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Sea Surface Temperature, Sea level rise indices and related drivers in the State of the Climate in Africa Report

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Sea Surface Temperature indices and related drivers

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

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];

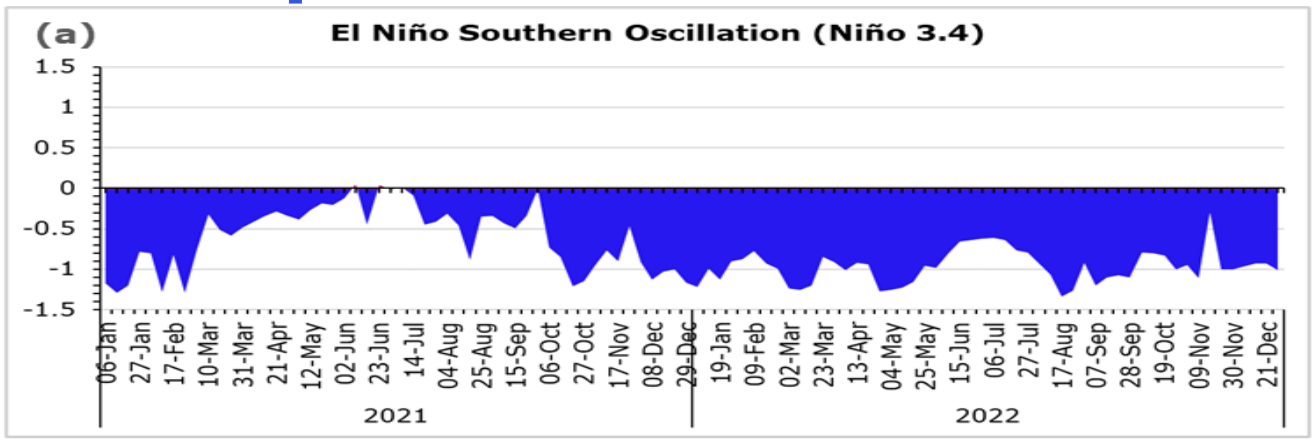
(c) Tropical Southern Atlantic index [0–20°S; 10°E–30°W];

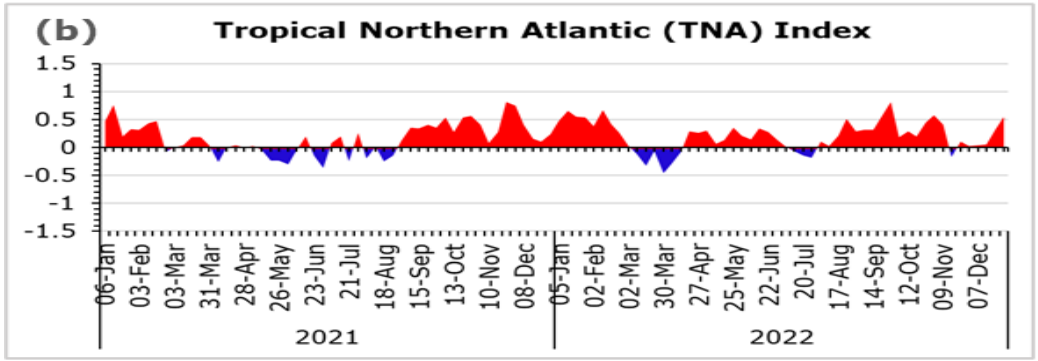
(d) South-western Indian Ocean index [32°S–25°S; 31°E–45°E];

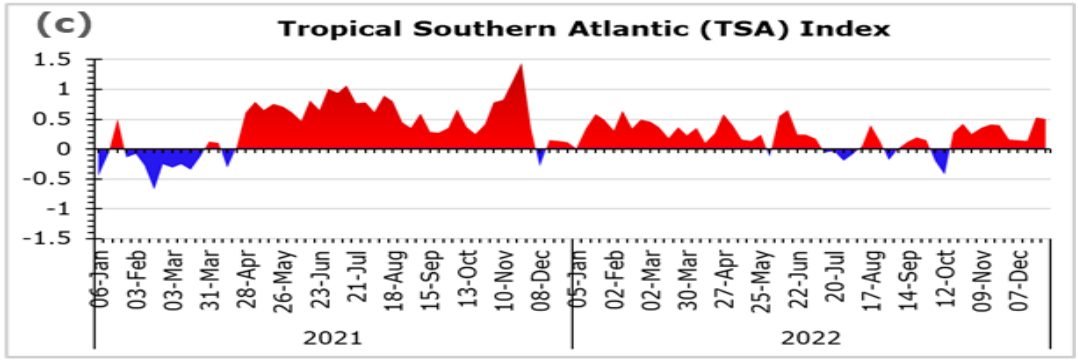
(e) Dipole Mode Index (DMI) (The DMI is the difference between the SST anomalies over the tropical western Indian Ocean [10°S–10°N; 50°E–70°E] and the tropical eastern Indian Ocean [10°S–0; 90°E–110°E])

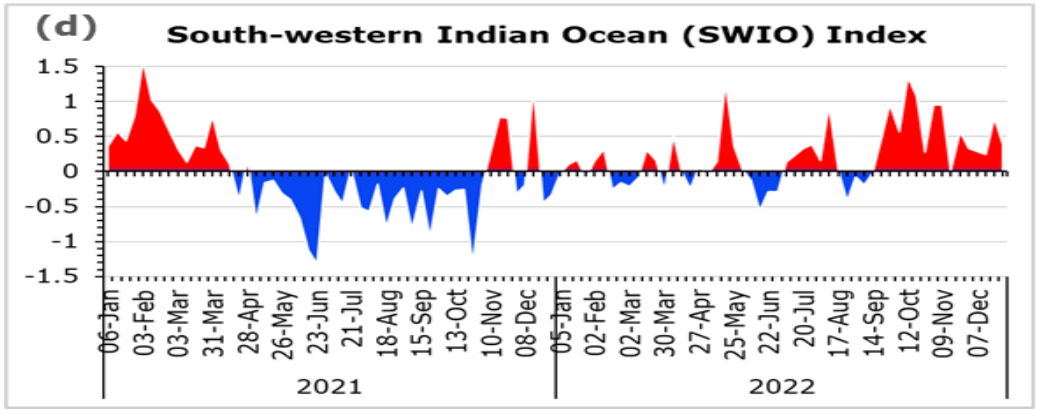
Source: Data from the State of the Ocean Climate and NOAA National Centers for Environmental Prediction (Reynolds, R. W.; Rayner, N. A.; Smith, T. M. et al. An Improved In Situ and Satellite SST Analysis for Climate. *Journal of Climate* **2002**, *15* (13), 1609–1625. https://doi.org/10.1175/1520-0442(2002)015<1609:AIISAS>2.0.CO;2.)

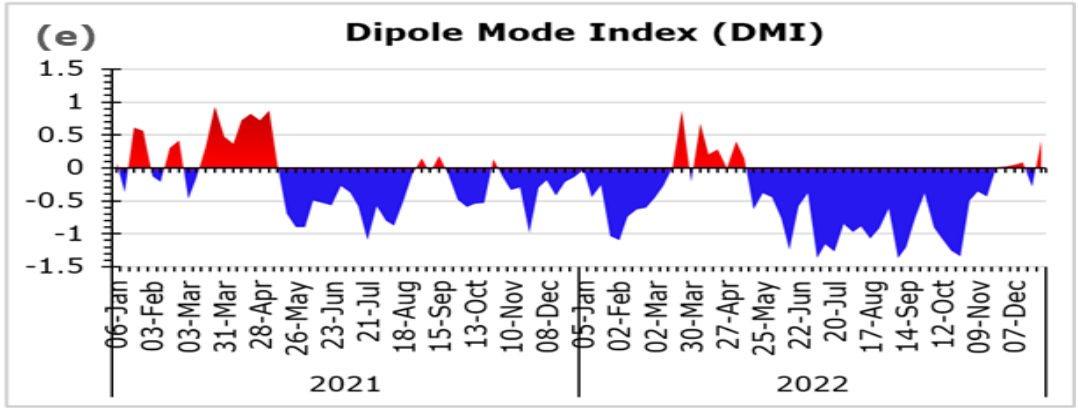
Sea Surface Temperature indices and related drivers











Interpretations

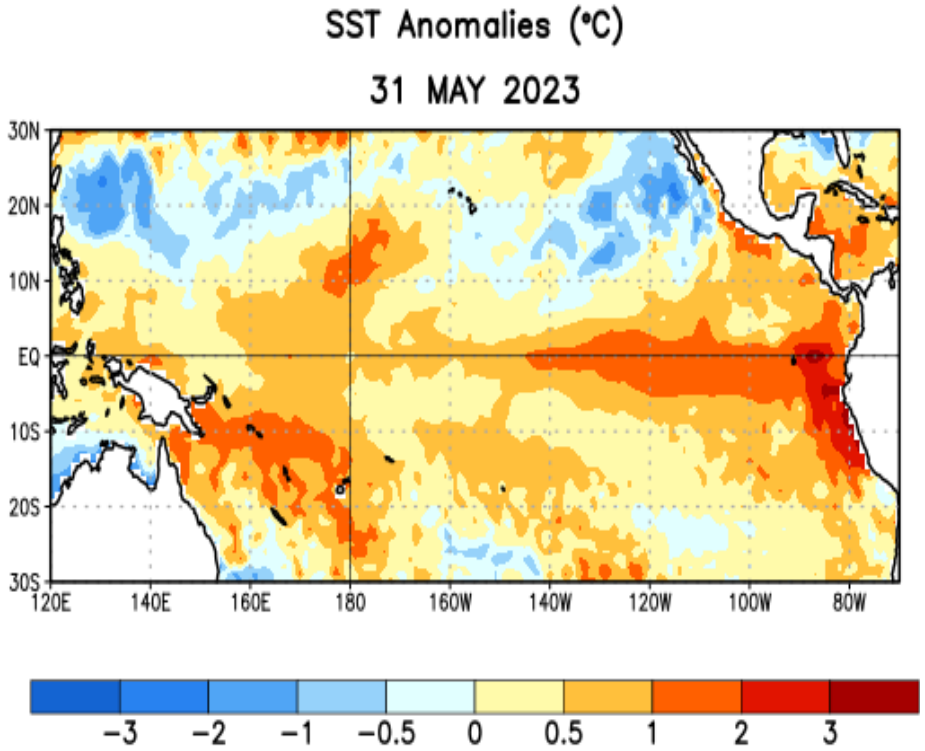
- La Niña episode signal measured using Niño 3.4 index started in 2020 and lasted through 2022 with brief interruption in 2021 (Figure 7a). It may have contributed to above-average summer precipitation in the Sahel.

- Positive SST anomalies over the tropical Atlantic Ocean are usually favourable for above-average summer rainfall over West Africa (Figure 7b and Figure 7c).

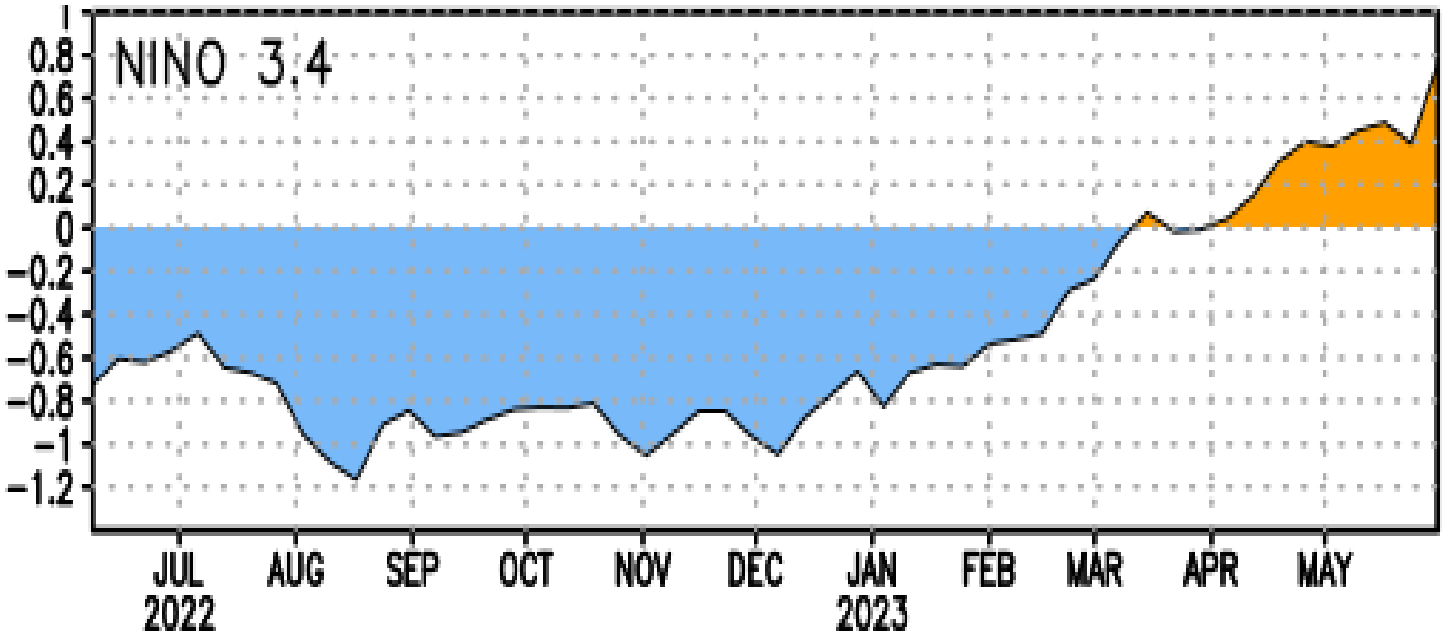
- Warmer SSTs over the SWIO region favoured well above-average precipitation in many parts of South Africa and South Madagascar (Figure 7d).

- 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.

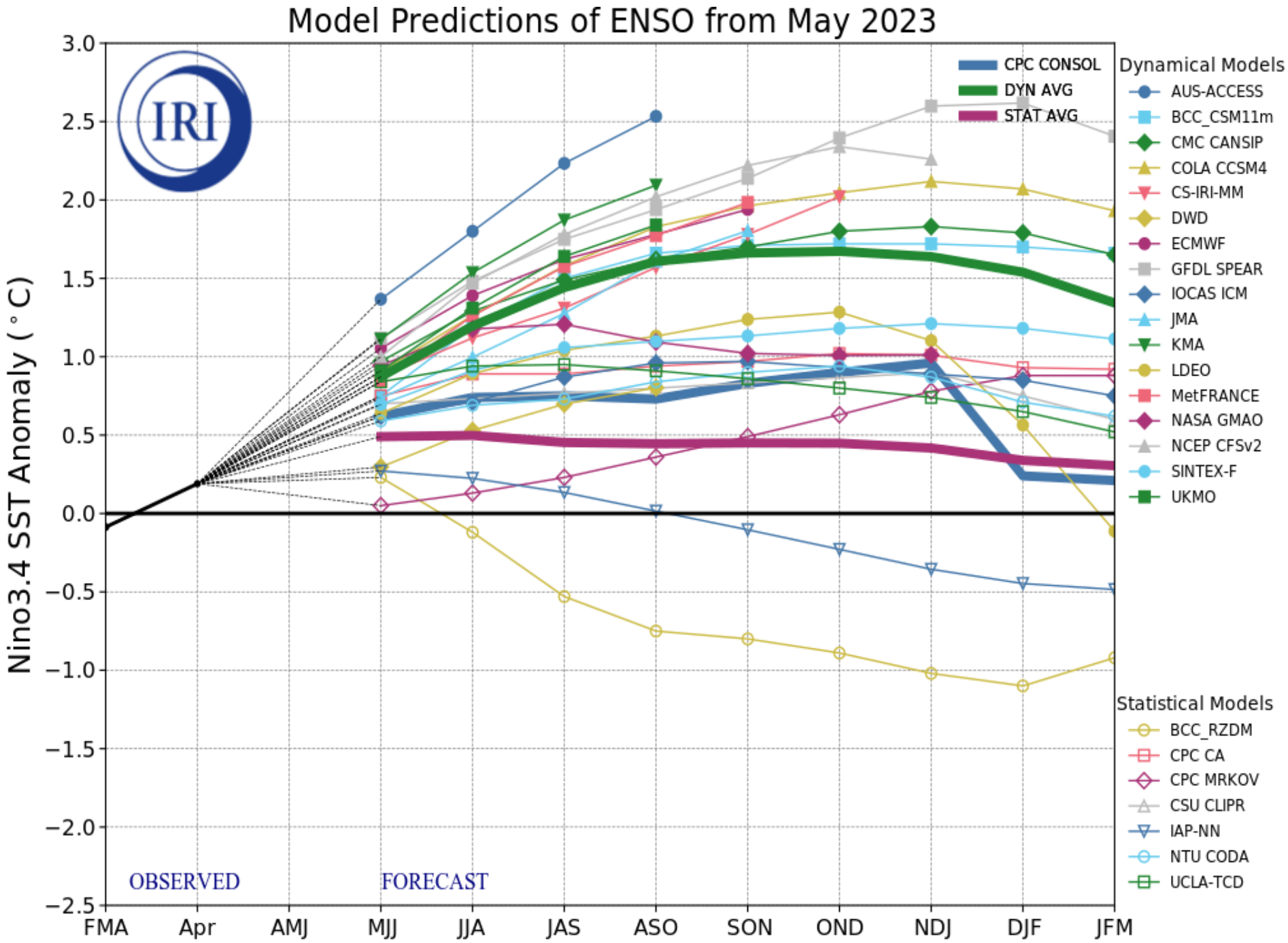
CLIMATE PREDICTION CENTER/NCEP/NWS
8 June 2023



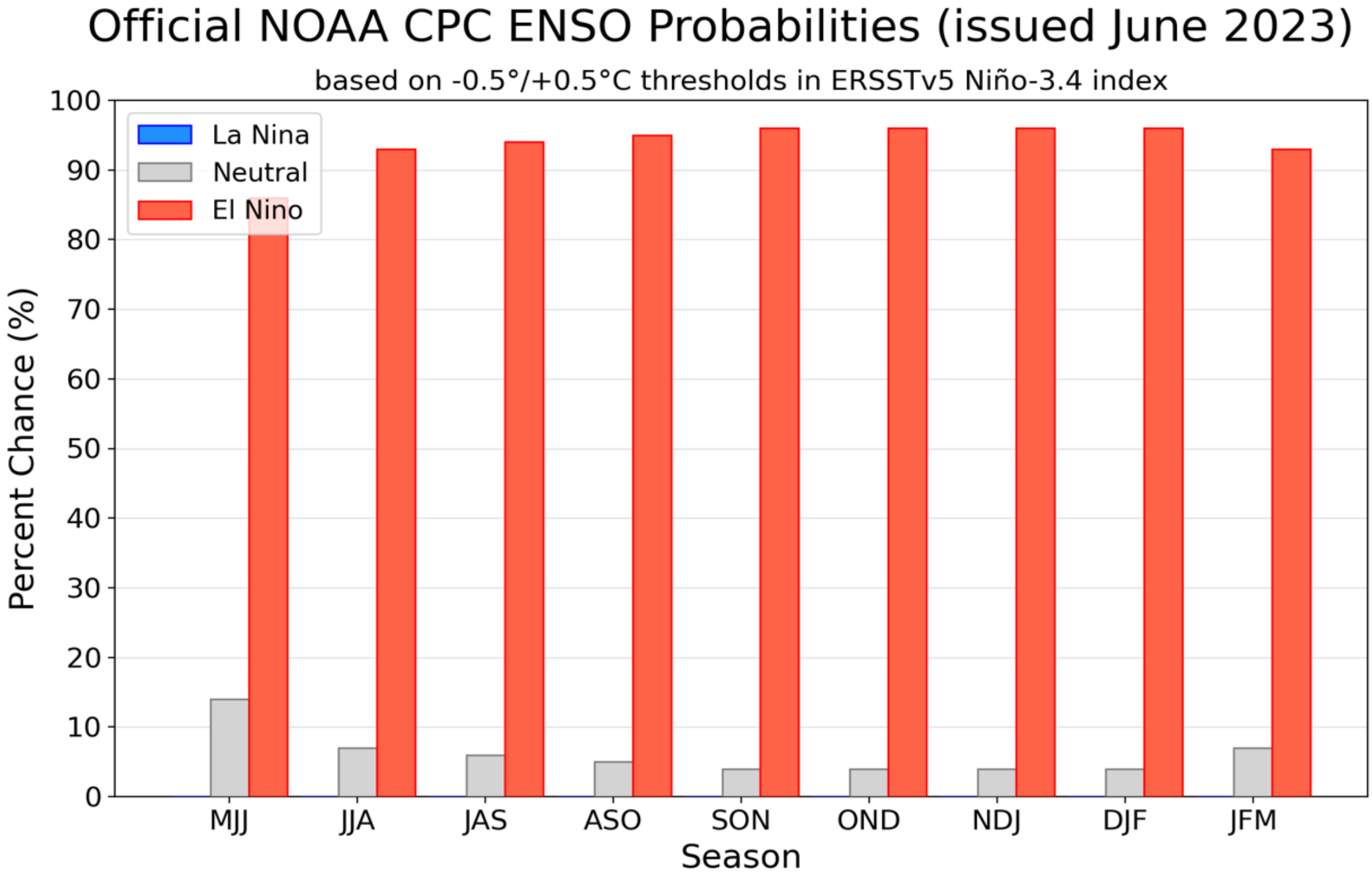
Average sea surface temperature (SST) anomalies (°C) for the week centered on 31 May 2023. Anomalies are computed with respect to the 1991-2020 base period weekly means.



Time series of area-averaged sea surface temperature (SST) anomalies (°C) in the Niño regions - Niño-3.4 (5°N-5°S, 170°W-120°W). SST anomalies are departures from the 1991-2020 base period weekly means.



Forecasts of sea surface temperature (SST) anomalies for the Niño 3.4 region (5°N-5°S, 120°W-170°W). Figure updated 19 May 2023 by the International Research Institute (IRI) for Climate and Society.


Official NOAA CPC ENSO Probabilities (issued June 2023)
based on -0.5°/+0.5°C thresholds in ERSSTv5 Niño-3.4 index
La Nina
Neutral
El Nino
Percent Chance (%)
100
90
80
70
60
50
40
30
20
10
0
MJJ
JJA
JAS
ASO
SON
OND
NDJ
DJF
JFM
Season

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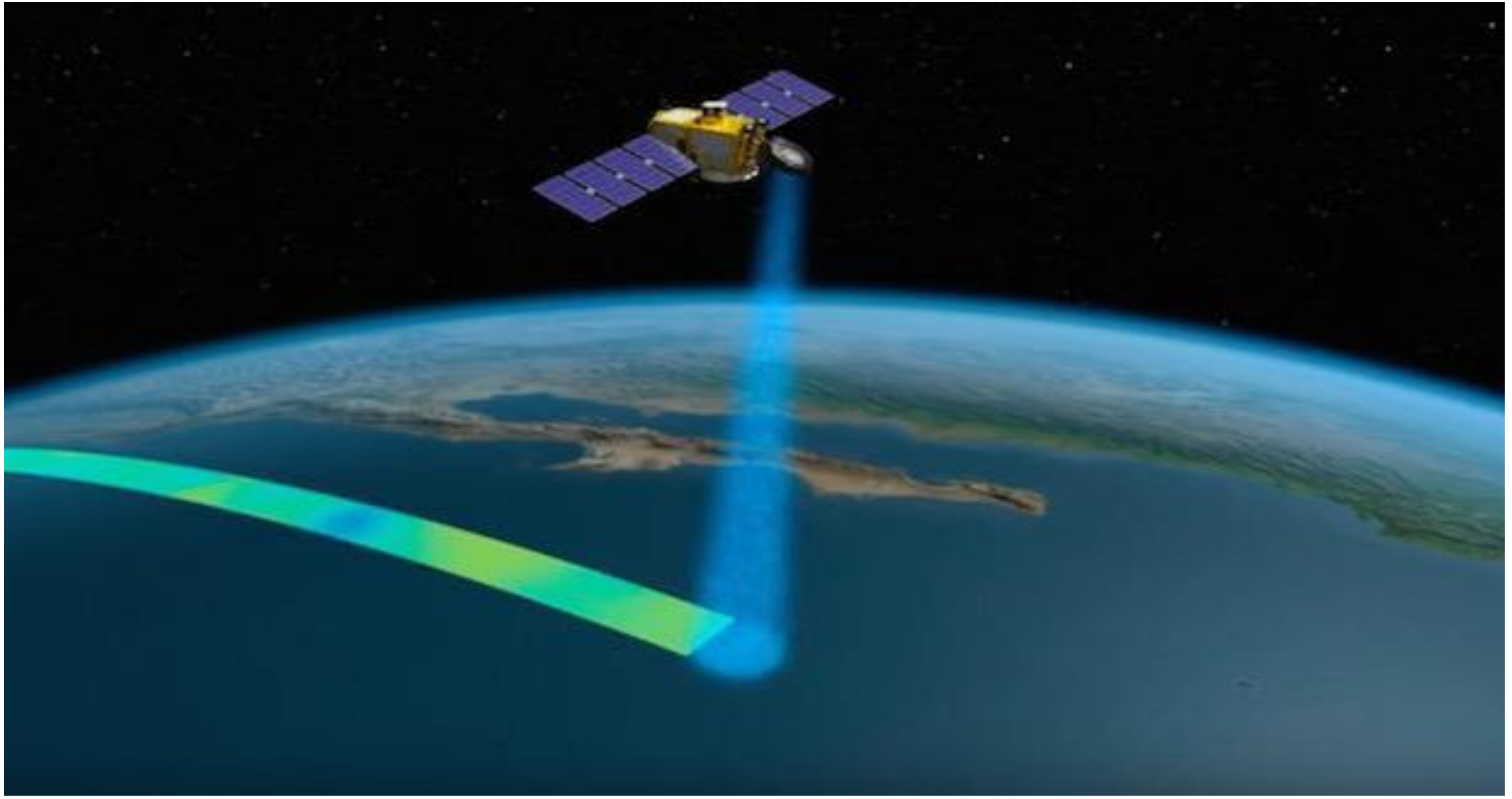
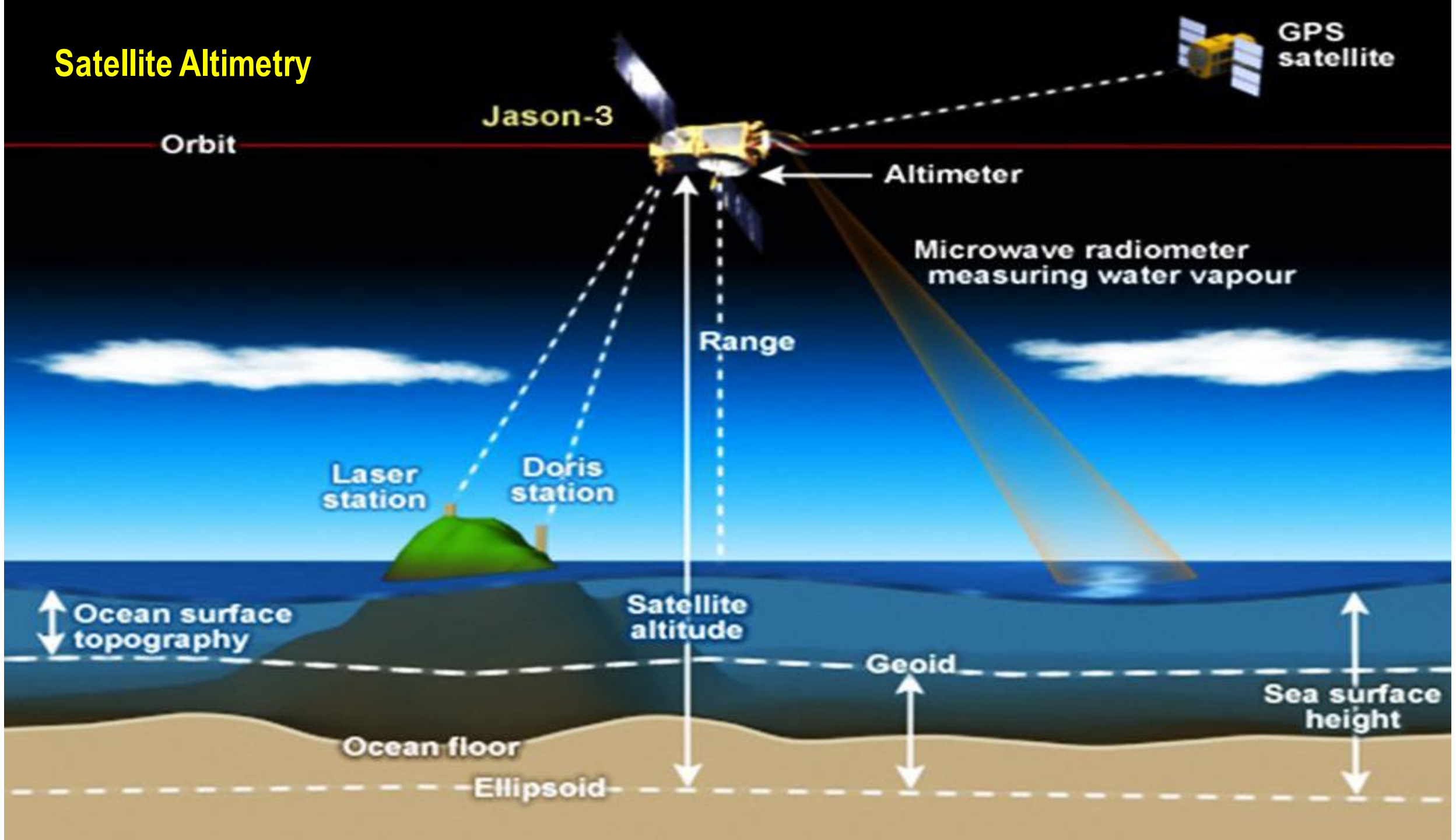
Satellite altimetry for measuring Sea Surface Topography

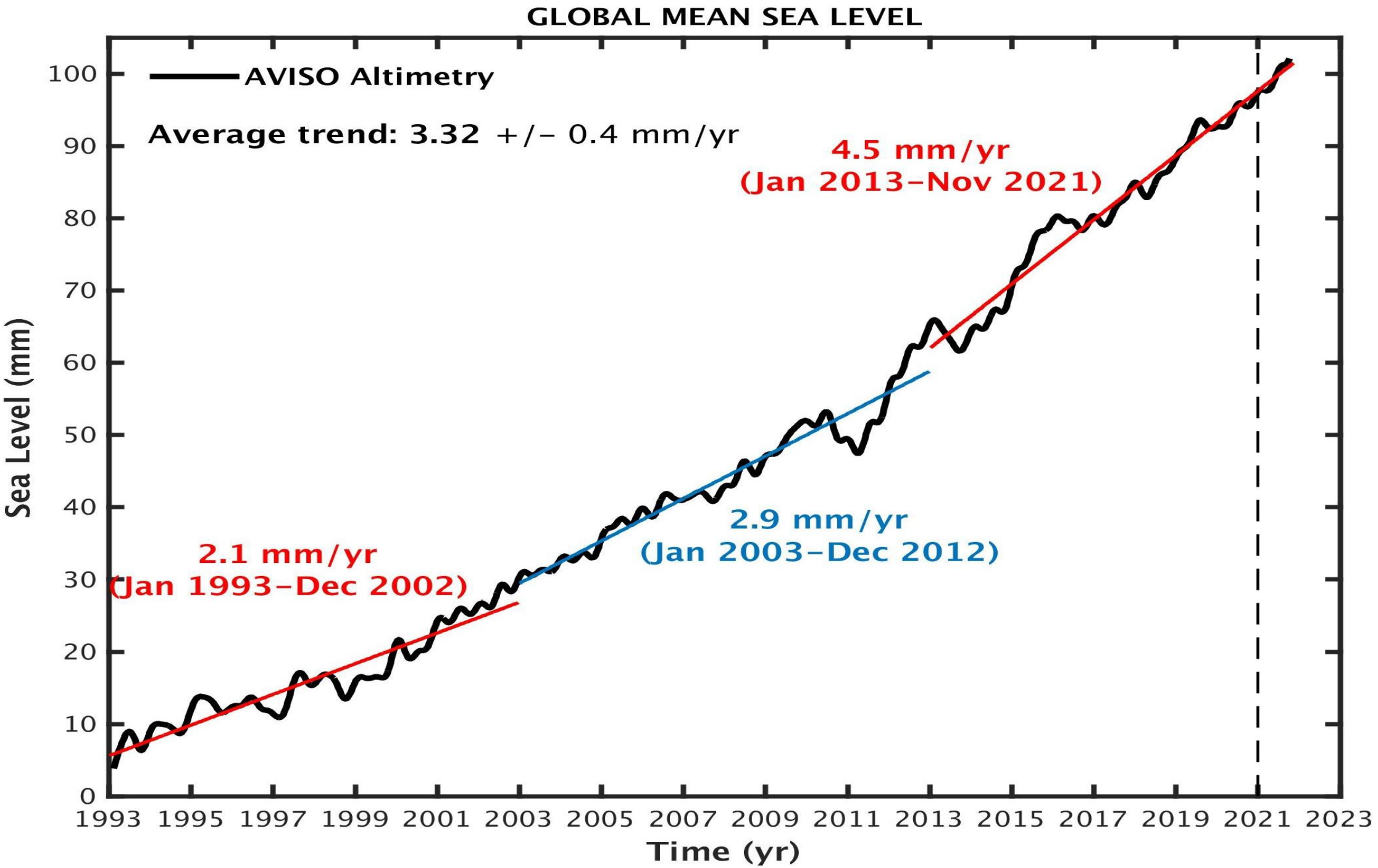


Applications of Sea Surface Height (SSH) measurements by satellite altimetry

- Mean sea surface and sea floor topography → marine geophysics
- Currents → ocean circulation
- Ocean tides
- ENSO event (El Nino, La Nina)
- Operational oceanography (ocean state forecast~2 weeks in advance)
- Sea level variations → most demanding application of satellite altimetry

Satellite Altimetry

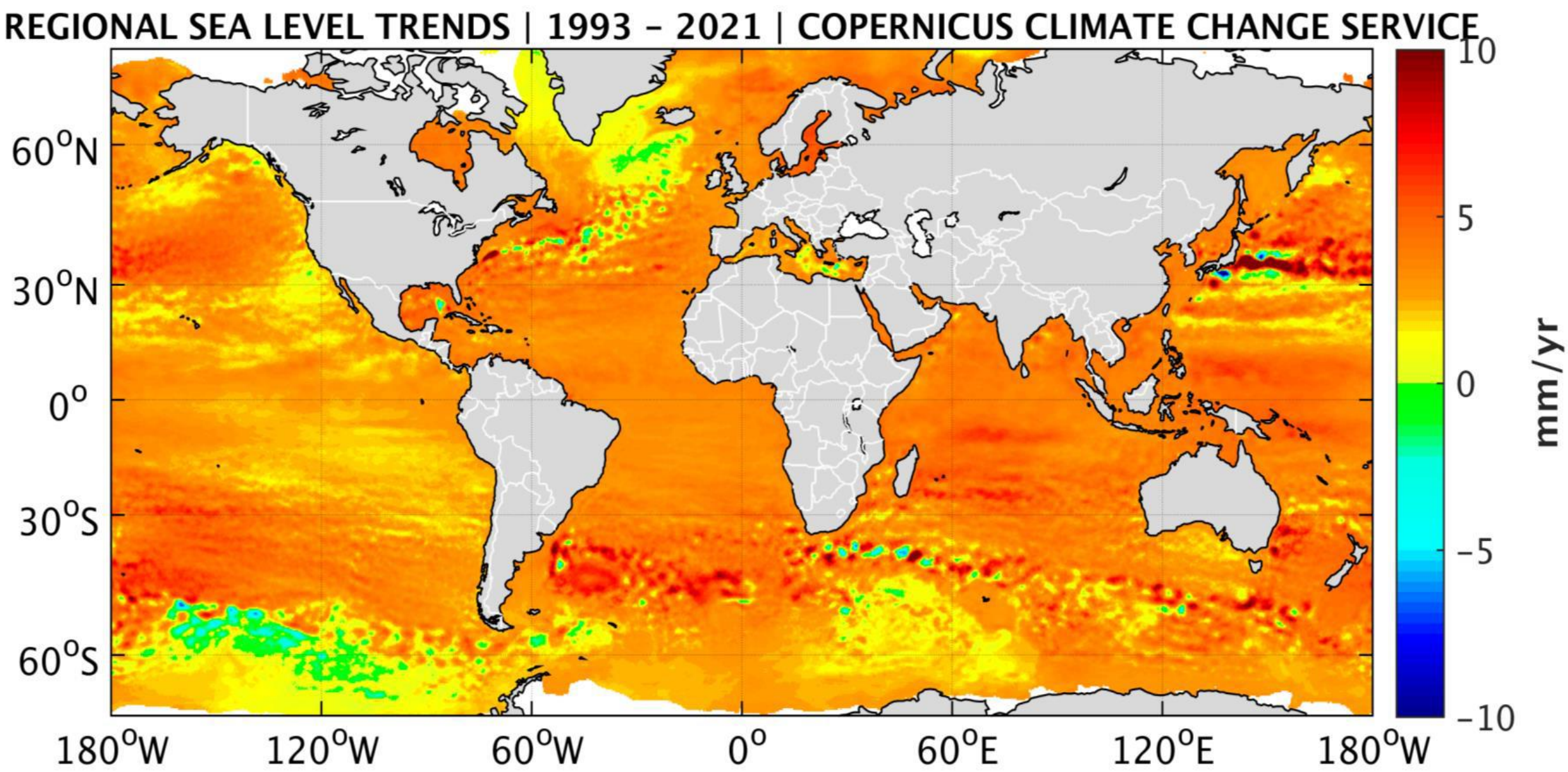




Source: LEGOS

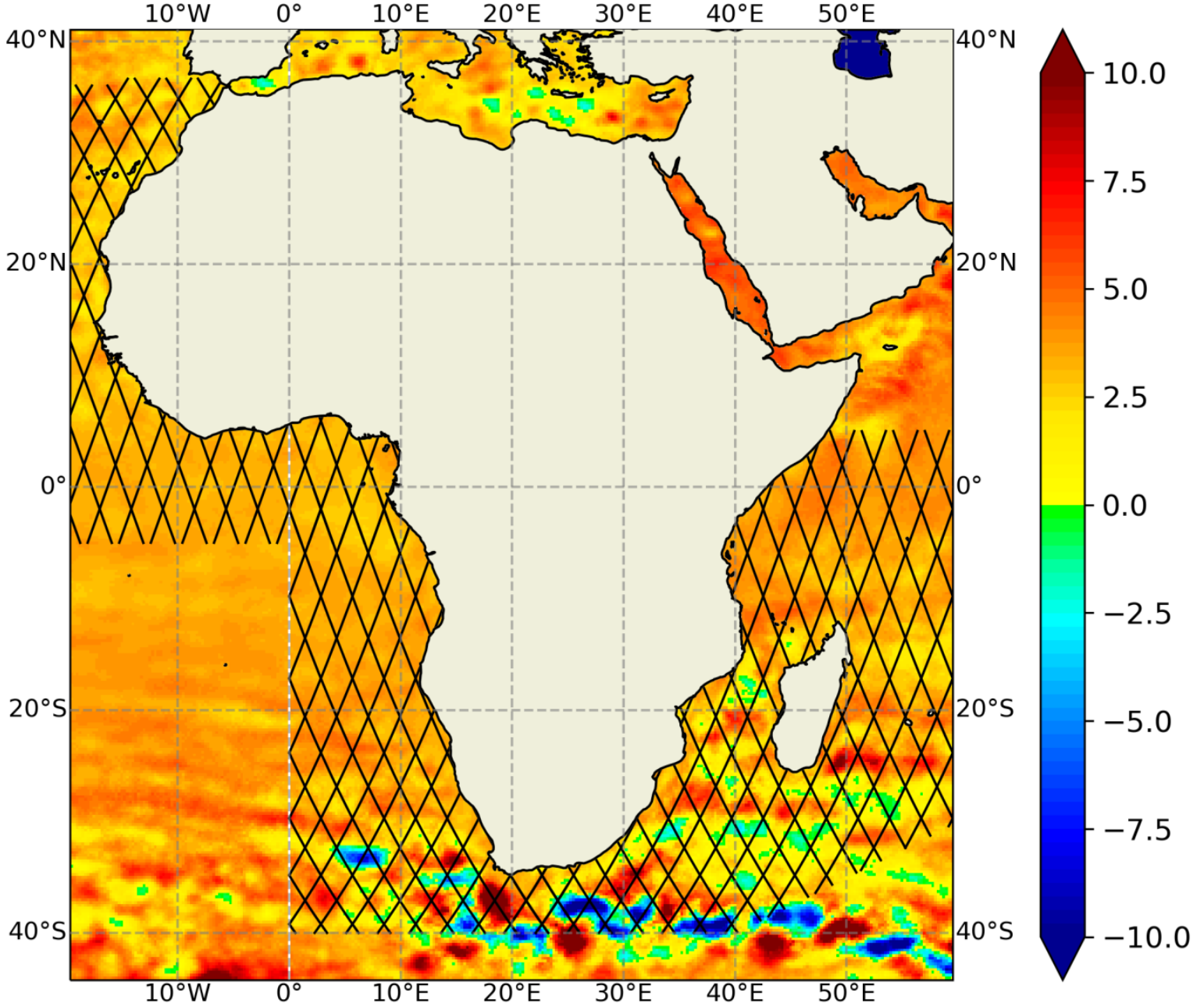
Main sources of sea level trend uncertainty

Source	Trend errors (mm/yr)
Orbit error	~ 0.2
Wet troposphere correction (instrumental drift of on board radiometers)	~0.2
Dry troposphere correction (uncertainty of atm. surface pressure data)	~ 0.1
Sea state bias correction	~ 0.1
Total error	~ 0.3

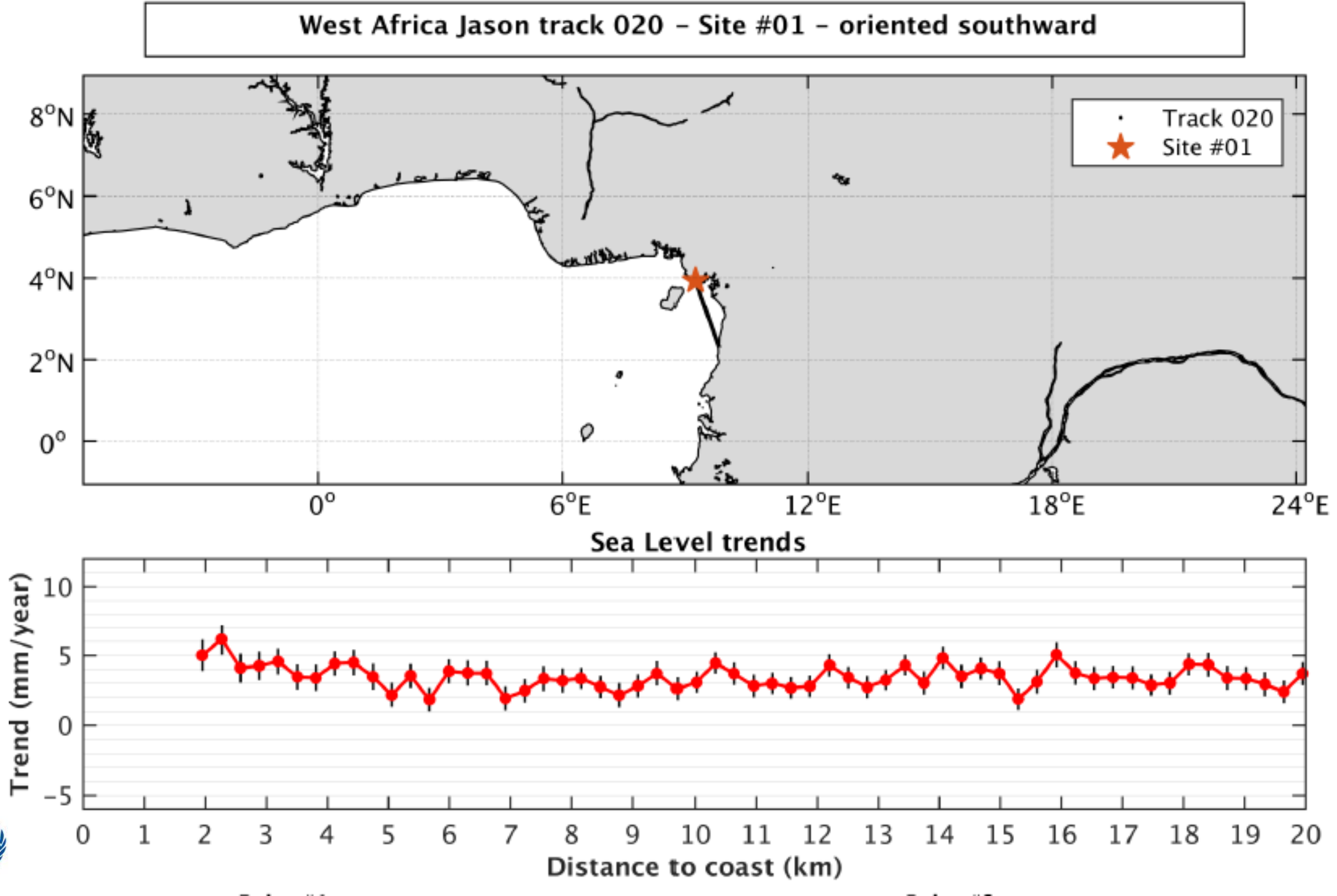

REGIONAL SEA LEVEL TRENDS | 1993 – 2021 | COPERNICUS CLIMATE CHANGE SERVICE
60°N
30°N
0°
30°S
60°S
180°W
120°W
60°W
0°
60°E
120°E
180°W
10
5
0
−5
−10
mm/yr
E.U. Copernicus, CNES, LEGOS, CLS

In many regions of the world, the shoreline is eroding and retreating

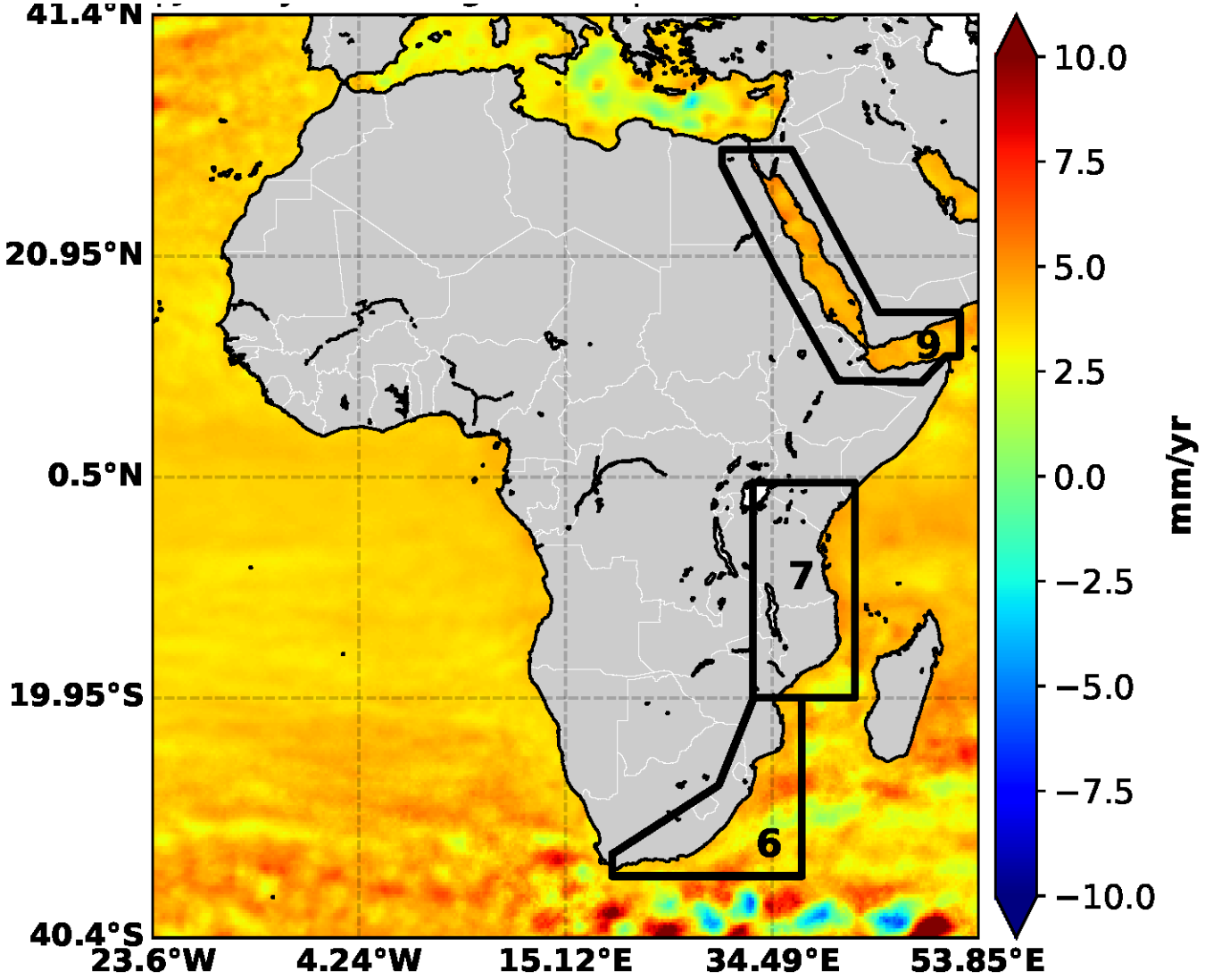
SEA LEVEL TRENDS | JANUARY 1993 - JUNE 2020 | COPERNICUS CLIMATE CHANGE SERVICE



WMO


West Africa Jason track 020 – Site #01 – oriented southward
Track 020
Site #01
8°N
6°N
4°N
2°N
0°
0°
6°E
12°E
18°E
24°E
Sea Level trends
Trend (mm/year)
10
5
0
−5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Distance to coast (km)

Sea Level Rise

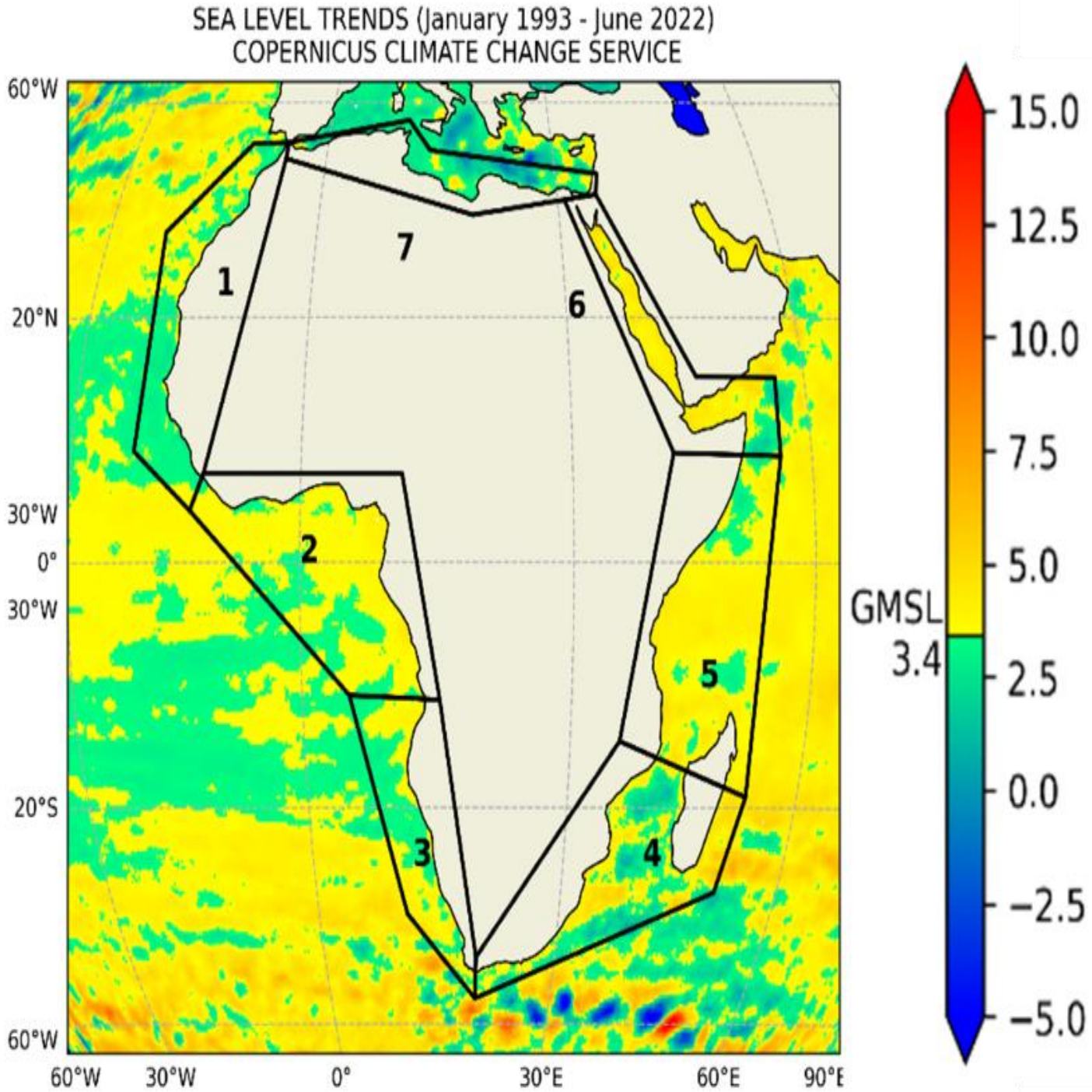


Rate of sea level rise in the 12 coastal regions of Africa. Source: Copernicus

- The rate of sea level rise around Africa is higher than the global mean (3.3 mm/year), as highlighted in the IPCC AR6.

- Relative sea level rise is likely to continue around Africa, contributing to increases in the frequency and severity of coastal flooding in low-lying areas. Associated damages of sea level rise in sub-Saharan countries could amount **2-4%** of the GDP by 2050.

- The highest rates of sea level rise observed in 2021 around Africa are observed along Southwest Indian Ocean and the Red Sea with approximately **4 mm/yr**



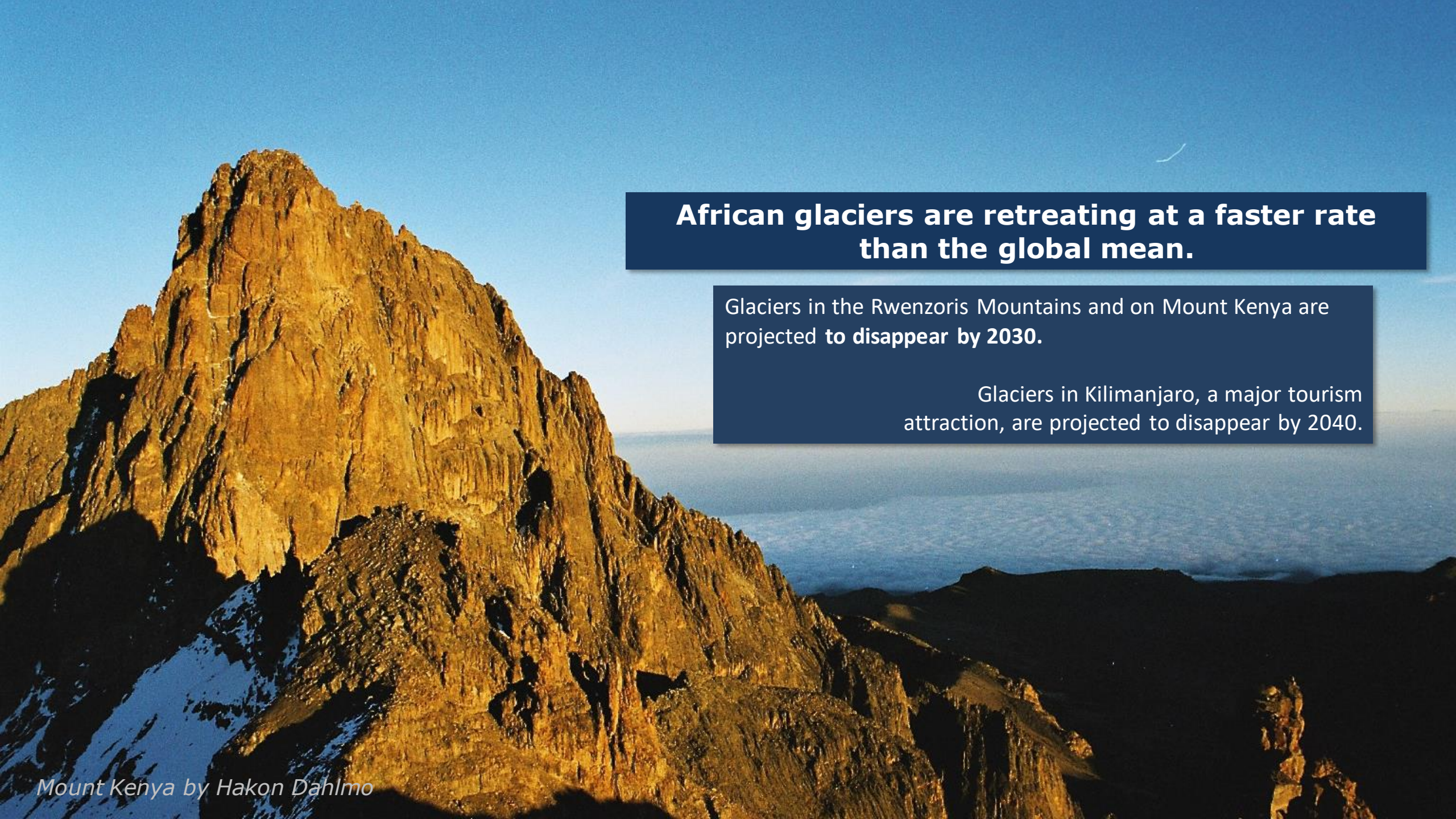
Box number	Ocean	Rate of sea level rise (mm/yr)
1	Northeast Atlantic	3.15 ± 0.1
2	Tropical Atlantic	3.38 ± 0.1
3	Southeast Atlantic	3.33 ± 0.1
4	Southwest Indian Ocean	3.23 ± 0.1
5	Western Indian Ocean	3.55 ± 0.2
6	Red Sea	3.71 ± 0.2
7	Southern Mediterranean Sea	2.36 ± 0.2
-	**Global**	**3.4 ± 0.3**

Sea-level trends at the 7 coastal regions of Africa covering the period from January 1993 to June 2022: the Northeast Atlantic (1), the Tropical Atlantic (2), the Southeast Atlantic (3), the Southwest Indian Ocean (4), the western Indian Ocean (5), the Red Sea (6), and the southern Mediterranean Sea (7). Right: Table indicating the sea-level rise in mm/yr for the 7 coastal regions of Africa and the global ocean.

Source: **Copernicus Climate Change Service (C3S). See C3S Climate Data Store for more information on the data sets and methodology used to measure sea-level rise.**

COASTAL SEA LEVEL OVER AFRICA

- **Since the early 1990s, sea level has been routinely measured globally and regionally by high-precision altimeter satellites**
- **Over the past three decades, the global mean sea level has risen at an average rate of 3.4 ± 0.3 mm/yr and has accelerated in response to ocean warming and land ice melt**
- **The rate of sea-level rise in the coastal regions of Africa does not differ much from the global mean over the same period**
- **The highest rate of sea-level rise around Africa has been observed along the coastal areas of the Red Sea (box 6), with a rate of 3.71 mm/yr, followed by the western Indian Ocean (box 5), where the rate exceeds 3.55 mm/yr. The rate of sea-level rise is lower than the global mean over the Mediterranean Sea (box 7), with a rate of about 2.36 mm/yr.**
- **The sea-level rise was measured in the 7 coastal regions of Africa from January 1993 to June 2022 (Figure next).**



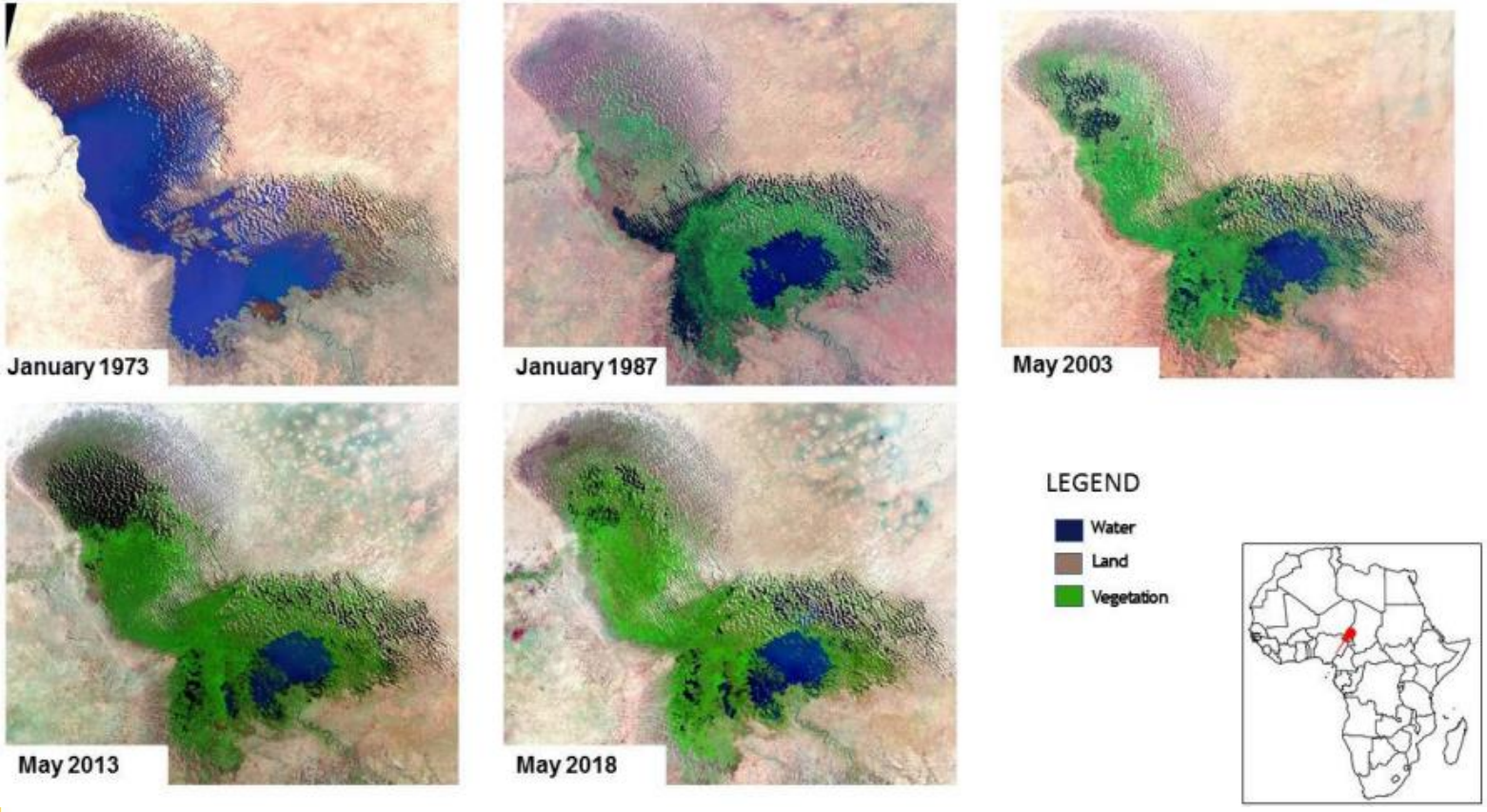
African glaciers are retreating at a faster rate than the global mean.

Glaciers in the Rwenzoris Mountains and on Mount Kenya are projected **to disappear by 2030.**

Glaciers in Kilimanjaro, a major tourism attraction, are projected to disappear by 2040.

Mount Kenya by Hakon Dahlmo

Continental Water Bodies: Lake Chad



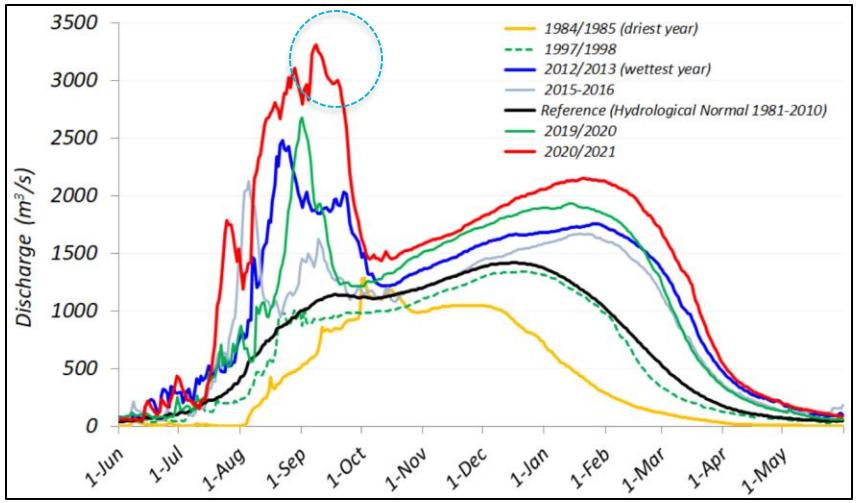
- A major evidence of threats to natural fresh water bodies, is the shrinking of natural lakes, due to various factors, including land use and climate change.
- The water surface area of Lake Chad shrunk 90% from the 1960s - 2000s average levels. *Maps are based on Landsat images from the United States Geological Survey*

Lake Chad – Declining water levels from January 1973 to May 2018. Source: UNU-INWEH, based on Landsat images from the United States Geological Survey"

Rainfall and river flows

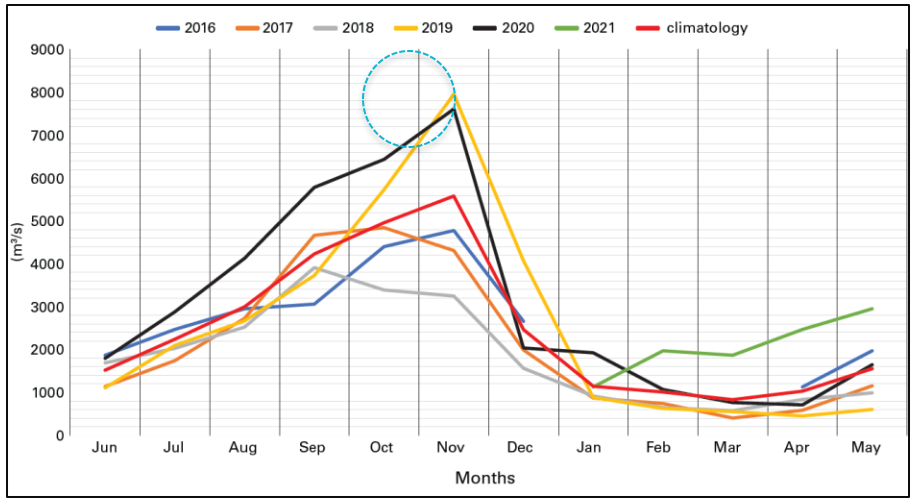
In 2020 many African lakes and rivers reached record high levels, including Lake Victoria, the Niger River and the Blue Nile

Daily flows (m^3/s) of the Niger River, at Niamey station



Source: Regional Training Centre for Agrometeorology and Operational Hydrology and their Applications (AGRHYMET)

Monthly flow (m^3/s) of the Congo-Oubangui river



Source: Hydroweb, http://hydroweb.theialand.fr/hydroweb/

The monthly flow of rivers Congo-Oubangui and Niger, significantly exceeded the average values due to higher-than-normal rainfall recorded in Congo basin and the Sahel

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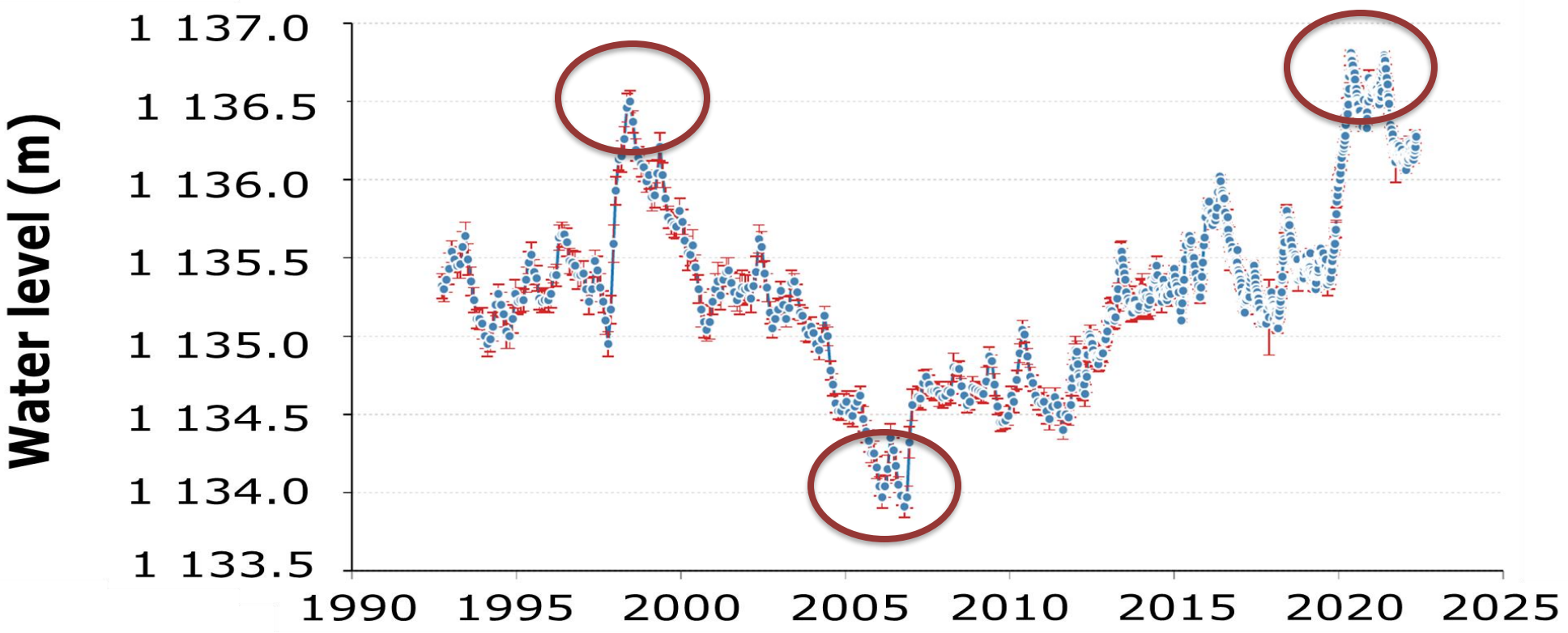
Continental Water Bodies: Lake Victoria

Around 80% of the refill of Lake Victoria comes from direct rainfall and only 20% from the basin discharge.



Lake Victoria water level from September 1992 to May 2022. Source: Hydroweb portal

1997/1998: Extreme precipitation associated with El Niño

2006: Severe drought and strong negative IOD phase

Late 2019/early 2020: Intense precipitation and positive phase of the IOD

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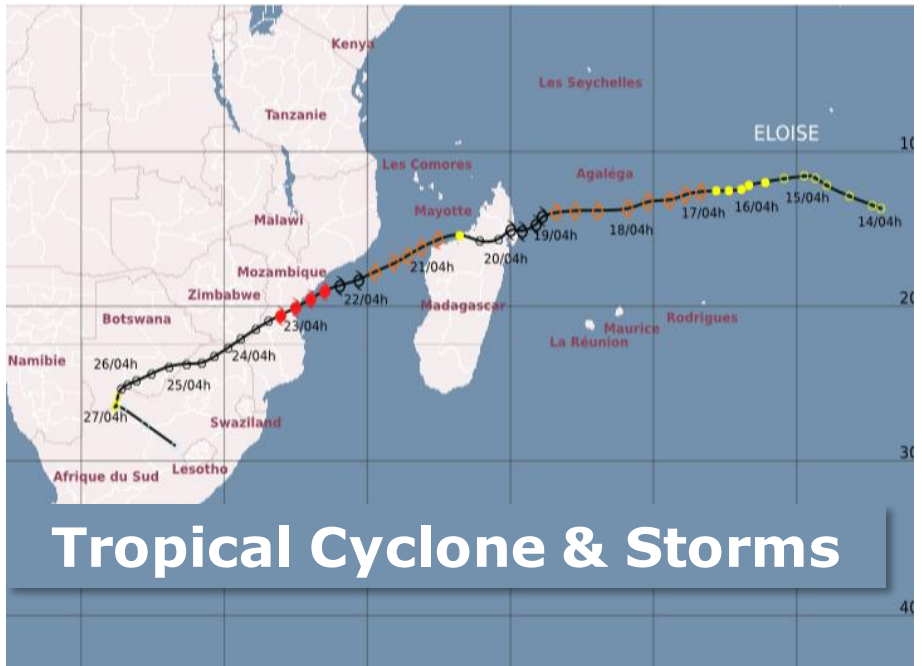
Extreme Events in Africa



Extreme & High-Impact Events

- **80 meteorological, hydrological and climate-related hazards reported in 2022**
- **56% were flood-related events**
- **Natural hazard events resulted in around 5,000 fatalities, of which 48% were associated with drought and 43% were associated with flooding**
- **Overall, more than 110 million people were directly affected by these disaster events, causing a total economic damage of over USD 8.5 billion**
- **Drought was the leading cause of death and people affected**
- **Flood was the leading cause of economic damages during the year**
- **WARNING:** *Real figures related to the impacts of extreme events are presumed to be greater because of underreporting*

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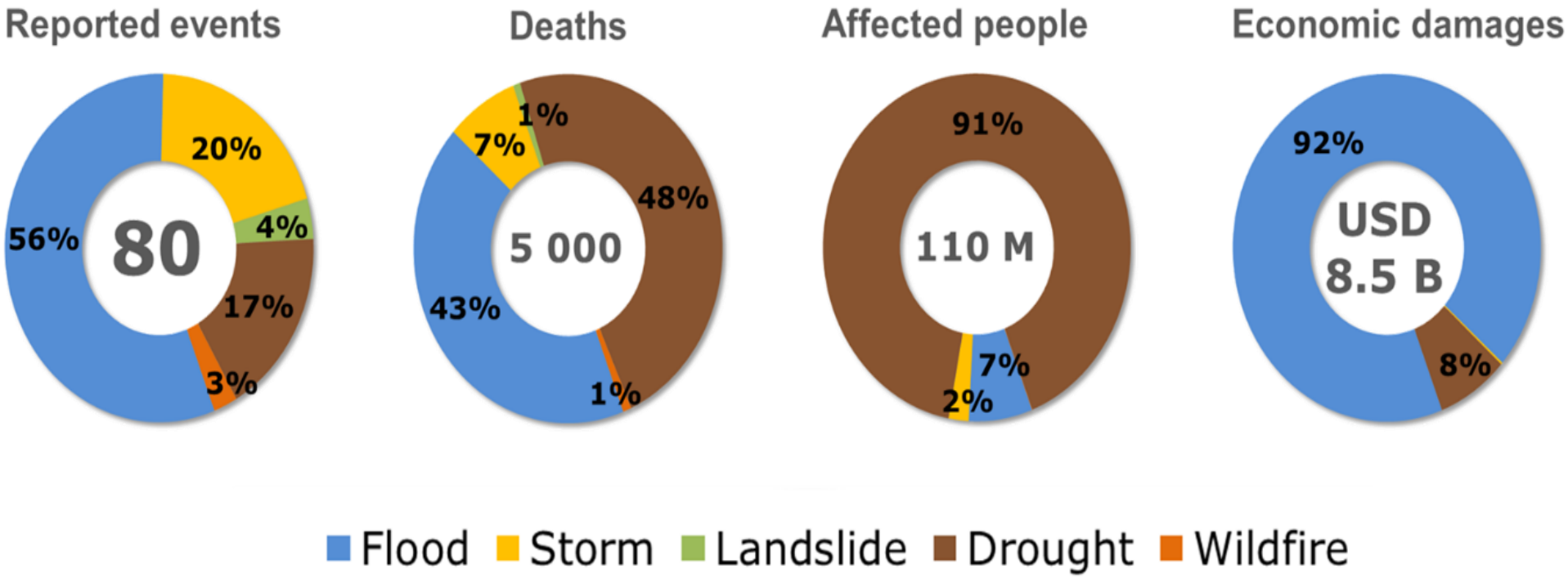
Source: International Disaster Database (EM-DAT)

Extreme Events in 2022



Weather-, climate- and water-related disasters in Africa in 2022. Note: Figures, including economic damages of some disaster occurrences are not presented in the diagram due to data unavailability. *Source*: Data from EM-DAT

Extreme Events

- **The worst flooding in the year affected 5.9 million people across 20 countries in West and Central Africa**
- **In West and Central Africa, floods killed more than 1 000 people, injured 40 000 and displaced over 1.8 million people**
- **Reports from OCHA indicated that Nigeria, Chad, Niger, the Republic of Congo, the Democratic Republic of Congo, Cameroon, Central Africa Republic, and Liberia were severely impacted by heavy rains and floods**
- **The worst drought in more than 40 years hit the Horn of Africa due to five consecutive below-average rainfall. It affected Eritrea, Ethiopia, Djibouti, Kenya and Somalia**

- https://reliefweb.int/report/nigeria/west-and-central-africa-flooding-situation-8-november-2022#:~:text=Attachments&text=As%20of%208%20November%202022%2C%20the%20worst%20flooding%20in%20years,in%20West%20and%20Central%20Africa.
- https://reliefweb.int/report/democratic-republic-congo/west-and-central-africa-weekly-regional-humanitarian-snapshot-14-20-march-2023
- https://reliefweb.int/report/ethiopia/horn-africa-drought-regional-humanitarian-overview-call-action-published-4-july-2022

North Africa

Snow accumulation on 25 January 2022 over buildings and roads (left). Sandstorm with low visibility in Tripoli from 19 – 20 March 2022 (right)

***Source*: Archives of Libyan Meteorological Services**

West Africa

- **Nigeria experienced one of the worst floods in 2022. The flooding was aggravated by the release of water from Lagdo Dam in Cameroon. OCHA indicated that 4.4 million people were affected, 2.4 million people were displaced and over 600 died. 4.1 million people faced food insecurity and over 650 000 hectares of farmland were destroyed. The flooding brought about a severe cholera outbreak that killed over 465 people and affected over 18 000 people.**

- **The floods experienced in West Africa resulted from extreme rainfall events leading to the overflow of rivers and the spillage of artificial dams. The spillage of the Weija Dam on 3 October 2022 led to the submergence of several communities in Accra, Ghana.**

- **The spillage of the Bagre Dam in Burkina Faso on 4 September 2022, affected about 28 districts and several communities living along the Black and White Volta rivers in northern Ghana.**

- **Other notable events included windstorms and hailstones in Nigeria. The harmattan dust haze with visibility less than 500 m affected the aviation industry, leading to delays and cancellations of flights with losses in millions of dollars.**

Central Africa

Floods in the Far North Region of Cameroon, October 2022. *Source*: OCHA and UNHCR/Moise

East Africa

A total of 70 million people were exposed to some level of drought risk

According to UNOCHA, people needing humanitarian help totaled 7 million in Ethiopia, 4 million in Kenya, and 5 million in South Sudan. In Somalia, as of May 2022, 6.1 million people have been affected by the drought emergency

The drought conditions from the East Africa Drought Watch of the Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC) showed drought stress relating to precipitation deficit over large part of southern and eastern Ethiopia, most of Somalia, Uganda, southern South Sudan, coastal regions of Kenya and some spots in Tanzania

https://www.unocha.org/sites/unocha/files/Global%20Humanitarian%20Overview%202022.pdf
https://edo.jrc.ec.europa.eu/documents/news/GDODroughtNews202208_East_Africa.pdf
https://droughtwatch.icpac.net/

Tropical storms/cyclones that affected Southern Africa during the 2022 cyclone season

S/N	Tropical Storm/ Cyclone	Month (2022)	Areas affected	Impacts
1	Ana	January	Madagascar, Mozambique, Malawi and Zimbabwe	171 deaths and 1.3 million affected
2	Batsirai and Emnati	February	Madagascar	136 deaths and 423 800 affected
3	Dumako	February	Madagascar and Mozambique	14 deaths and 33 700 affected
4	Gombe	March	Mozambique and Malawi	103 death and nearly 900 000 affected
5	Jasmine	April	Madagascar	5 000 affected with flooding, landslides, etc.

Agriculture and Food Security

58 million people in East Africa are experiencing acute food insecurity.

23.7 million people in the Sahel and West Africa were estimated to be in crisis or worse (IPC Phase 3)

Temperature rise contributed to a 34% reduction in agricultural productivity in Africa since 1961, more than any other region in the world.

Population Displacement

Around 14.1 million people were internally displaced in Sub-Saharan Africa in 2021, including over 2.5 million due to disasters.

High water stress is expected to displace up to 700 million people by 2030.

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