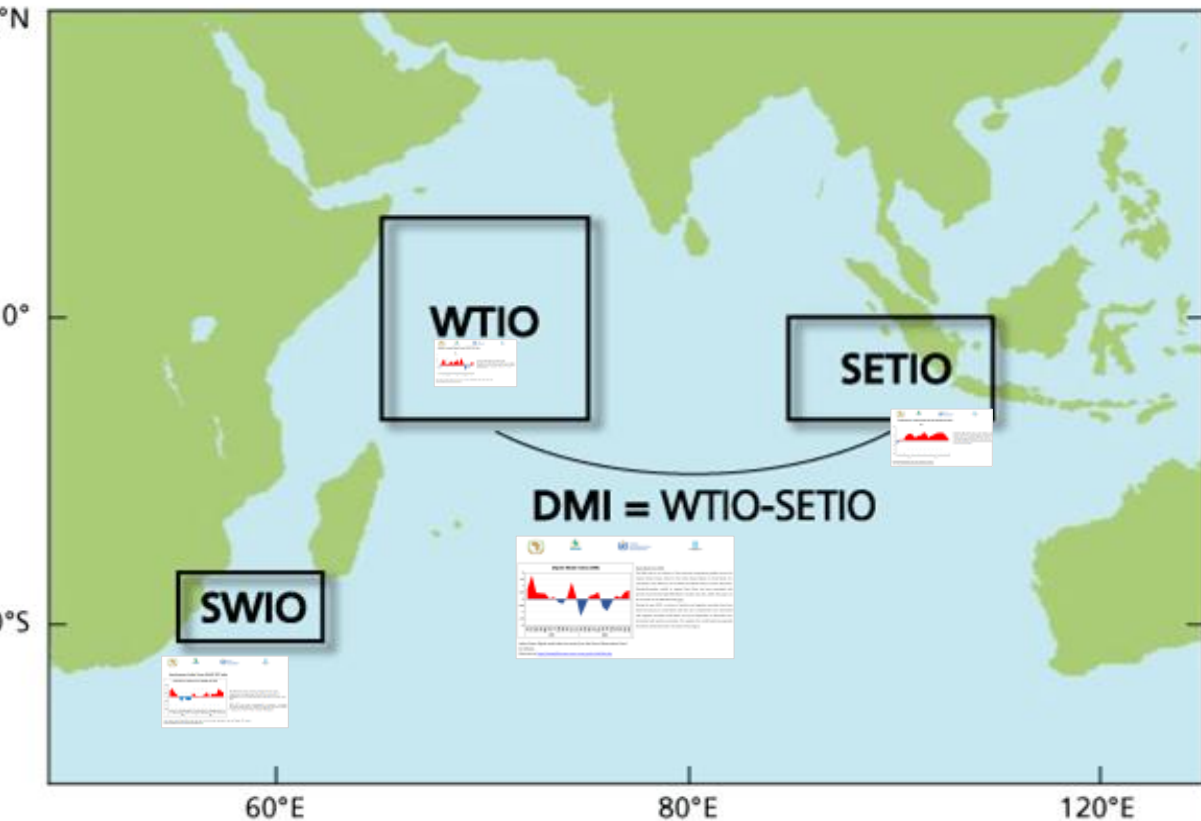
Benguela Nino index
Source: https://stateoftheocean.osmc.noaa.gov/sur/

The state of the ocean climate: Indian Ocean

Western Tropical Indian Ocean (WTIO) SST index
The WTIO SST anomaly index is an indicator of the surface temperatures in a cross-equatorial region spanning the western tropical Indian Ocean. It is calculated with SSTs in the box 50°E - 70°E, 10°S - 10°N.

Southeastern Tropical Indian Ocean (SETIO) SST index
The SETIO SST anomaly index is an indicator of the surface temperatures in the southeastern tropical Indian Ocean, west of the Indonesian island of Sumatra. It is one-half of the Dipole Mode Index, an indicator of the east-west gradient in sea surface temperatures in the Indian Ocean. It is calculated with SSTs in the box 90°E - 110°E, 10°S - 0°.

Dipole Mode Index (DMI)(IOD)
The DMI index is an indicator of the east-west temperature gradient across the tropical Indian Ocean, linked to the Indian Ocean Dipole or Zonal Mode. It is calculated as the difference of the WTIO and SETIO indices. Extreme December-October-November rainfall in tropical East Africa has been associated with periods of persistently high DMI (Black et al.,*Mon. Wea. Rev.*, 2003; this paper can be accessed via the AMS Web site here).

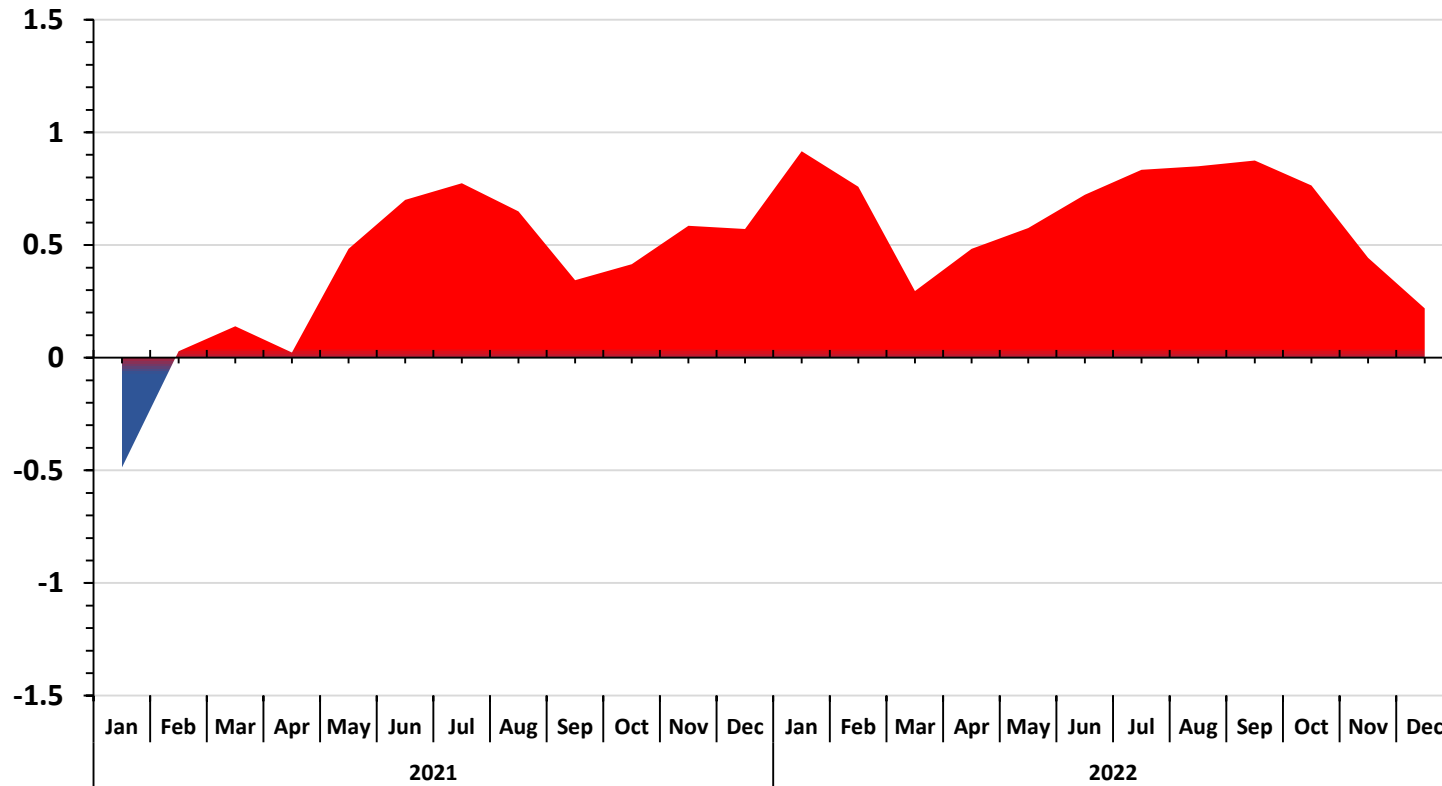**Southwestern Indian Ocean (SWIO) SST index**
The SWIO SST anomaly index is an indicator of the surface temperatures in a region east of South Africa and south of Madagascar. It is calculated with SSTs in the box 31°E - 45°E, 32°S - 25°S.

The state of the ocean climate: Indian Ocean

Source: https://stateoftheocean.osmc.noaa.gov/sur/ind/

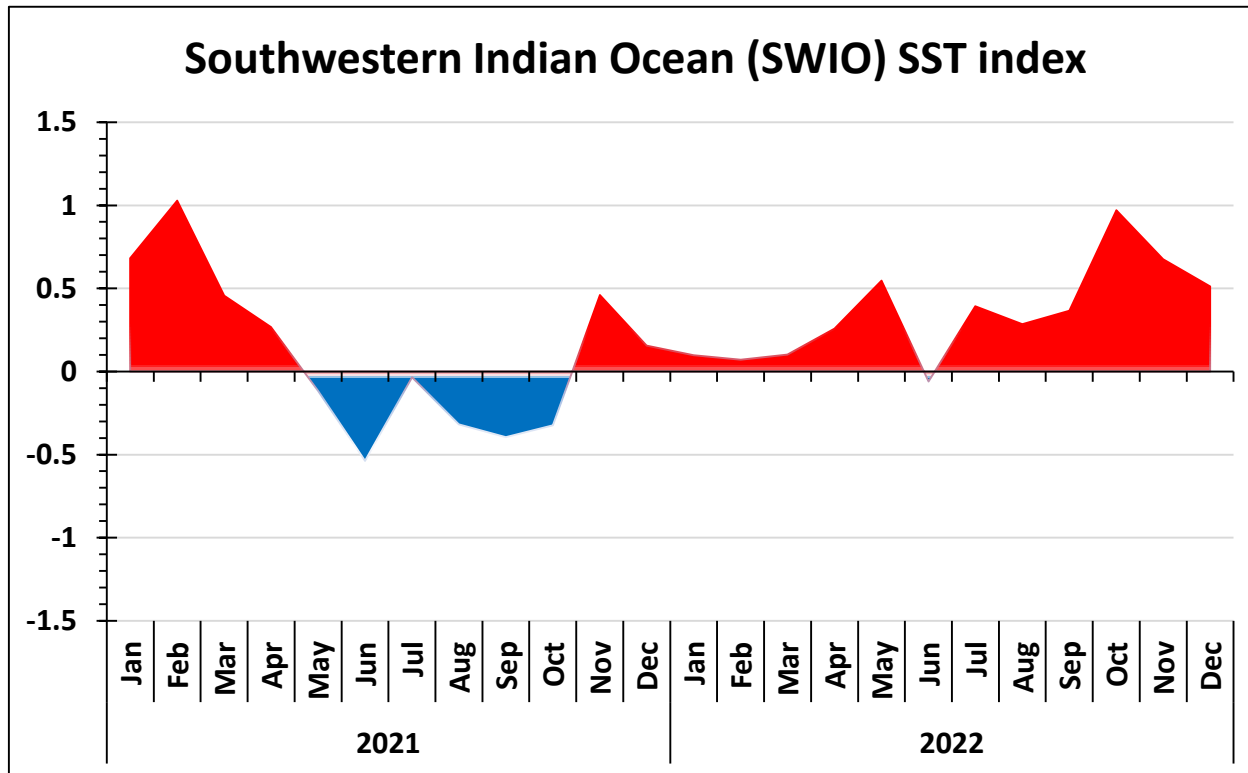# Southeastern Tropical Indian Ocean (SETIO) SST index

SETIO

The SETIO SST anomaly index is an indicator of the surface temperatures in the southeastern tropical Indian Ocean, west of the Indonesian island of Sumatra. It is calculated with SSTs in the box 90°E - 110°E, 10°S - 0°.
Year 2022 has been dominated by the positive anomalies from January till December.

Observed monthly anomaly sea surface temperature of SETIO
Source: https://stateoftheocean.osmc.noaa.gov/sur/ind/setio.php

Southwestern Indian Ocean (SWIO) SST index

Southwestern Indian Ocean (SWIO) SST index

The SWIO SST anomaly index is an indicator of the surface temperatures in a region east of South Africa and south of Madagascar. It is calculated with SSTs in the box 31°E - 45°E, 32°S - 25°S

SWIO SST have been characterised by positive anomalies throughout 2022 and this explains the well and well above rainfall in many parts of South Africa and South Madagascar

South Indian Ocean Dipole West Index time series from the Ocean Observations Panel for Climate. Data source:
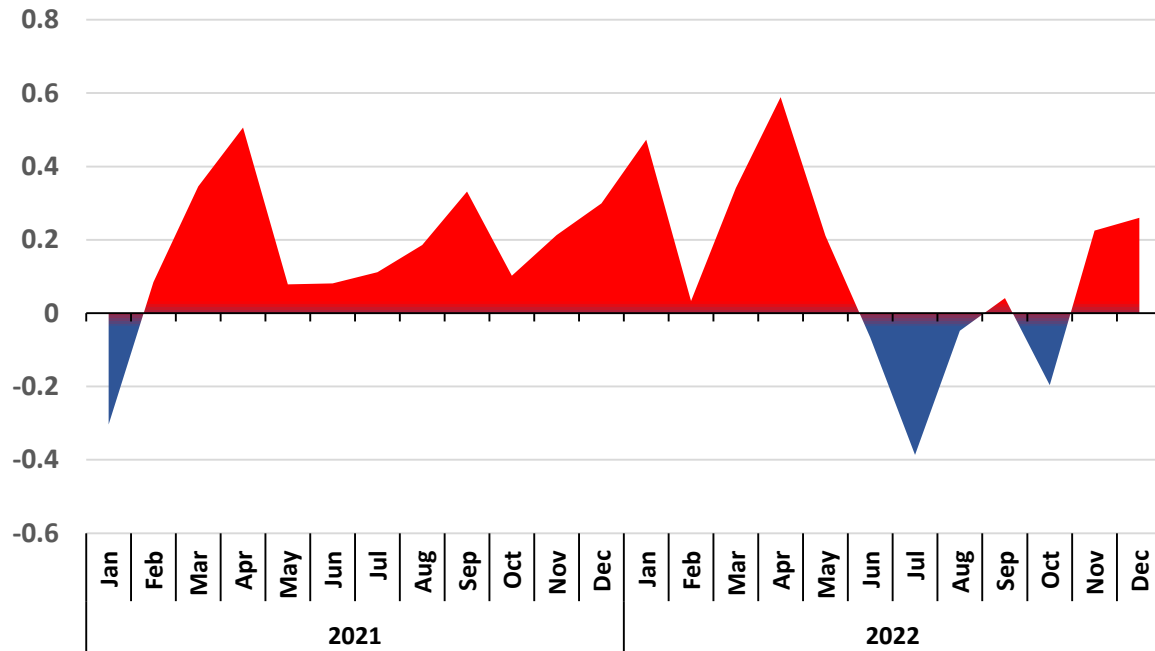https://stateoftheocean.osmc.noaa.gov/sur/ind/swio.php

Western Tropical Indian Ocean (WTIO) SST index

WTIO

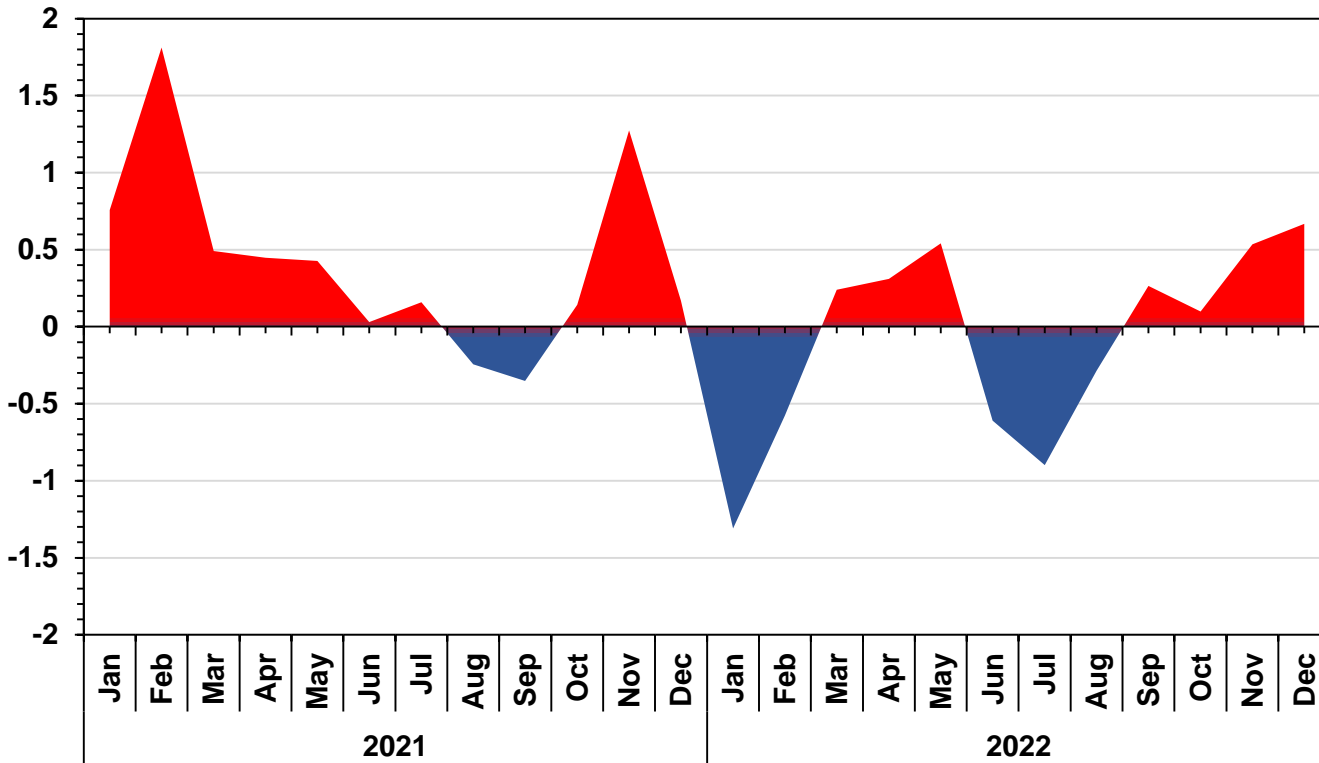**Western Tropical Indian Ocean (WTIO) SST index**
The WTIO SST anomaly index is an indicator of the surface temperatures in a cross-equatorial region spanning the western tropical Indian Ocean. It is calculated with SSTs in the box 50°E - 70°E, 10°S - 10°N

South Indian Ocean Dipole West Index time series from the Ocean Observations Panel for Climate. Data source:
https://stateoftheocean.osmc.noaa.gov/sur/ind/swio.php

Dipole Mode Index (DMI)

Indian Ocean Dipole mode Index time series from the Ocean Observations Panel for Climate.
Data source: https://stateoftheocean.osmc.noaa.gov/sur/ind/dmi.php

Dipole Mode Index (DMI)

The DMI index is an indicator of the east-west temperature gradient across the tropical Indian Ocean, linked to the Indian Ocean Dipole or Zonal Mode. It is calculated as the difference of the WTIO and SETIO indices. Extreme December-October-November rainfall in tropical East Africa has been associated with periods of persistently high DMI (Black et al.,*Mon. Wea. Rev.*, 2003; this paper can be accessed via the AMS Web site here).

During the year 2022, a mixture of positive and negative anomalies have been observed: January to early March and later Jun to September were dominated with negative anomalies while March to July and September to December were dominated with positive anomalies. This explains the rainfall patterns-especially the deficit rainfall observed in the Easter Africa region.

Major drivers of climate variability affecting the region in SoC in 2022

The phases of the El Niño Southern Oscillation (ENSO) and the sea-surface temperature (SST) anomaly patterns in the tropical Atlantic Ocean and the Indian Ocean are the main drivers of the rainfall variability in Africa.

La Niña episode signal measured using Niño 3.4 index started in 2020 and lasted through 2022 with a brief interruption in 2021 (Figure 7a). It may have contributed to above-average summer precipitation in the Sahel.

Positive SST anomalies over the tropical Atlantic Ocean are usually favourable for above-average summer rainfall over West Africa (Figure 7b and Figure 7c). Warmer SSTs over the SWIO region favoured well above-average precipitation in many parts of South Africa and South Madagascar (Figure 7d).

The Indian Ocean Dipole (IOD) was characterized mainly by a negative anomaly (Figure 7e). The La Niña signal, coupled with negative IOD values, contributed to drier-than-normal conditions in East Africa. Indeed, Ethiopia, Kenya, and Somalia experienced the failure of the *Gu* rains (April-May-June) and *Deyr* rains (October-November-December), leading to an exceptional multi-seasonal drought. These are the two main rainy seasons in Somalia affected by several factors, including ENSO events, which typically causes flooding and increased rainfall in El Nino years and droughts in La Nina years.

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[1] The DMI is the difference between the SST anomalies over the tropical western Indian Ocean [10°S–10°N; 50°E–70°E] and the tropical eastern Indian Ocean [10°S–0; 90°E–110°E].
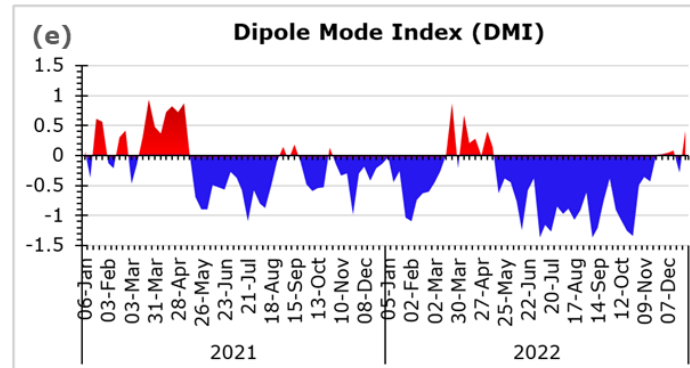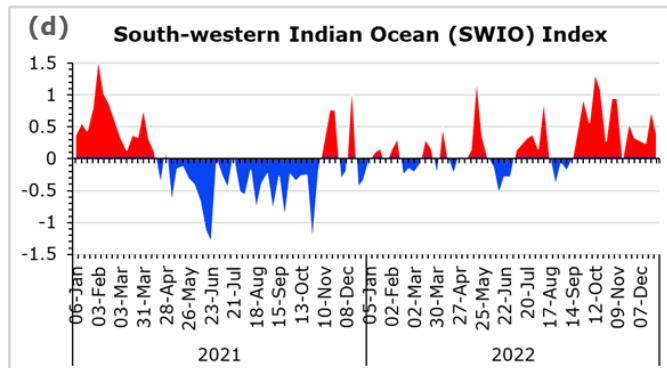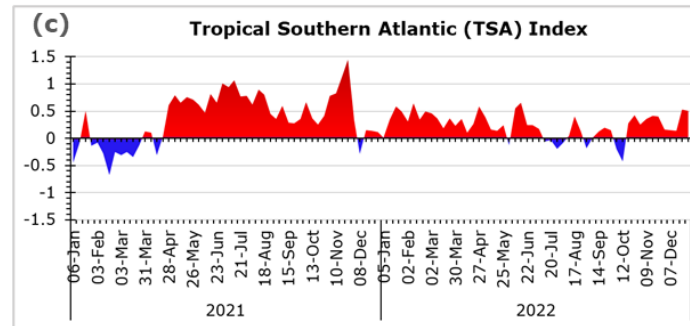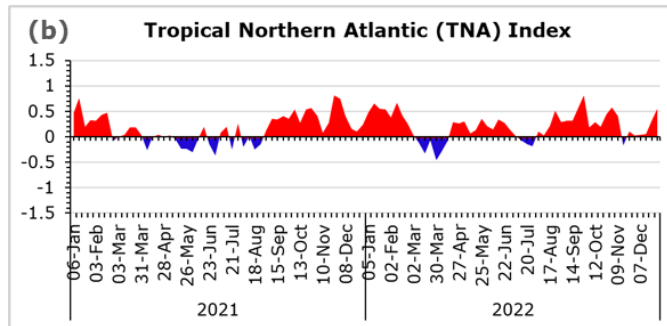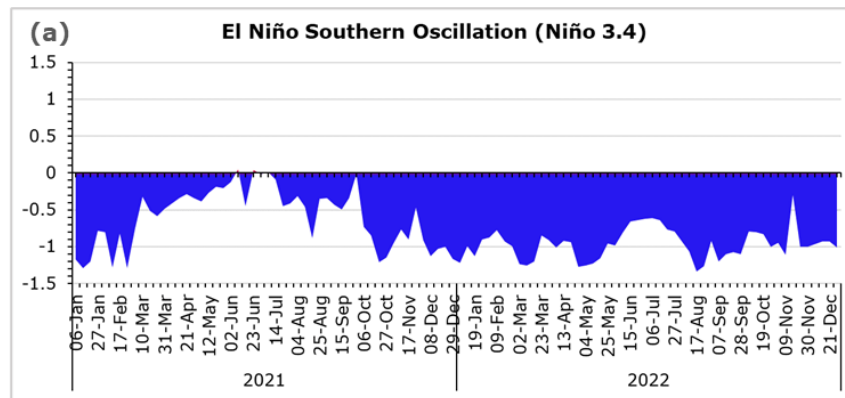
Figure 7. Time series of climate indices for 2021 and 2022 relative to 1981–2010: (a) Niño 3.4 index [5°S–5°N; 170°W–120°W]; (b) Tropical Northern Atlantic index [5.5°N-23.5°N; 15°W-57.5°W]; (c) Tropical Southern Atlantic index [0–20°S; 10°E–30°W]; (d) South-western Indian Ocean index [32°S–25°S; 31°E–45°E]; (e) Dipole Mode Index (DMI)[1].

Source: ACMAD, based on data from the State of the Ocean Climate and NOAA National Centers for Environmental Prediction (Reynolds, R. W.; Rayner, N. A.; Smith, T. M. et al. An Improved In Situ and Satellite SST Analysis for Climate. *Journal of Climate* **2002**, *15* (13), 1609–1625. https://doi.org/10.1175/1520-

Thank you for your attention! Any questions?

7/12/2023