- Intra-ACP Climate Services and Related Applications
- Programme

- CLIMSA Presentations for 3rd Forum:
- 11 - 13 September 2023

UIP Infrastructure, Composition, Products and Services

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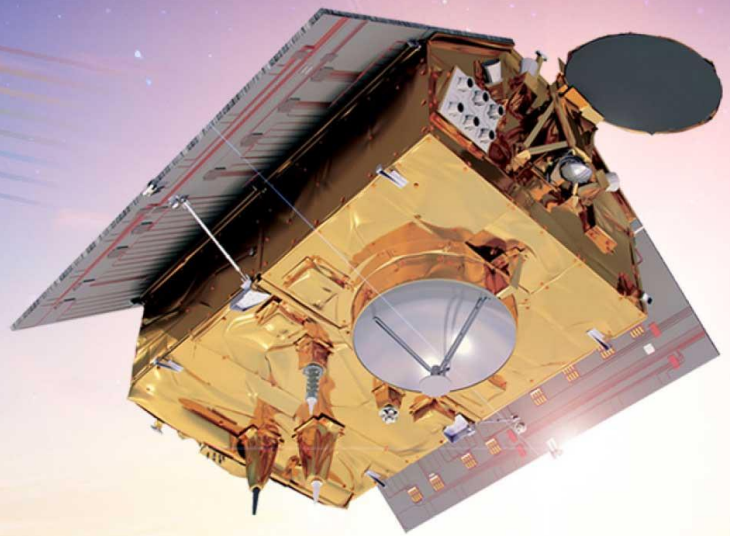
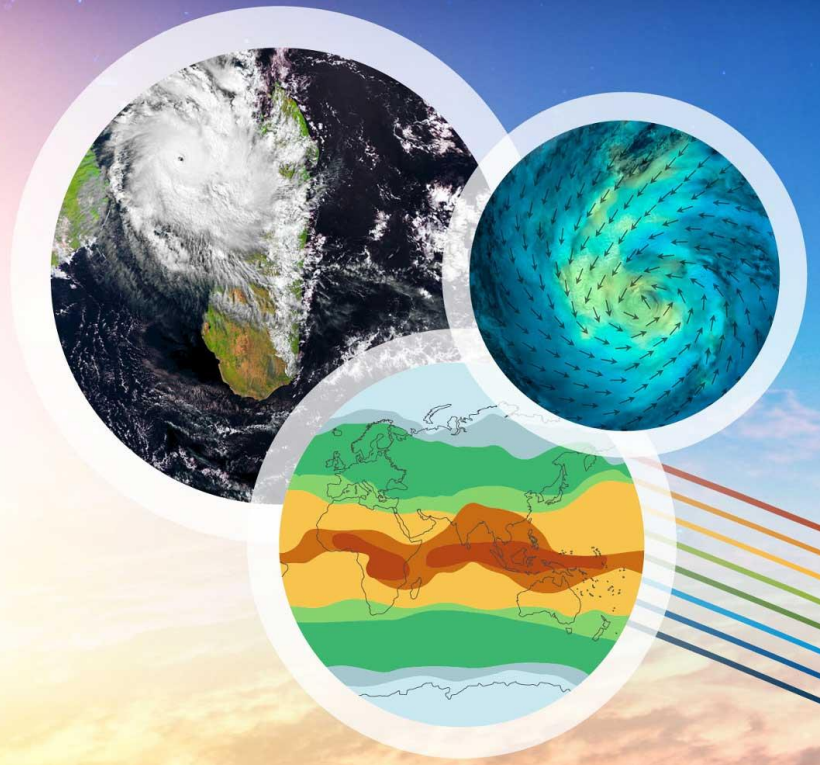
ACMAD

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

UIP Infrastructure, Composition, Products and Services





- OUTLINE OF
- CONTENT

01 Introduction
Objectives of presentation

02 Activities in ACMAD

03 Observation and Historical Climate

04 Future Scenarios

05 Likely Effects of Extreme Climates on Infrastructures

06 Conclusions

01 Introduction

02 Objectives of Presentation

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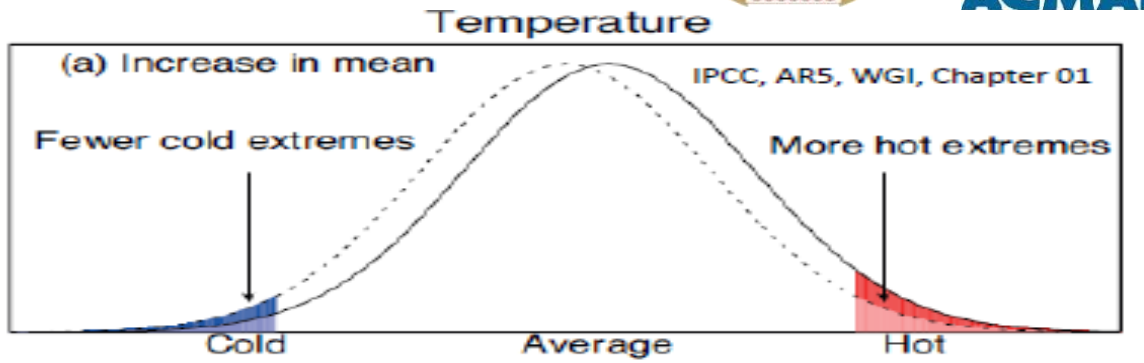
User Interface Platform with Emphasis on Climate Resilient Infrastructure Development in Africa:

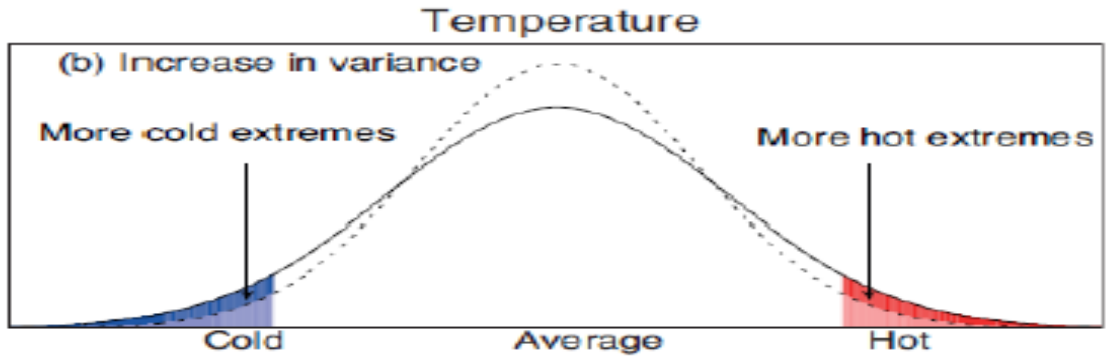
From a Climate Change Perspective

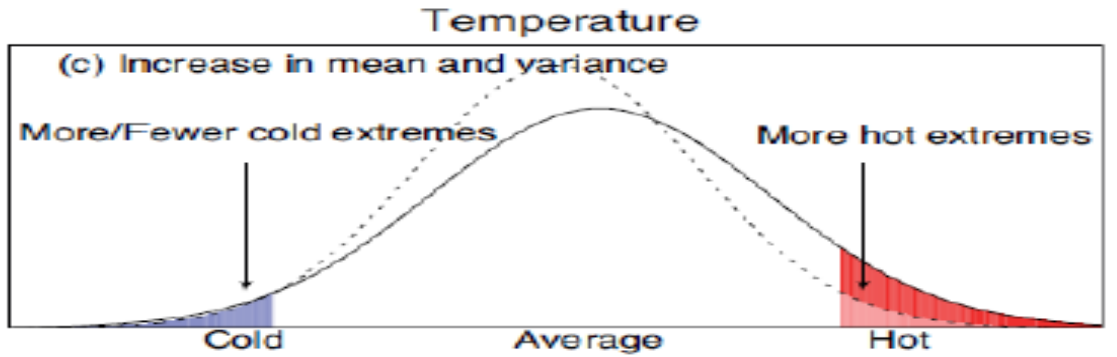
- ✓ **This presentation is targeted at discussing the climate crisis that are becoming recognized as national security crisis on African Continent.**

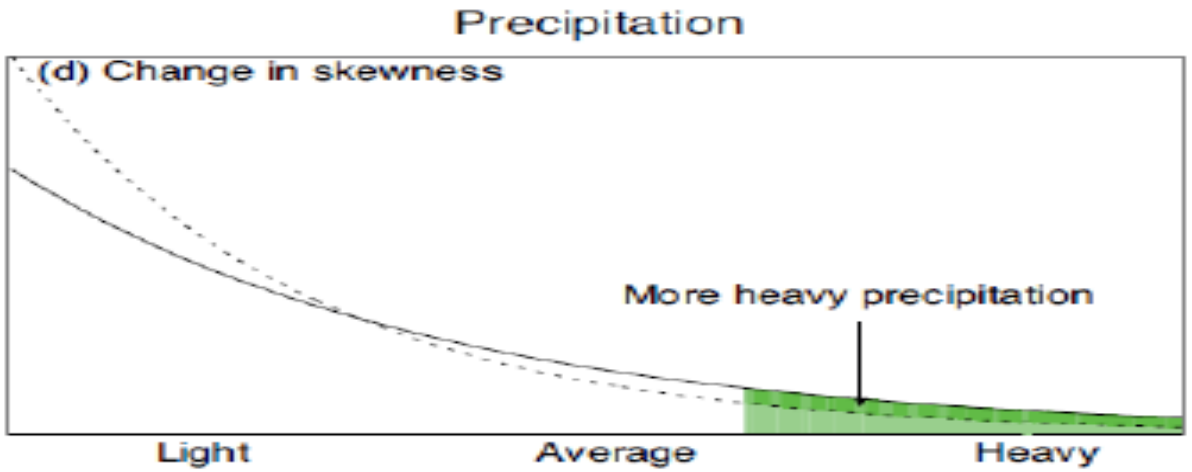
- ✓ **The presentation will raise scientific awareness on impacts of climate, specifically, on critical national infrastructures and advocate the development and use of Early Warning and Early Action for all.**

Coping with a changing climate and changes in extreme weather and climate events have significant impacts; and are among the most serious challenges to our societies.



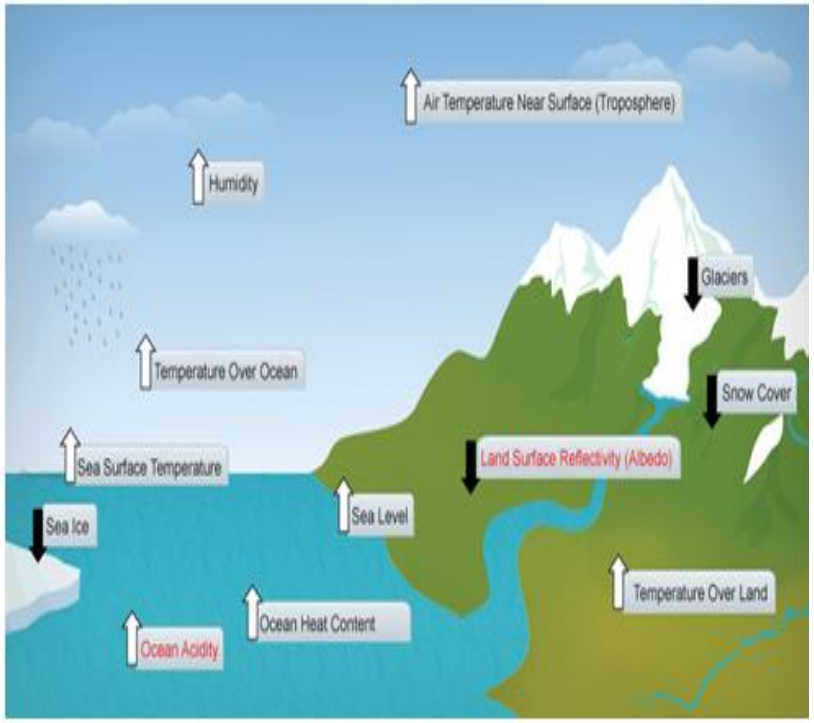




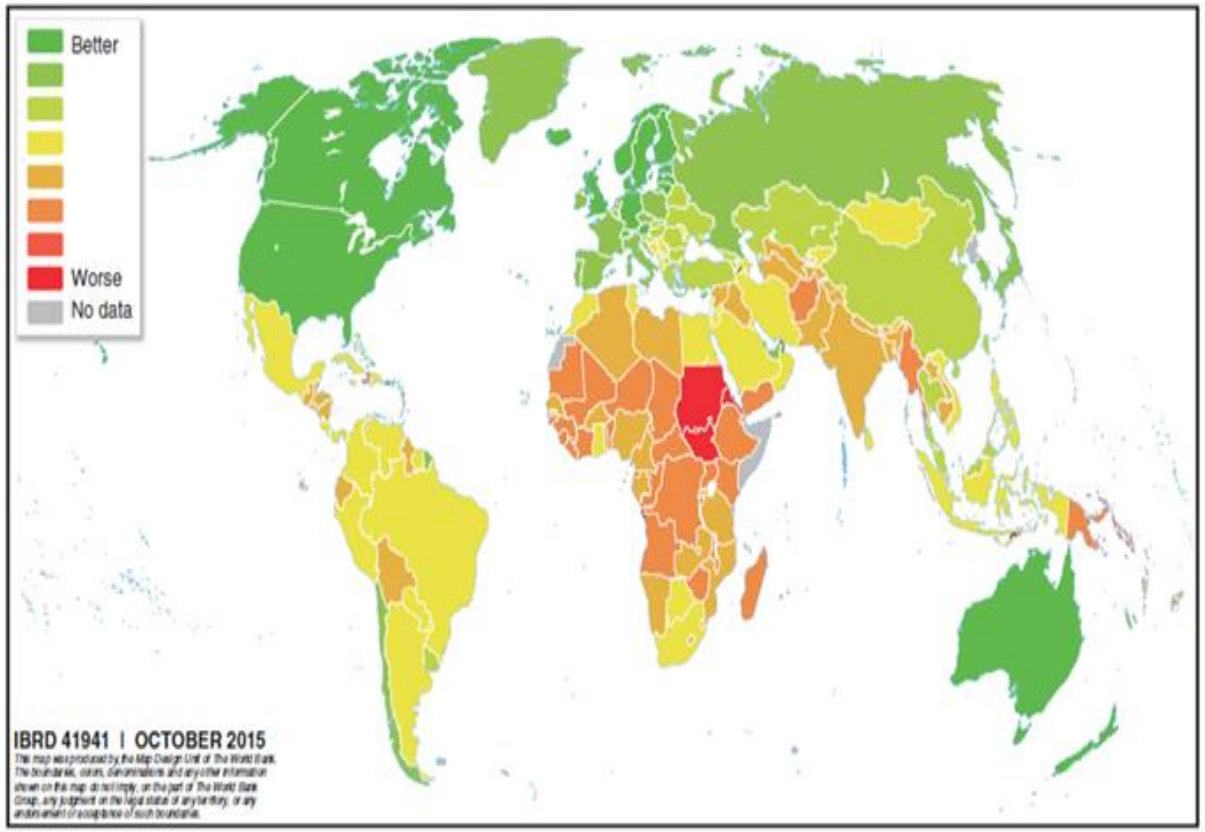


Key Indicators of a Changing Climate System

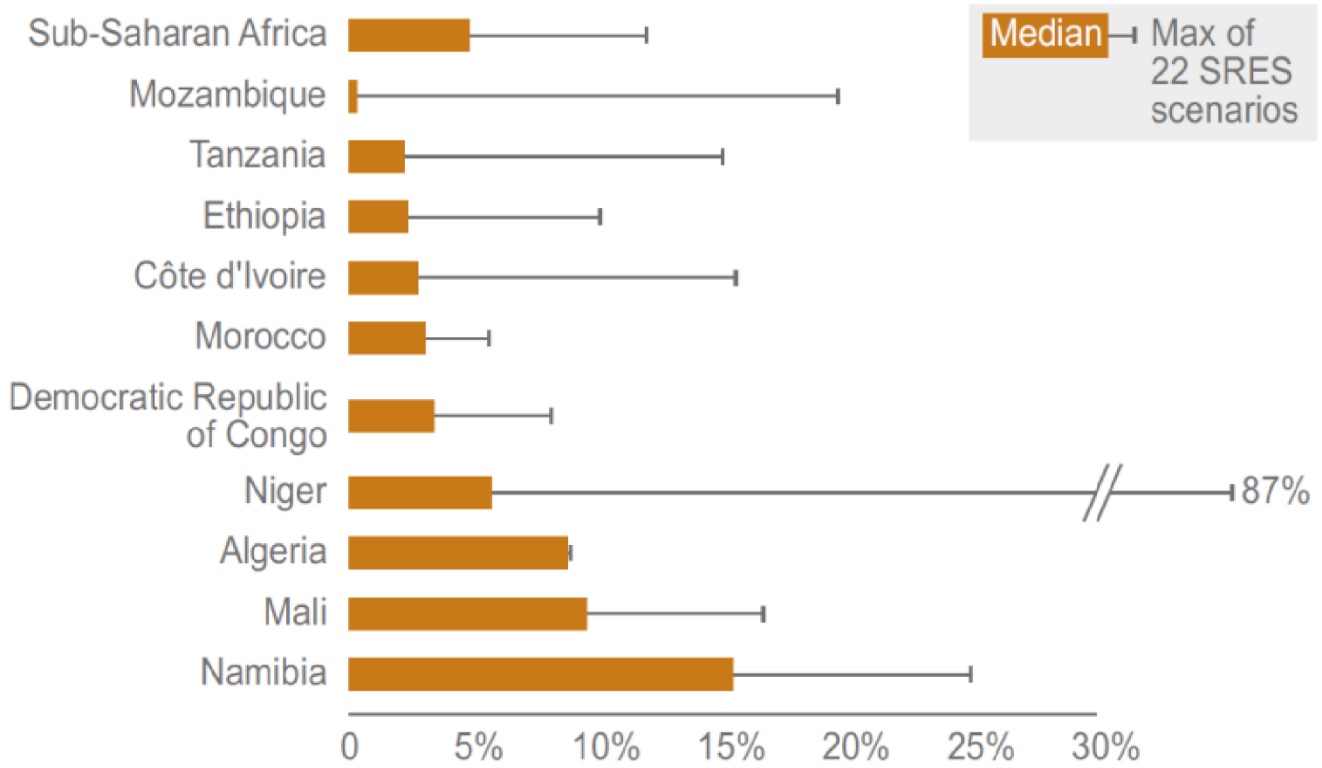
- **Temperature:** Global mean temperature is 0.8°C above pre-industrial levels
- **Ocean warming:** Oceans have warmed 0.09°C since the 1950s
- **Sea level rise:** Has risen 15-20 cm since pre-industrial times
- **Precipitation:** Increasing upward & downward trends
- **Ice melt:** Glaciers are melting at unprecedented rate



Depending on Location, Countries Face Differing Levels of Vulnerability to Climate Change



- **Nations spend enormous resources to build and maintain infrastructures.**
- **Nations will continue to spend more enormous resources to protect infrastructures from extreme and hazardous climate events.**



Percentage of 2021 Gross Domestic Product of some African countries needed to repair and maintain road infrastructure in future changing climate. (Source IPCC, Trisos et al., 2022)

Activities in ACMAD

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WHAT WE DID IN ACMAD

We adopted the use of Climate Change Detection Indices (ETCCDI) which were globally adopted for detecting Precipitation & Temperature extremes in 1997 at a WMO CLIVAR/GCOS workshop.

The climate change detection indices, i.e. ETCCDI, are used for detecting climate variability and extremes by assessing days in which temperature or precipitation observation are above or below specified thresholds.

These are 27 altogether but 22 were adopted here because of their relevance to African climate.

These indices are relevant to climate change monitoring and detection in Africa

Climate Change Detection Indices adopted for detecting Precipitation extremes

Indicator Name	Indicator Definition	Likely Sector Specific Utilization
PRCPTOT	Annual total precipitation (RR > = 1mm)	AFS, WRH, C, H
PRCPTOT99p	Annual total precipitation when RR>99p	AFS, WRH, C, H
R99p	Extremely wet-days when RR>99p	AFS, WRH, C, H, STE
PRCPTOT95p	Annual total precipitation when RR>95p	AFS, WRH, C, H
R95p	Very wet-days when RR>95p	AFS, WRH, C, H, STE
CWD	Consecutive wet-days when RR>1mm	AFS, WRH, C, STE
CDD	Consecutive dry-days when RR<1mm	AFS, WRH, C, H, STE
R20mm	Very heavy precipitation days when RR>20mm	AFS, WRH, C
R10mm	Heavy precipitation days when RR>10mm	AFS, WRH, C
RX1mm	Wet days when RR>1mm	AFS, WRH, C, H
SDII	Simple daily intensity index	AFS, WRH, C, H, STE

AFS – Agriculture and Food Security
H – Health
C – Construction and Engineering Industries
WRH – Water Resources and Hydrology
STE – Sports, Tourism and Entertainments

Climate Change Detection Indices adopted for detecting Temperature extremes

Indicator Name	Indicator Definition	Likely Sector Specific Utilization
Tmax	Maximum Temperature (Tx)	AFS, WRH, H, STE
Max Tmax	Maximum values of maximum temperature	AFS, WRH, H, STE
Min Tmax	Minimum values of maximum temperature	
Tmin	Minimum Temperature (Tn)	AFS, WRH, C, H
Max Tmin	Maximum values of minimum temperature	
Min Tmin	Minimum values of minimum temperature	AFS, WRH, C, H
DTR	Diurnal temperature range	C, H
SU30	Summer days (Tx>30 deg. C)	AFS, WRH, H, STE
TR20	Tropical nights (Tn>20 deg. C)	AFS, H, STE
FD	Frost days (Tn<0 deg. C)	AFS, H, STE
TN10p	Cool nights (Tn<10 deg. C)	AFS, H, STE

AFS – Agriculture and Food Security
H – Health
C – Construction and Engineering Industries
WRH – Water Resources and Hydrology
STE – Sports, Tourism and Entertainments

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Observation and Historical Climate

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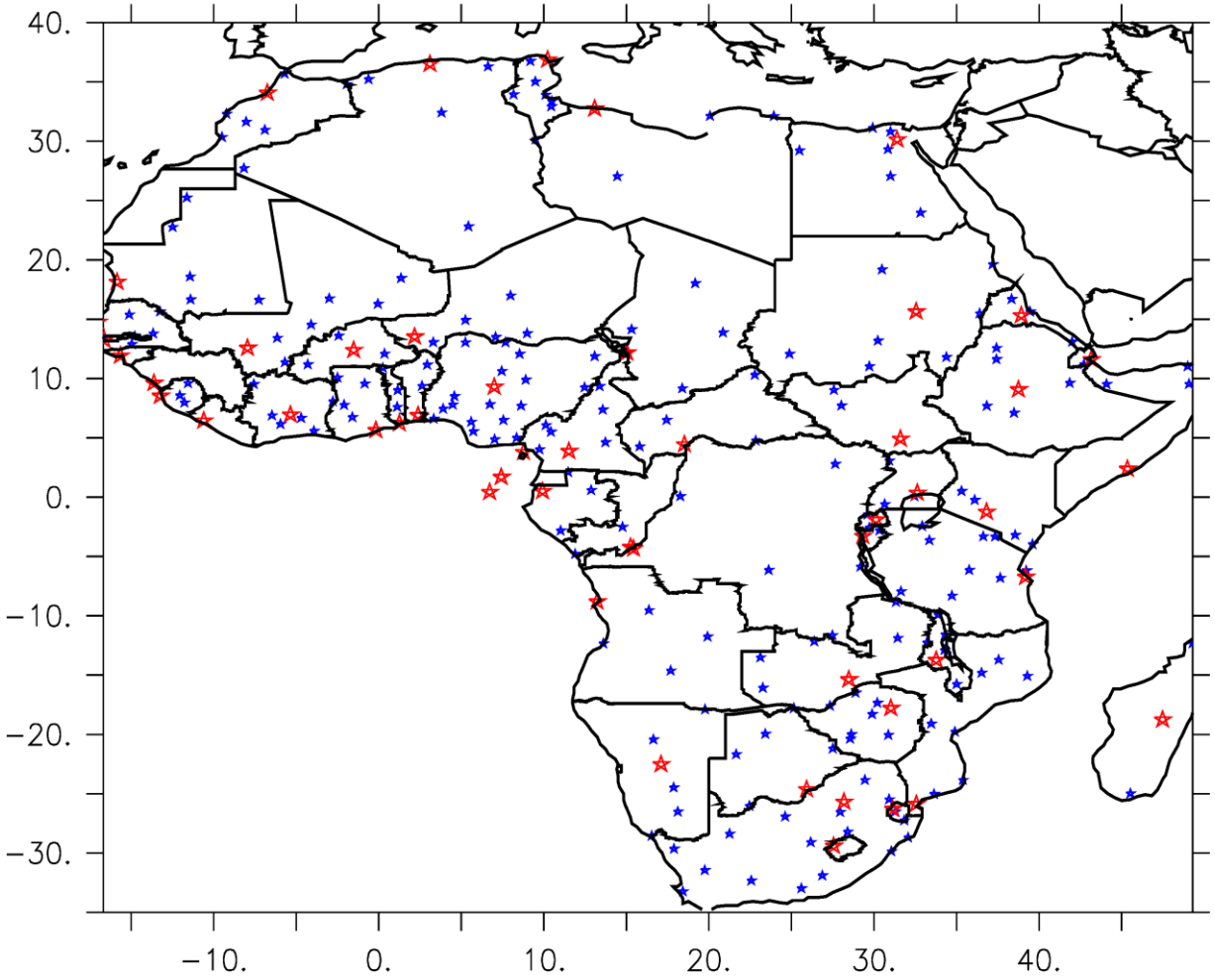
Observations

Here..., we analyzed the observed climate change detection indices for more than 1,000 African cities using the World Meteorological Organization (WMO) recommended climate change detection algorithms, e.g. ETCCDI.

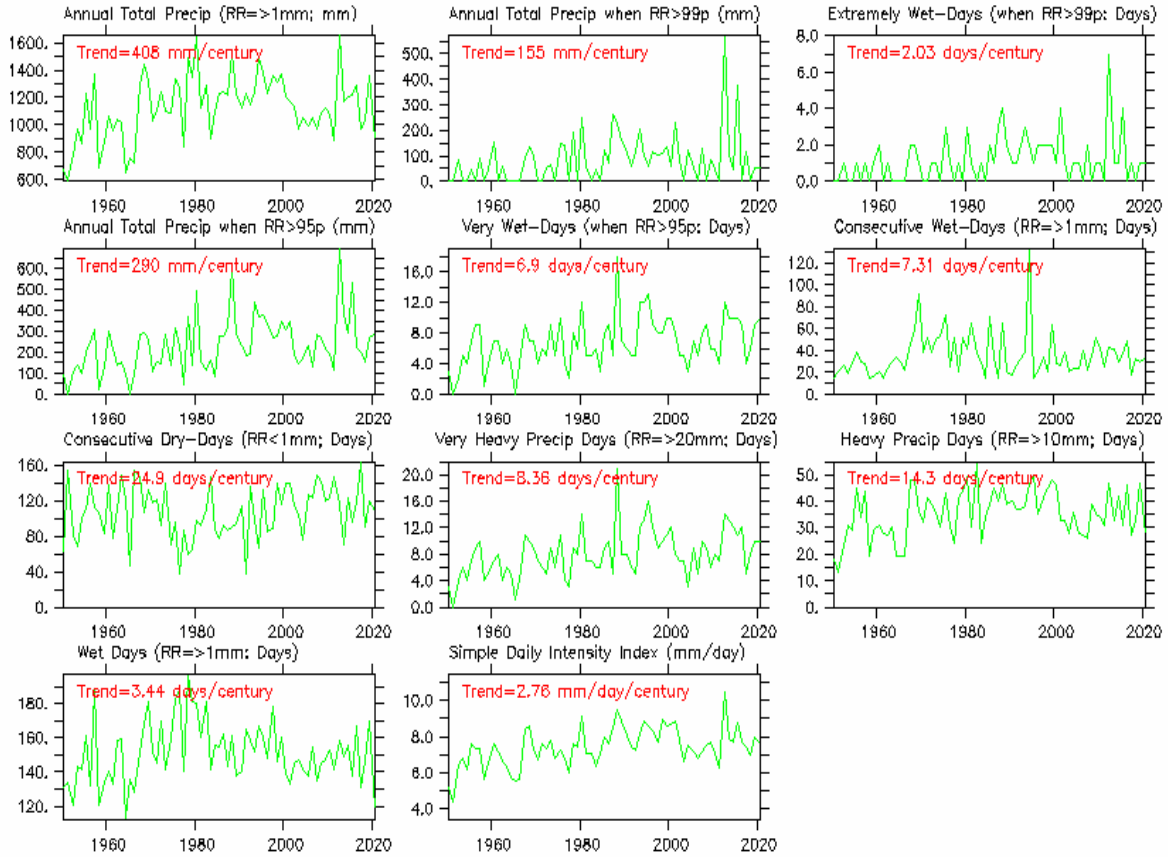
We utilized the 9km-resolution ERA5-Land reanalysis dataset (temperature and precipitation parameters), from ECMWF, for the observed climate over Africa (1950-2020).



Interannual Analyses of Extreme Precipitation Indices

Nigeria_ABUJA

Lon=7 ; Lat=9.25



Interannual Analyses of Extreme Temperature Indices

Nigeria_ABUJA

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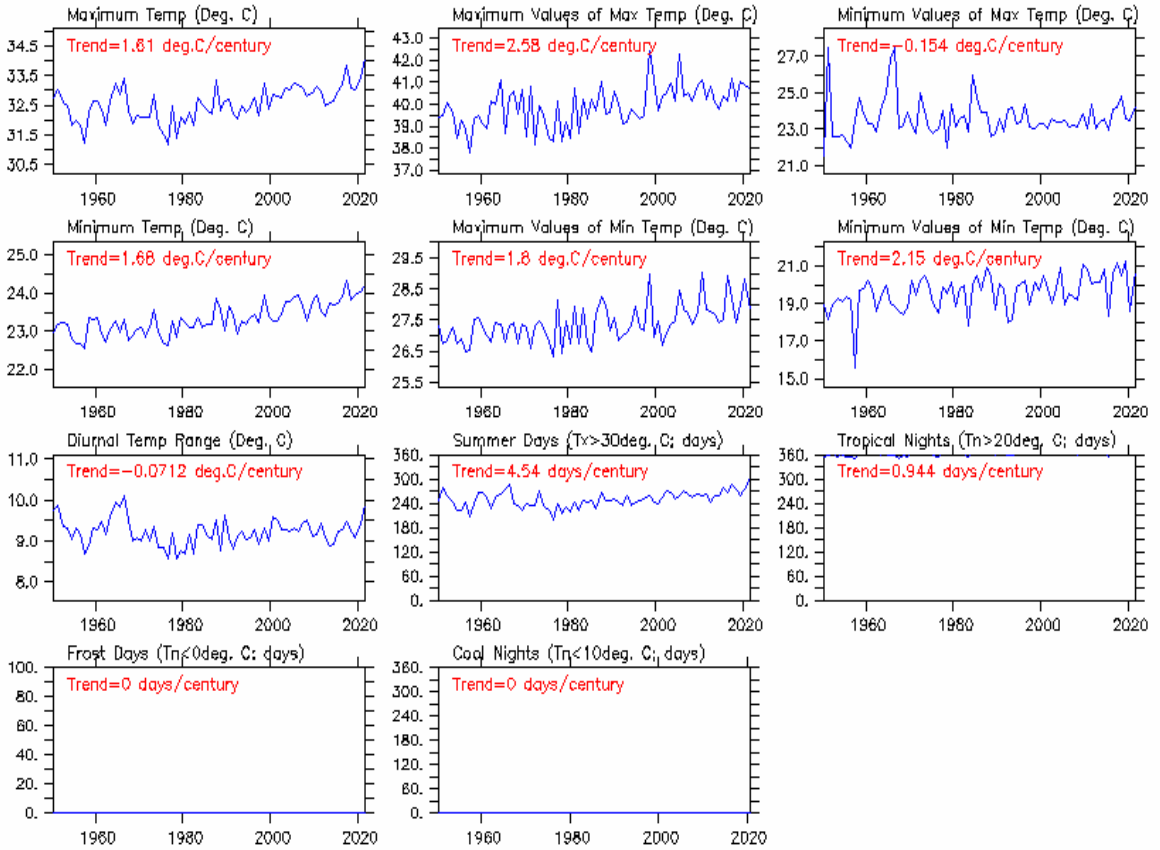

Decadal Analyses of Extreme Precipitation Indices

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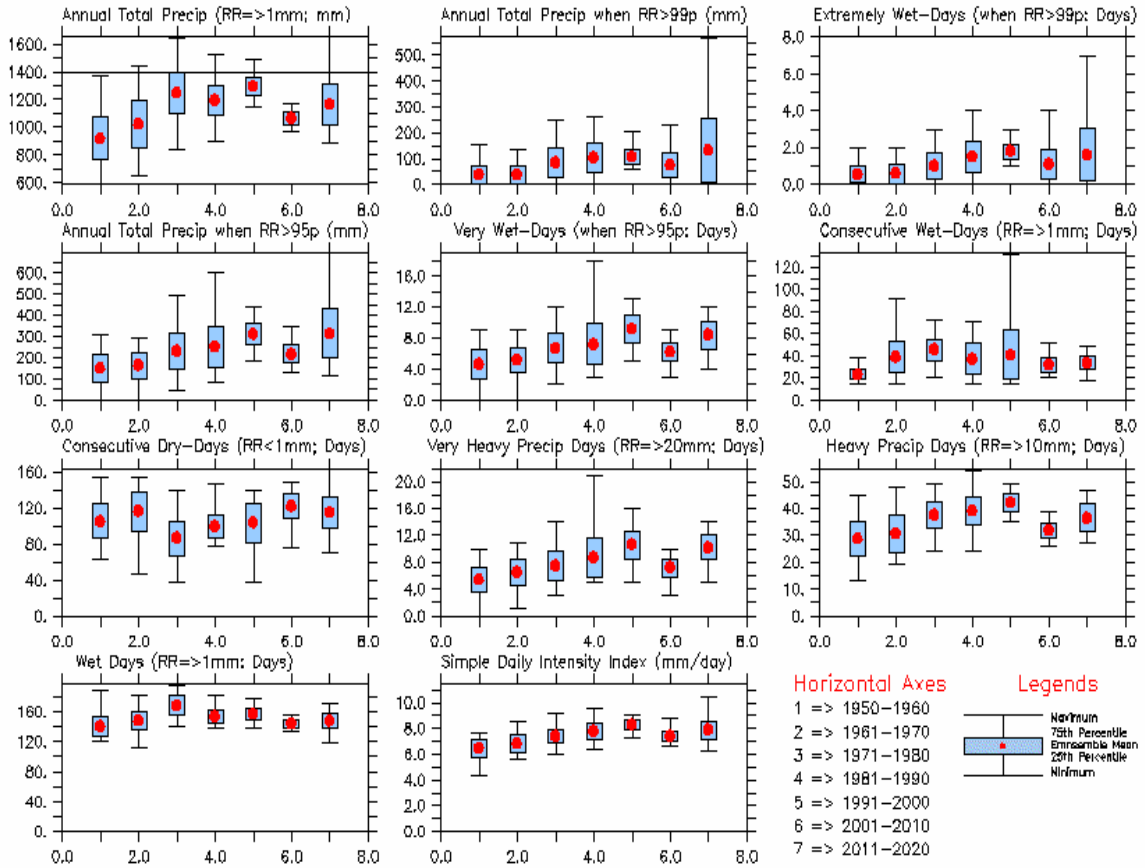
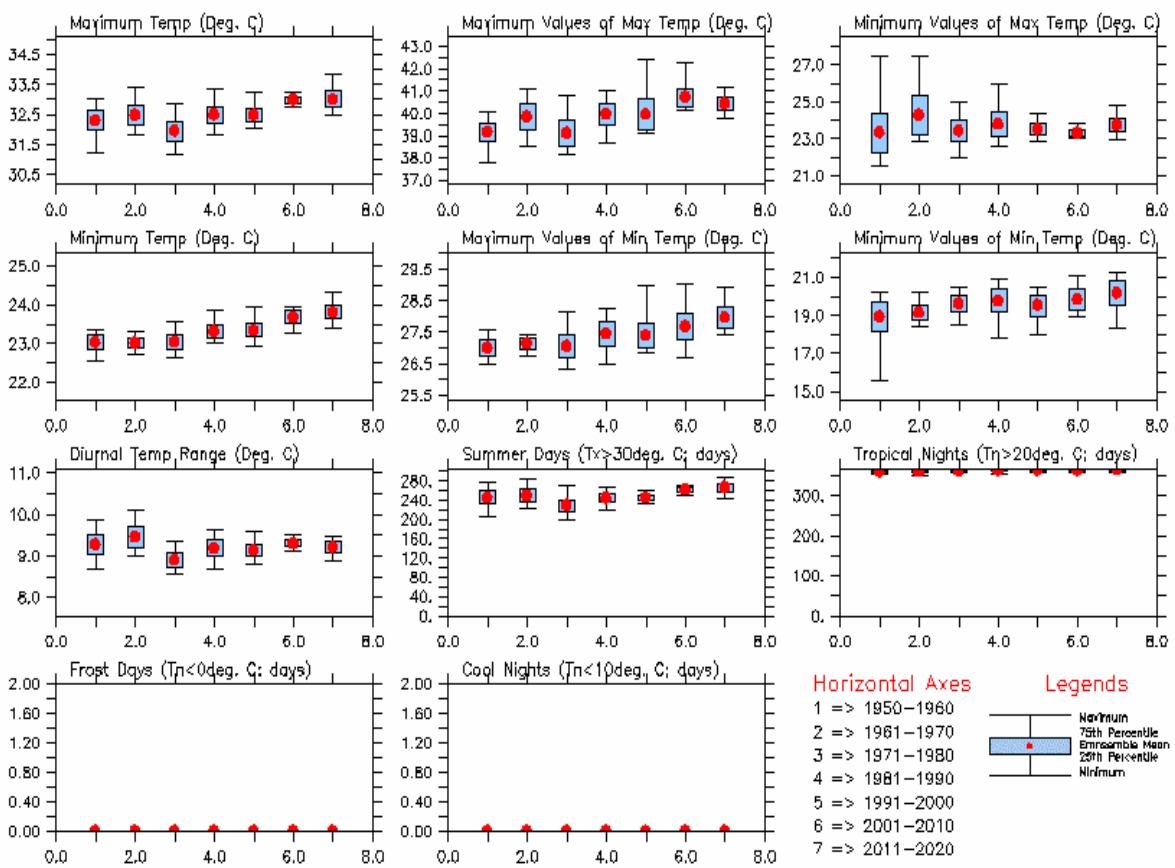


Decadal Analyses of Extreme Temperature Indices

Nigeria_ABUJA

Lon=7 ; Lat=9.25



Anomaly Analyses of Extreme Precipitation Indices

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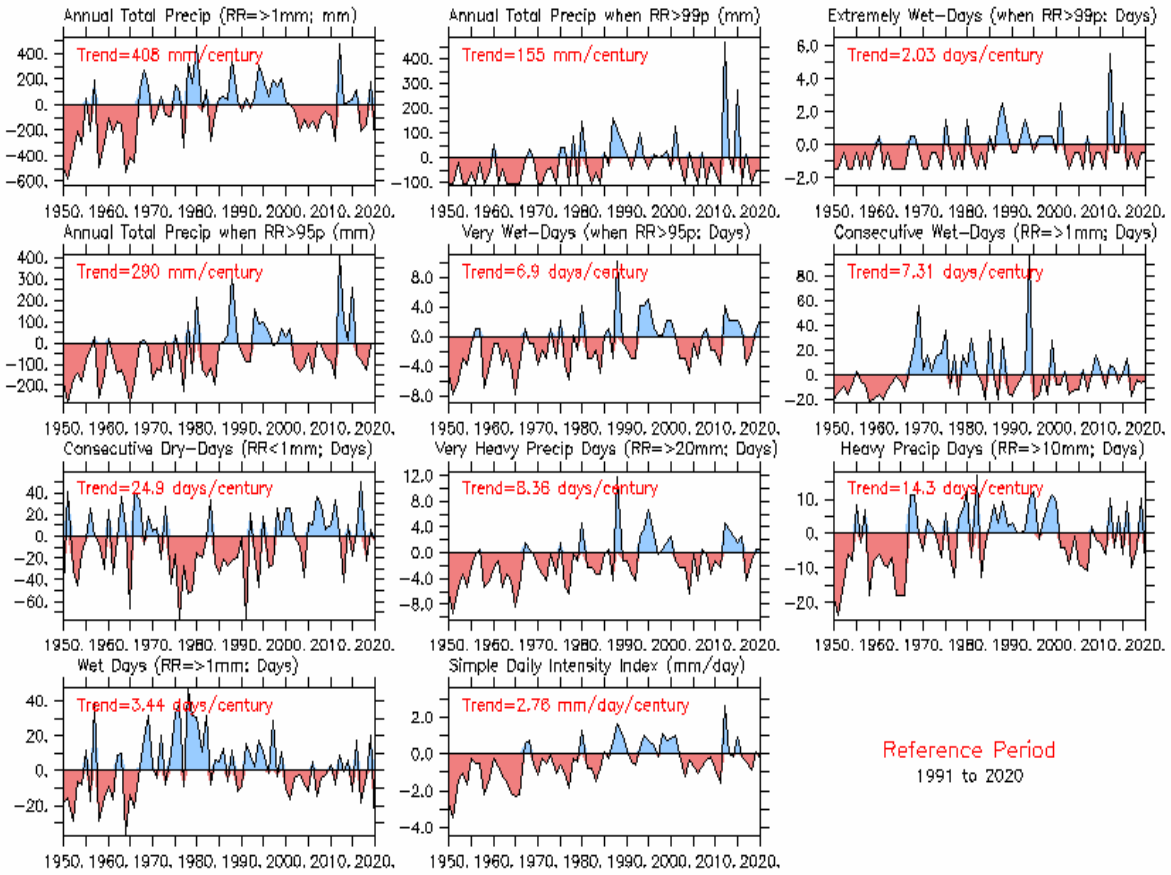

Reference Period
1991 to 2020

Anomaly Analyses of Extreme Temperature Indices

Nigeria_ABUJA

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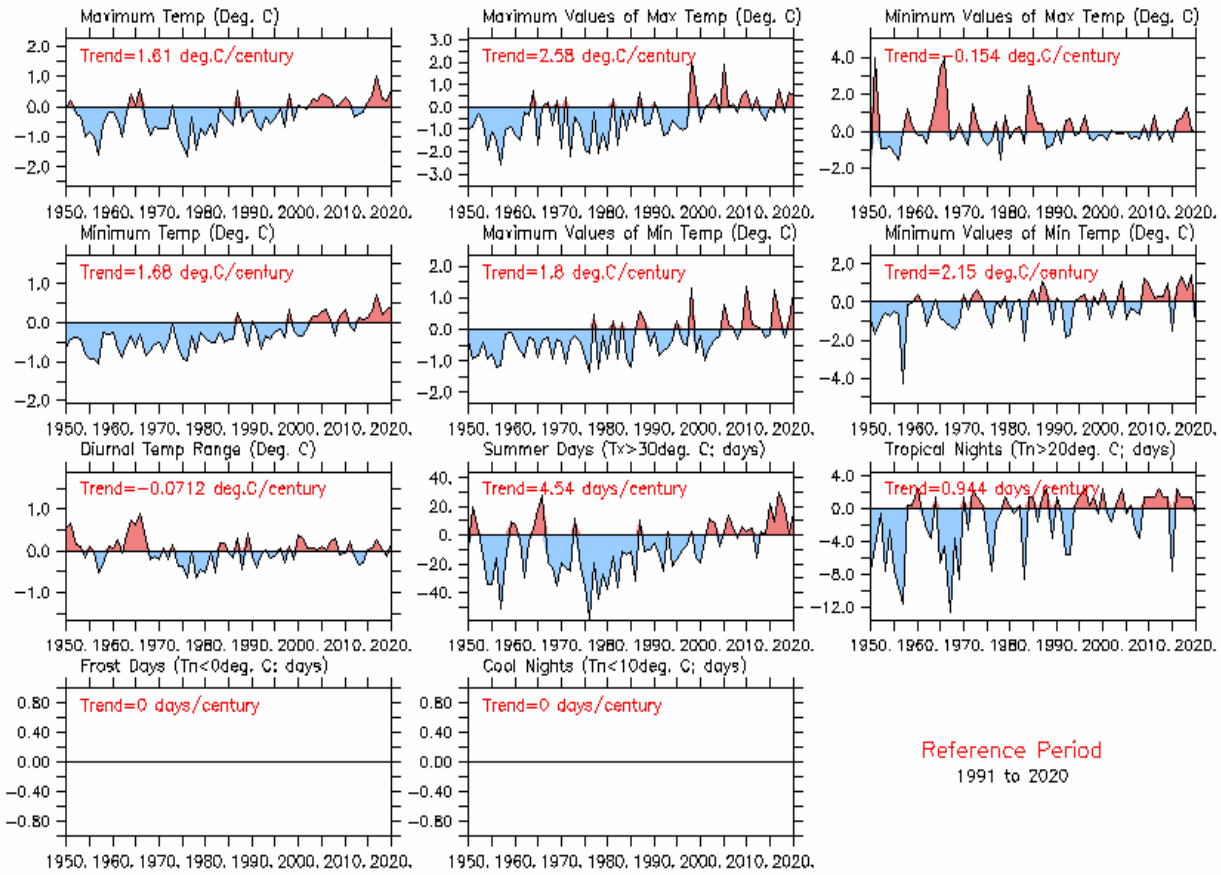
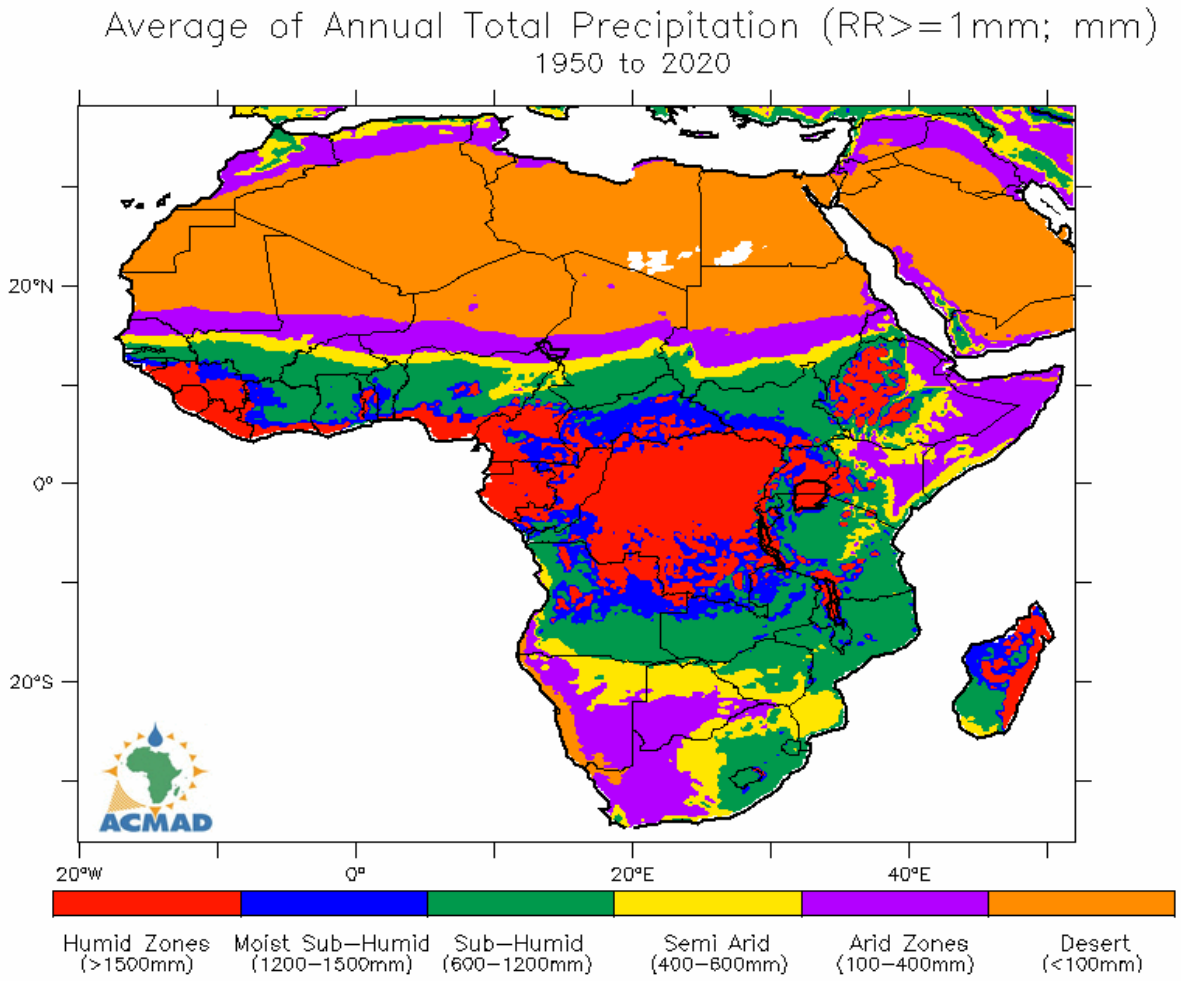
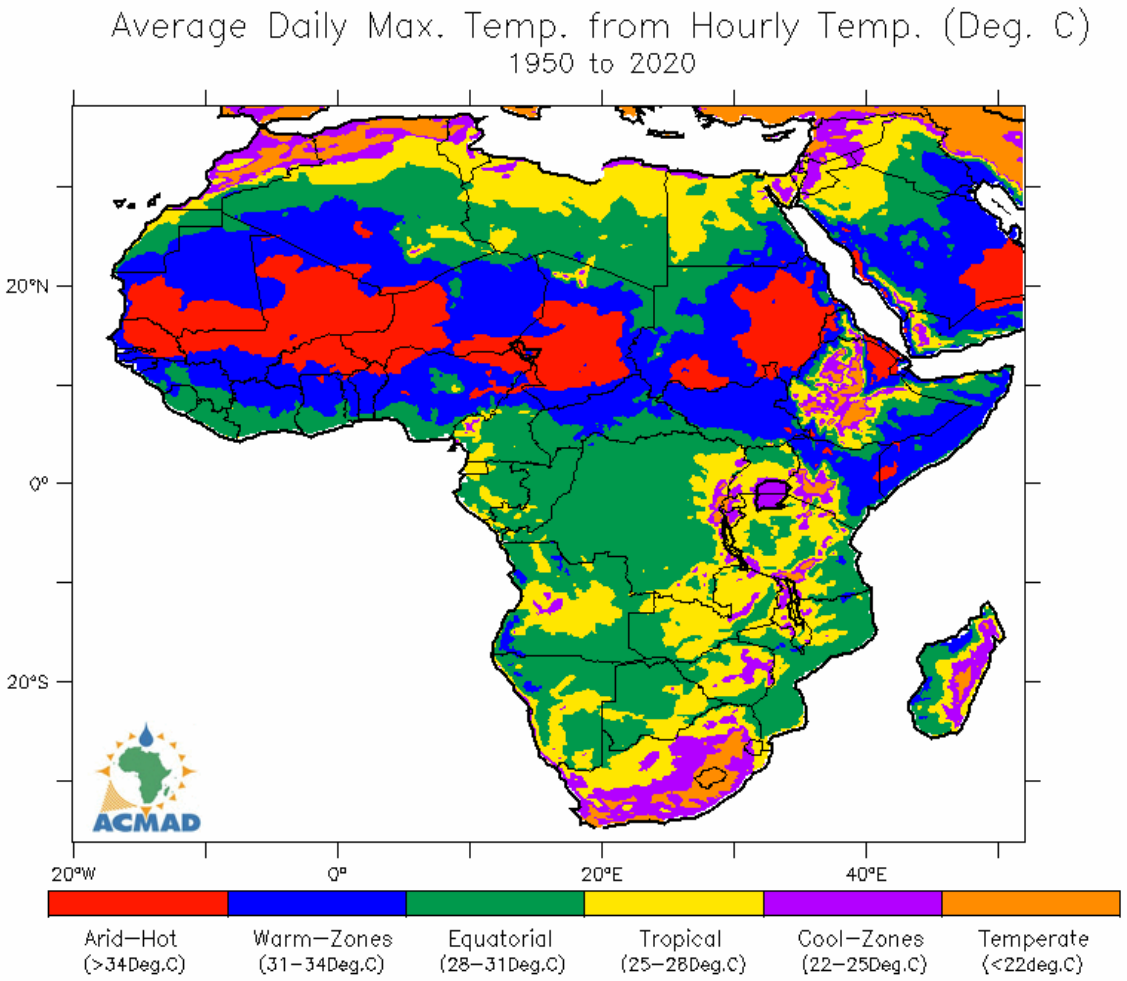


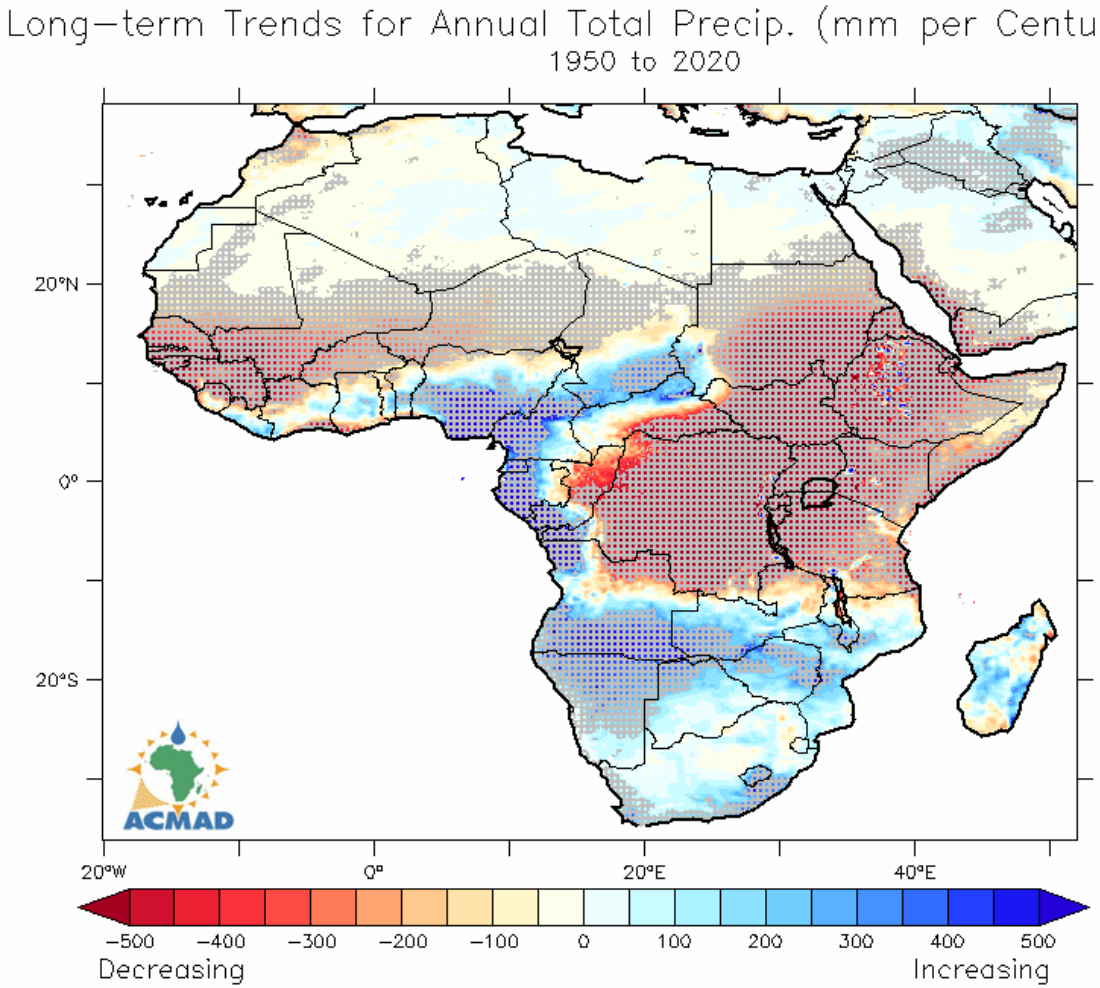
Reference Period
1991 to 2020

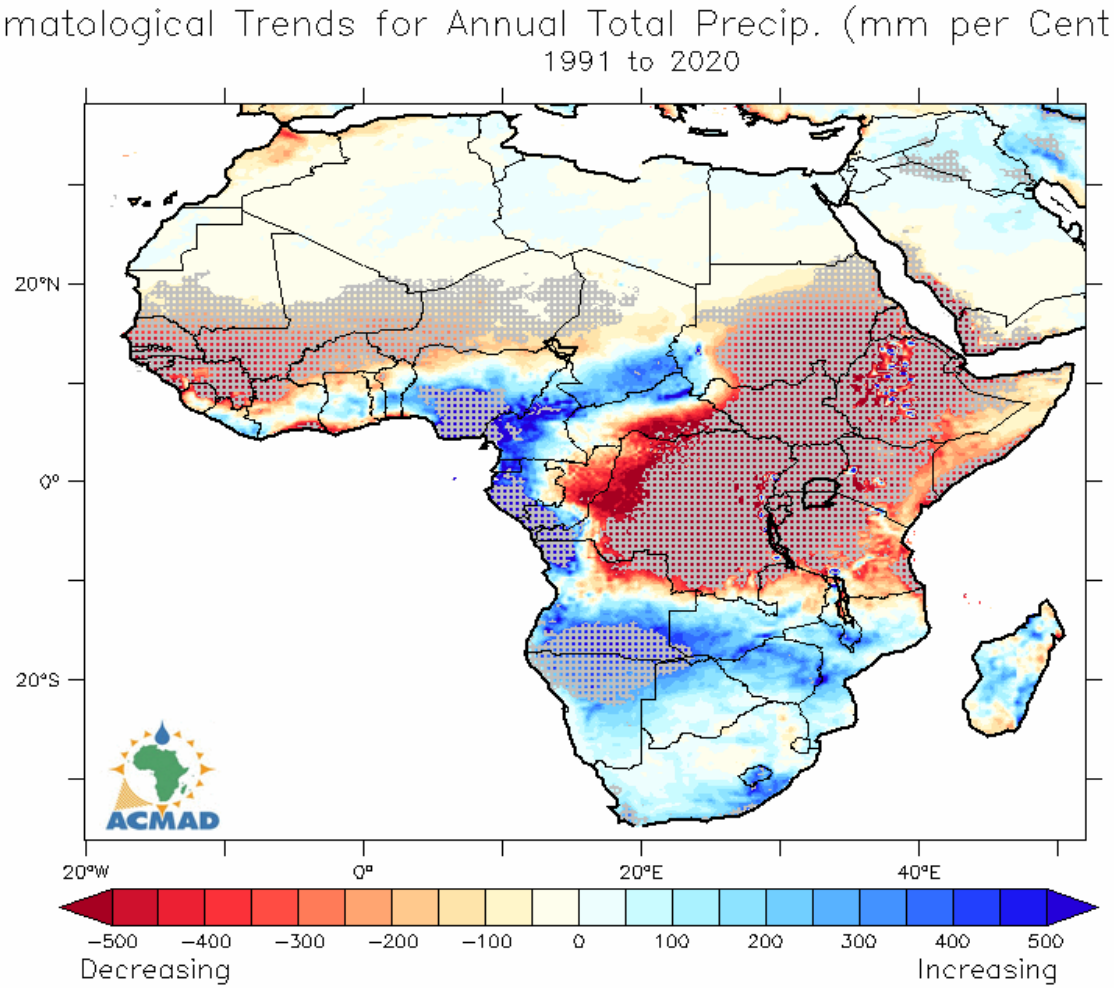
Spatial distributions of long-term annual total precipitation and max. temp. over Africa



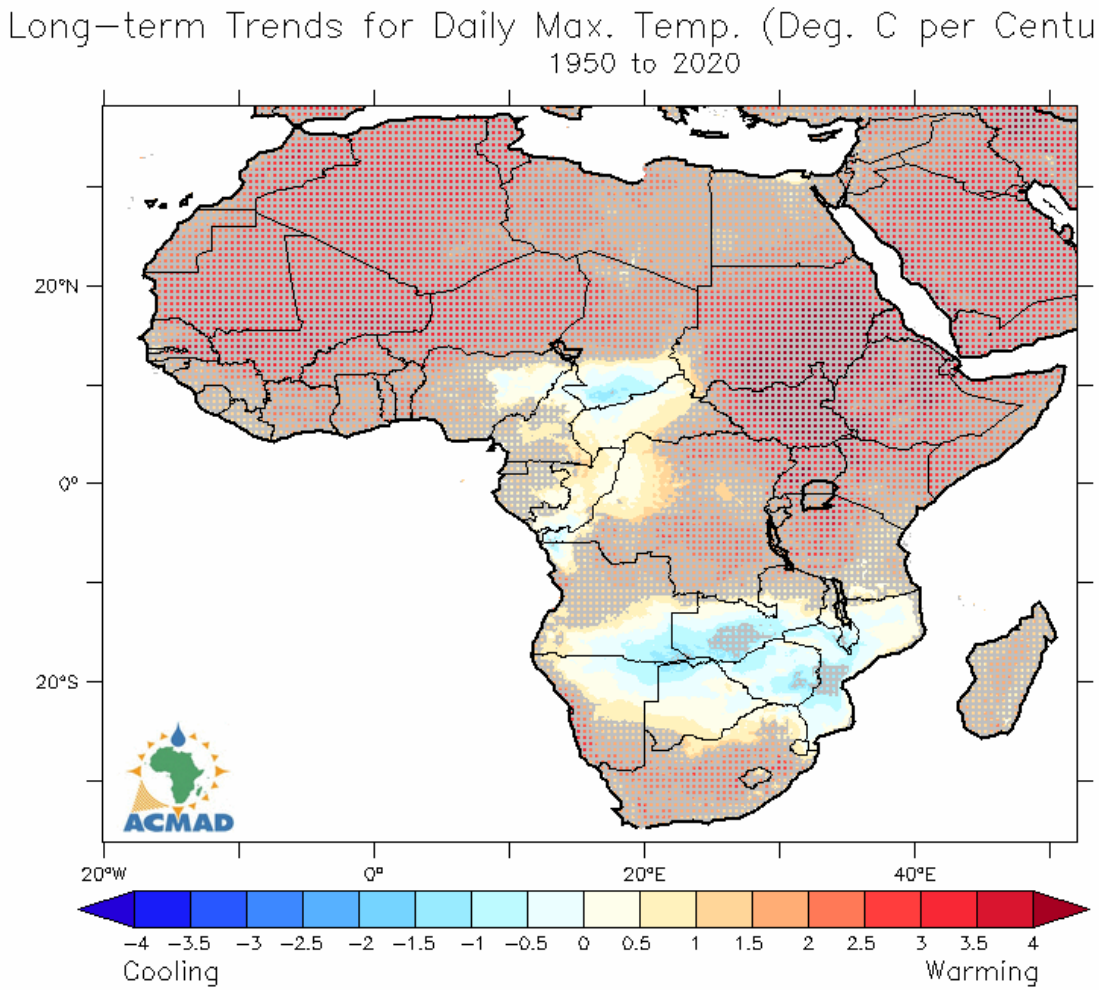


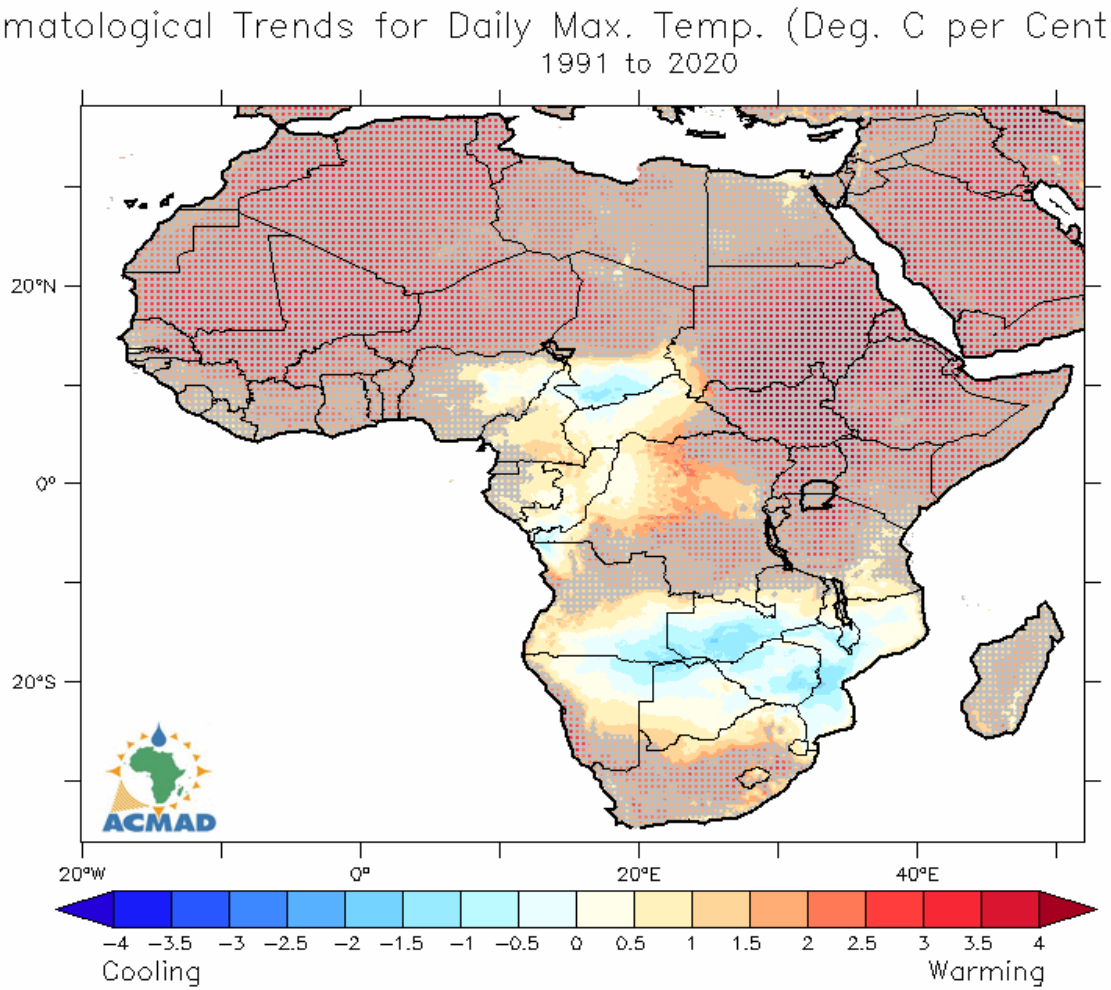
Spatial distributions of trends of annual total precipitation over Africa





Spatial distributions of trends of annual max. temp. over Africa





Future Scenarios

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Future Scenarios

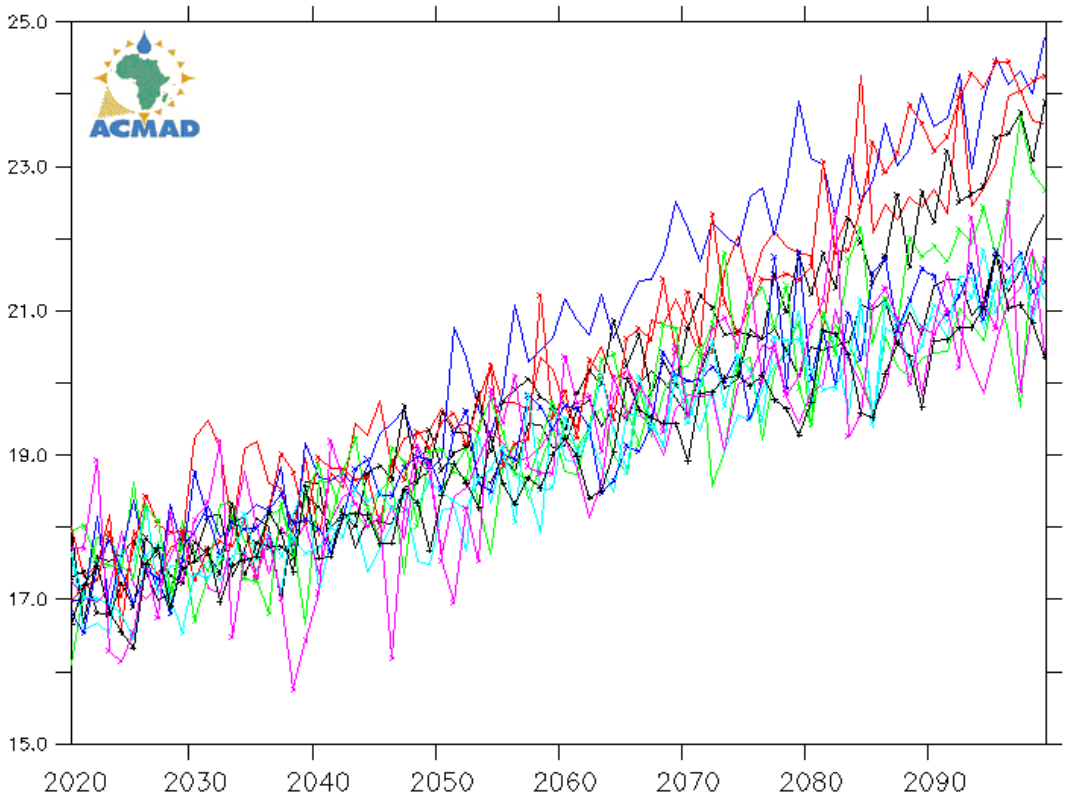
- We evaluated and analyzed the climate change detection indices for **future scenarios (2030 - 2100)** over Africa by using simulation dataset from 15 climate models for temperature and precipitation parameters for various Representative Concentration Pathways (RCPs) - **RCP2.6, RCP4.5, RCP6.0, and RCP8.5**.

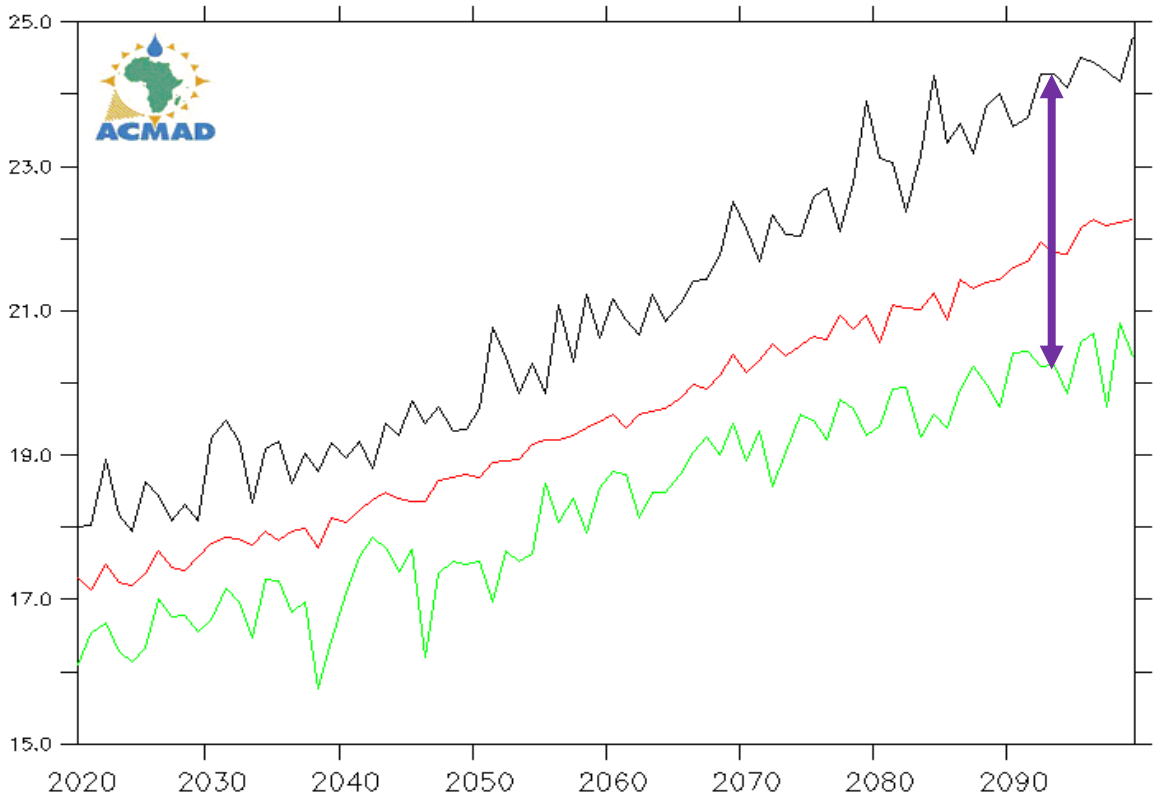
- **RCPs are greenhouse gas concentrations trajectory adopted by Intergovernmental Panel on Climate Change (IPCC) used for climate modelling and research.**

- After the processes of **bias-corrections**, we proceed to evaluate the projection of future climate scenarios (reference period: 1991 - 2020) for all the RCPs over African cities.

Climate models used for future scenarios

Dataset	Full name	Resolution	Period
bcc-csm1-1-m	Beijing Climate Center Climate System Model version 1.1	1.12^{O} x 1.13^{O}	1861-2099
CCSM4	Community Climate System Model version 4	85km x 85km	1861-2099
CNRM-CM5	National Center for Meteorological Research- Coupled Model Intercomparison Project phase 5	50km x 50km	1861-2099
CSIRO-Mk3-6-0	Commonwealth Scientific and Industrial Research Organization Model	1.9^{O} x 1.9^{O}	1861-2099
FGOALS-g2	Flexible Global Ocean-Atmosphere-Land System Model-Grid point version 2	1^{O} x 1^{O}	1861-2099
GFDL-CM3	Geophysical Fluid Dynamics Laboratory-Climate Model version 3	100km x 100km	1861-2099
GFDL-ESM2M	Geophysical Fluid Dynamics Laboratory-Earth System Model	100km x 100km	1861-2099
HadGEM2-ES	Hadley Center Global Environment Model version 2-Earth System	1.875^{O} x 1.25^{O}	1861-2099
IPSL-CM5A-LR	Institute Pierre Simon Laplace – Climate Model version 5 -Low Resolution	1.25^{O} x 2.5^{O}	1861-2099
IPSL-CM5A-MR	Institute Pierre Simon Laplace – Climate Model version 5 -Low Resolution-Medium Resolution	1.25^{O} x 2.5^{O}	1861-2099
MIROC5	Model for Interdisciplinary Research on Climate version 5	85km x 85km	1861-2099
MIROC-ESM-CHEM	Model for Interdisciplinary Research on Climate-Earth System Model-	85km x 85km	1861-2099
MPI-ESM-LR	Max Planck Institute for Meteorology-Earth System Model-Low Resolution	103km x 103km	1861-2099
MRI-CGCM3	Meteorological Research Institute	2.25^{O} x 1.125^{O}	1861-2099
NorESM1-M	Norwegian Earth System Model	2^{O} x 2^{O}	1861-2099

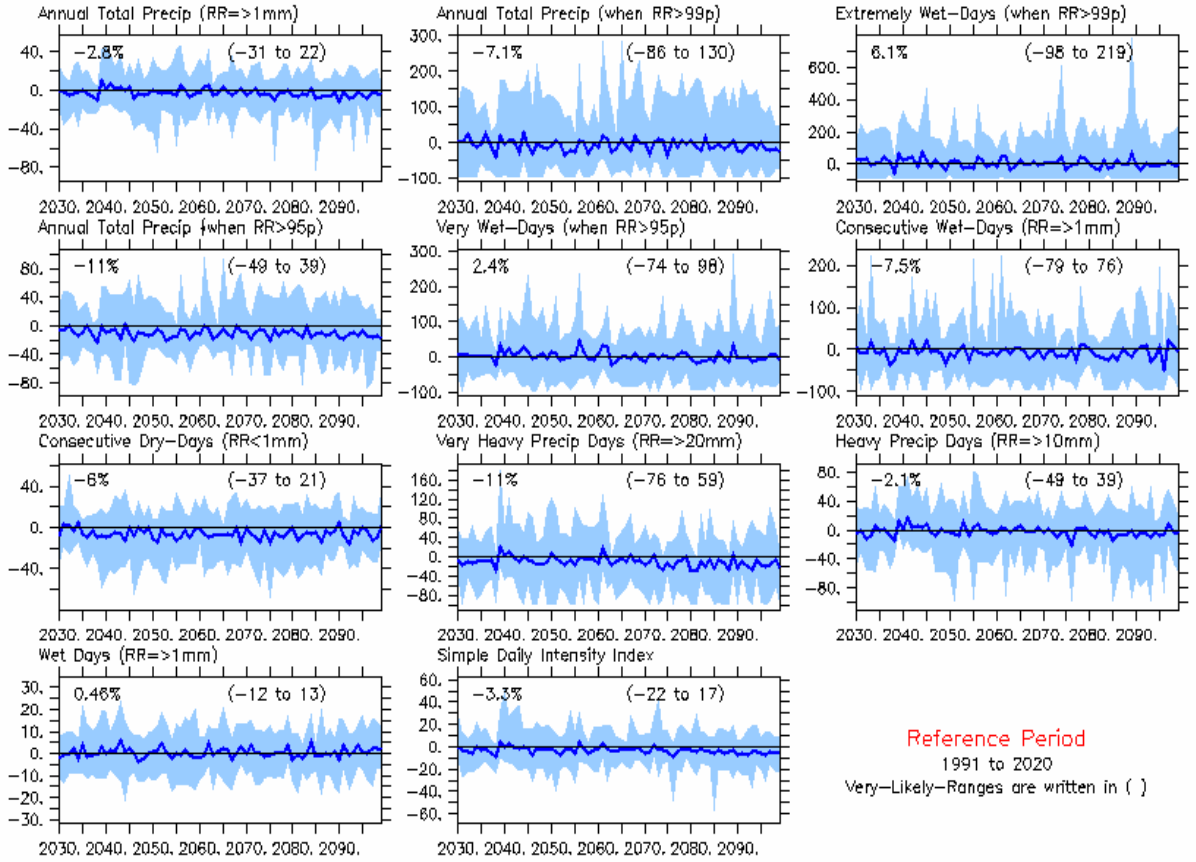

ACMAD
25.0
23.0
21.0
19.0
17.0
15.0
2020
2030
2040
2050
2060
2070
2080
2090


ACMAD
25.0
23.0
21.0
19.0
17.0
15.0
2020
2030
2040
2050
2060
2070
2080
2090

Projected Changes in Extreme Precipitation Indices (RCP26)

Nigeria_ABUJA

Lon=7 : Lat=9.25

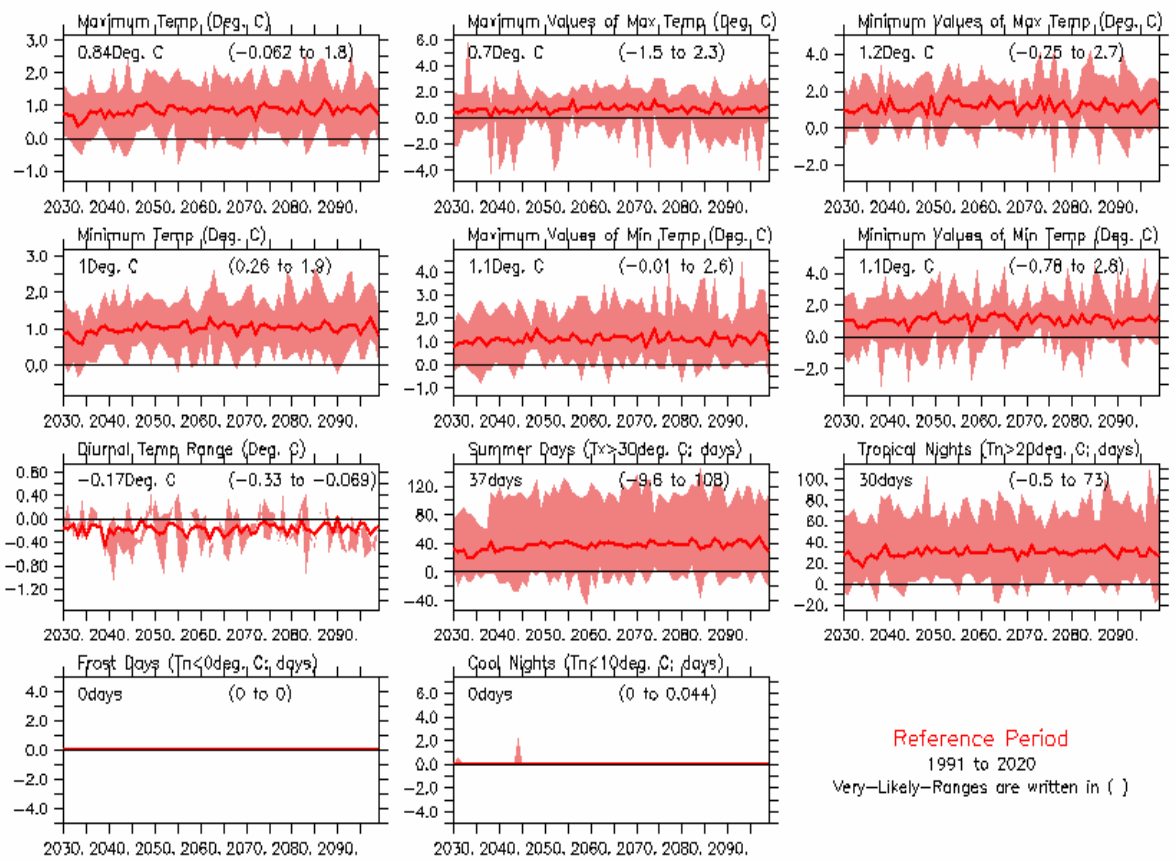


Reference Period
1991 to 2020
Very-Likely-Ranges are written in ( )

Projected Changes in Extreme Temperature Indices (RCP26)

Nigeria_ABUJA

Lon=7 : Lat=9.25



Reference Period
1991 to 2020
Very-Likely-Ranges are written in ( )

Projected Changes in Extreme Precipitation Indices (RCP45)

Nigeria_ABUJA

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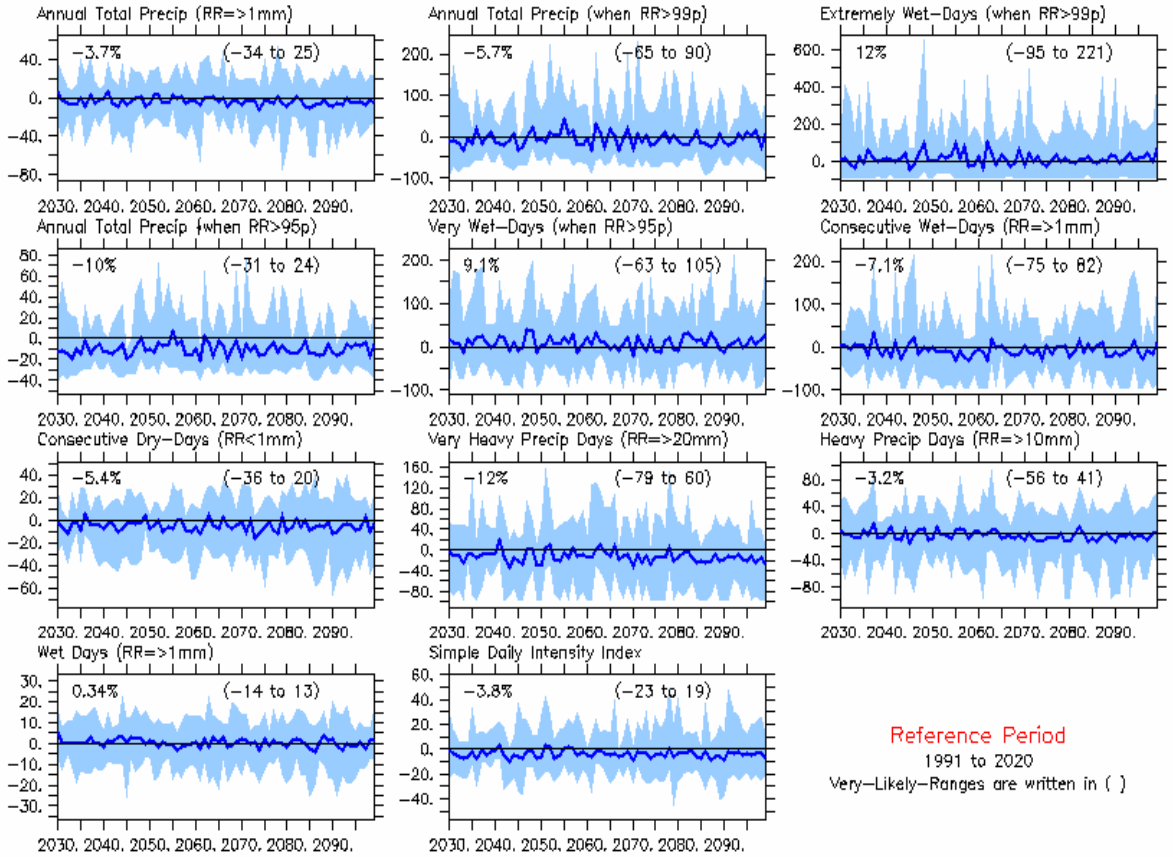
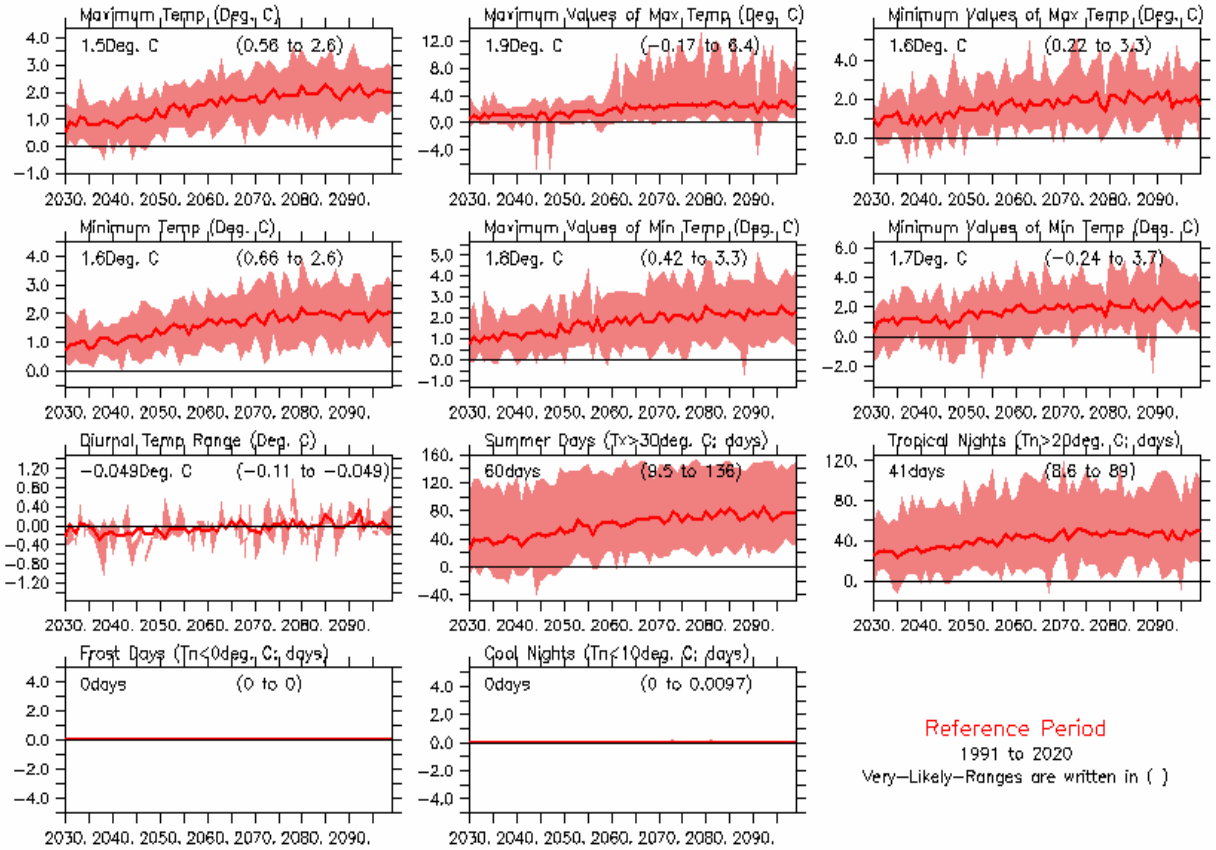


Reference Period
1991 to 2020
Very-Likely-Ranges are written in ( )

Projected Changes in Extreme Temperature Indices (RCP45)

Nigeria_ABUJA

Lon=7 : Lat=9.25



Reference Period
1991 to 2020
Very-Likely-Ranges are written in ( )

Projected Changes in Extreme Precipitation Indices (RCP60)

Nigeria_ABUJA

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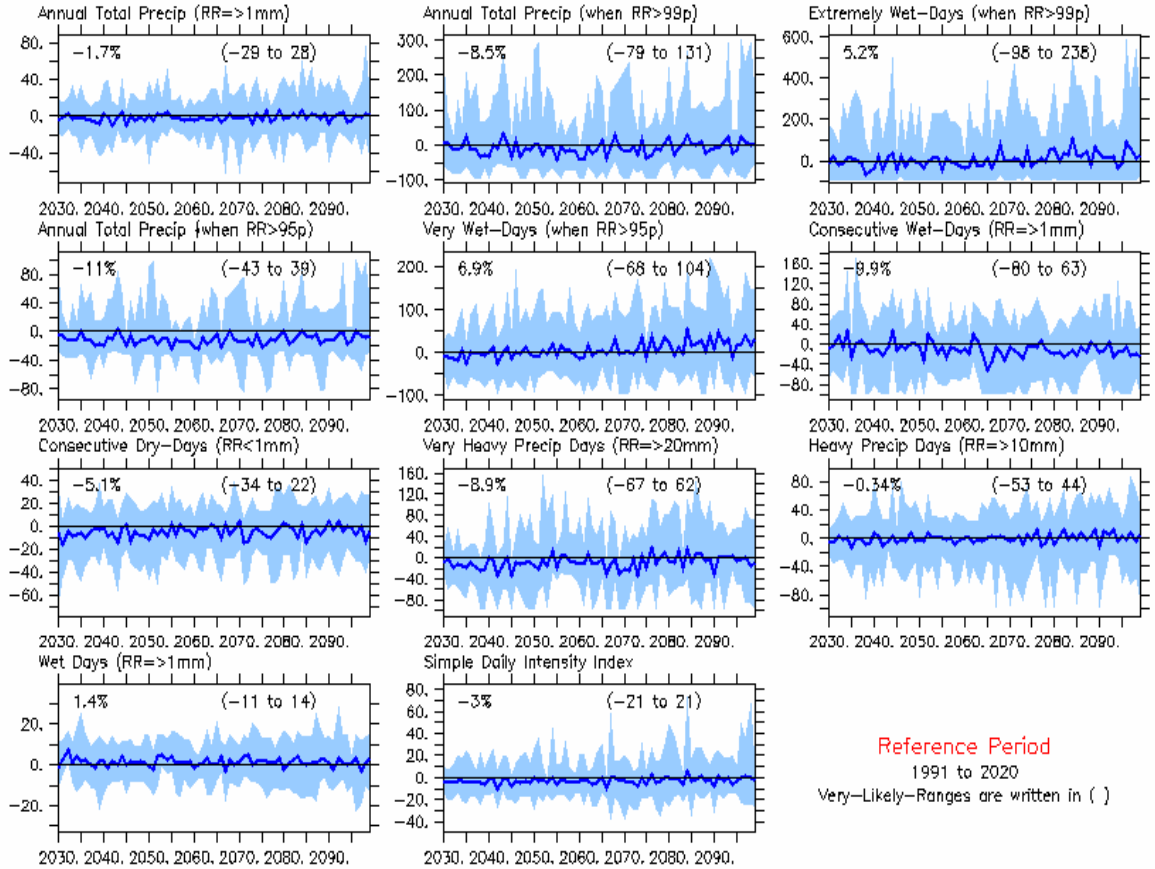
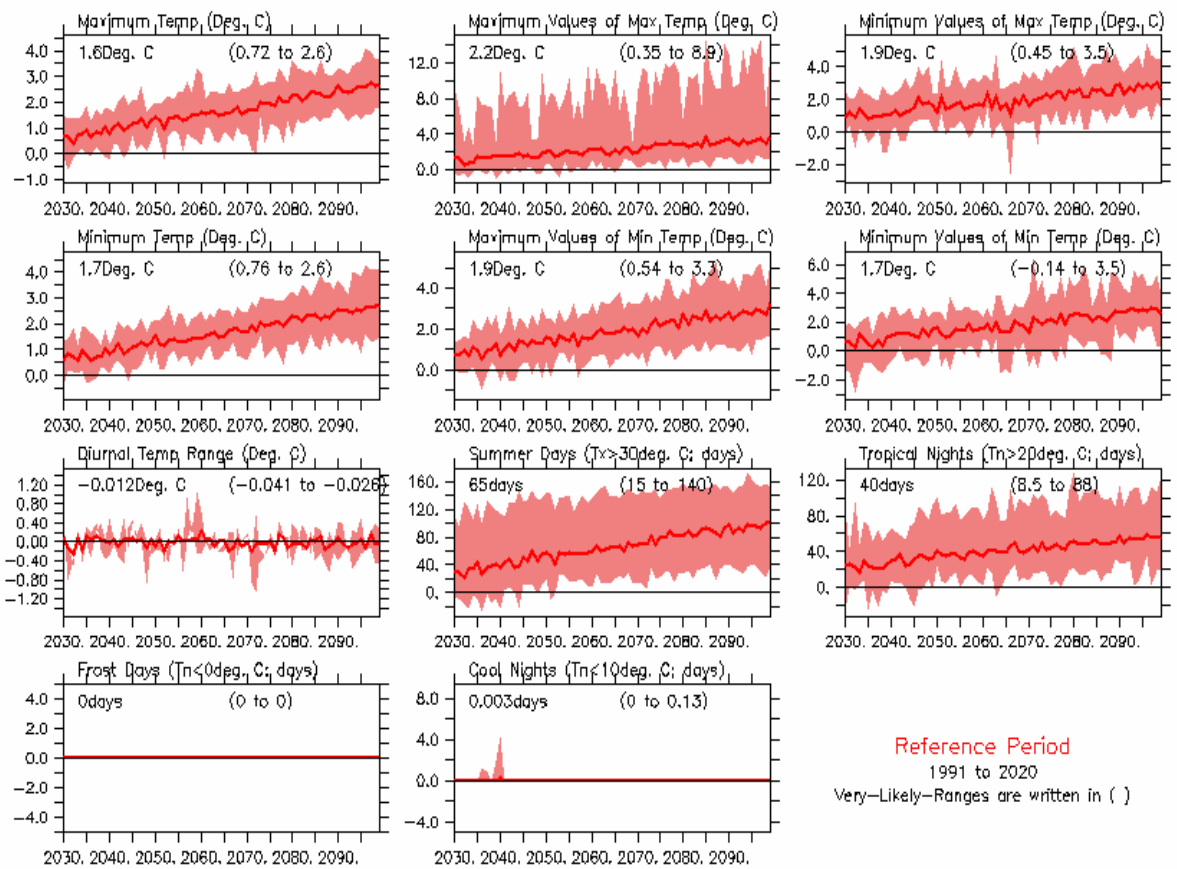


Reference Period
1991 to 2020
Very-Likely-Ranges are written in ( )

Projected Changes in Extreme Temperature Indices (RCP60)

Nigeria_ABUJA

Lon=7 ; Lat=9.25

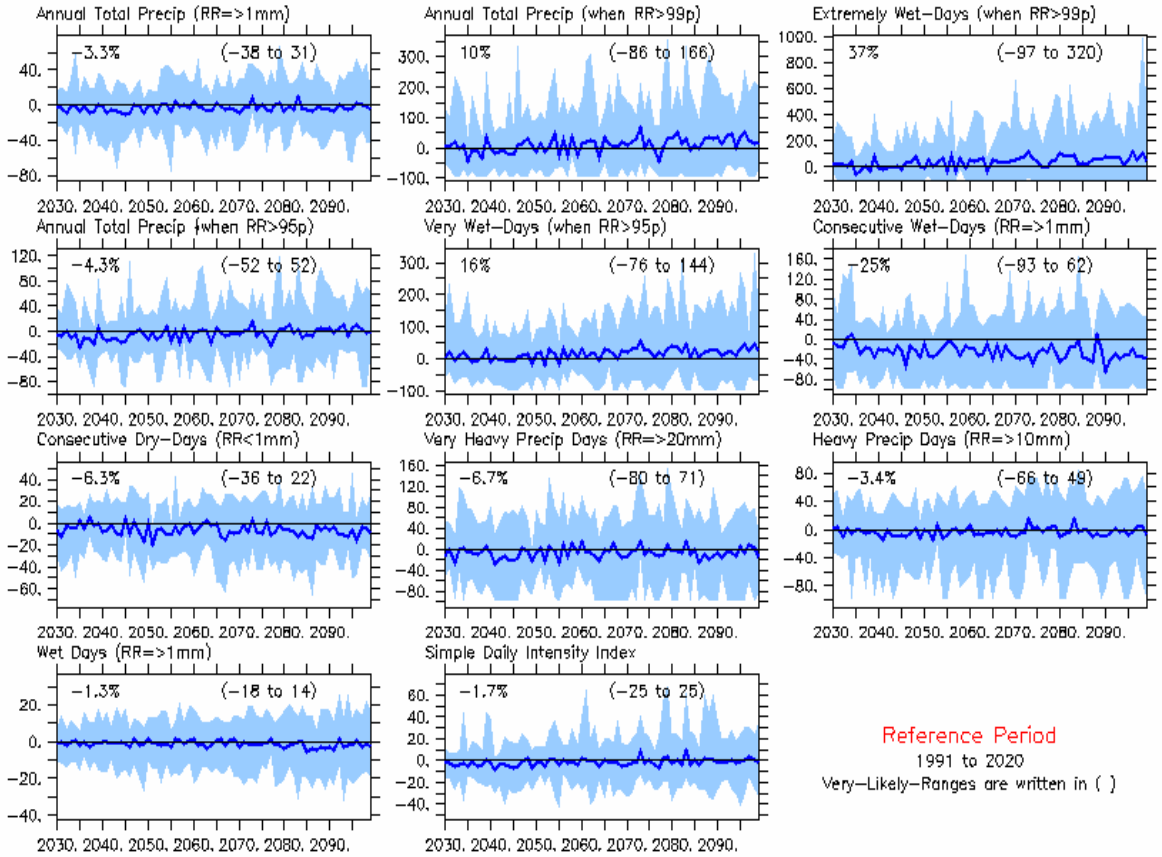


Reference Period
1991 to 2020
Very-Likely-Ranges are written in ( )

Projected Changes in Extreme Precipitation Indices (RCP85)

Nigeria_ABUJA

Lon=7 : Lat=9.25



Reference Period

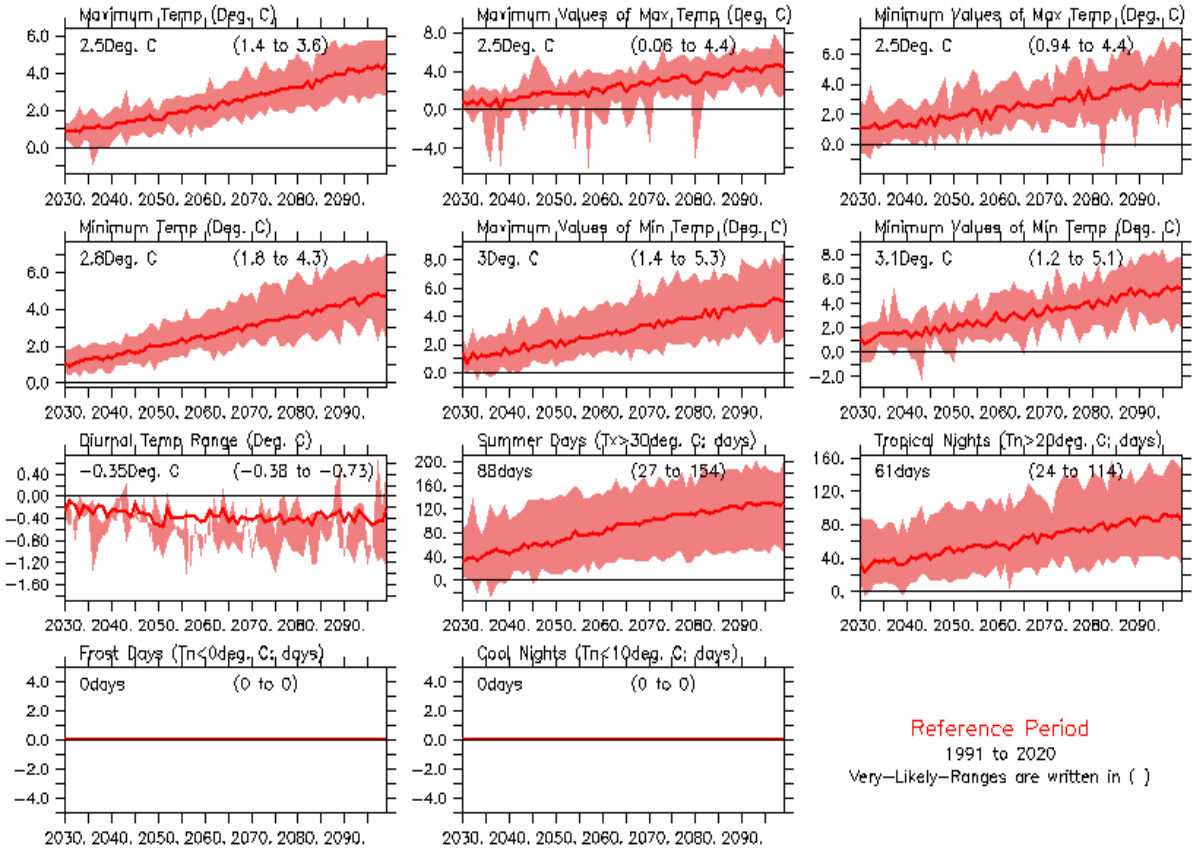
1991 to 2020

Very-Likely-Ranges are written in ( )

Projected Changes in Extreme Temperature Indices (RCP85)

Nigeria_ABUJA

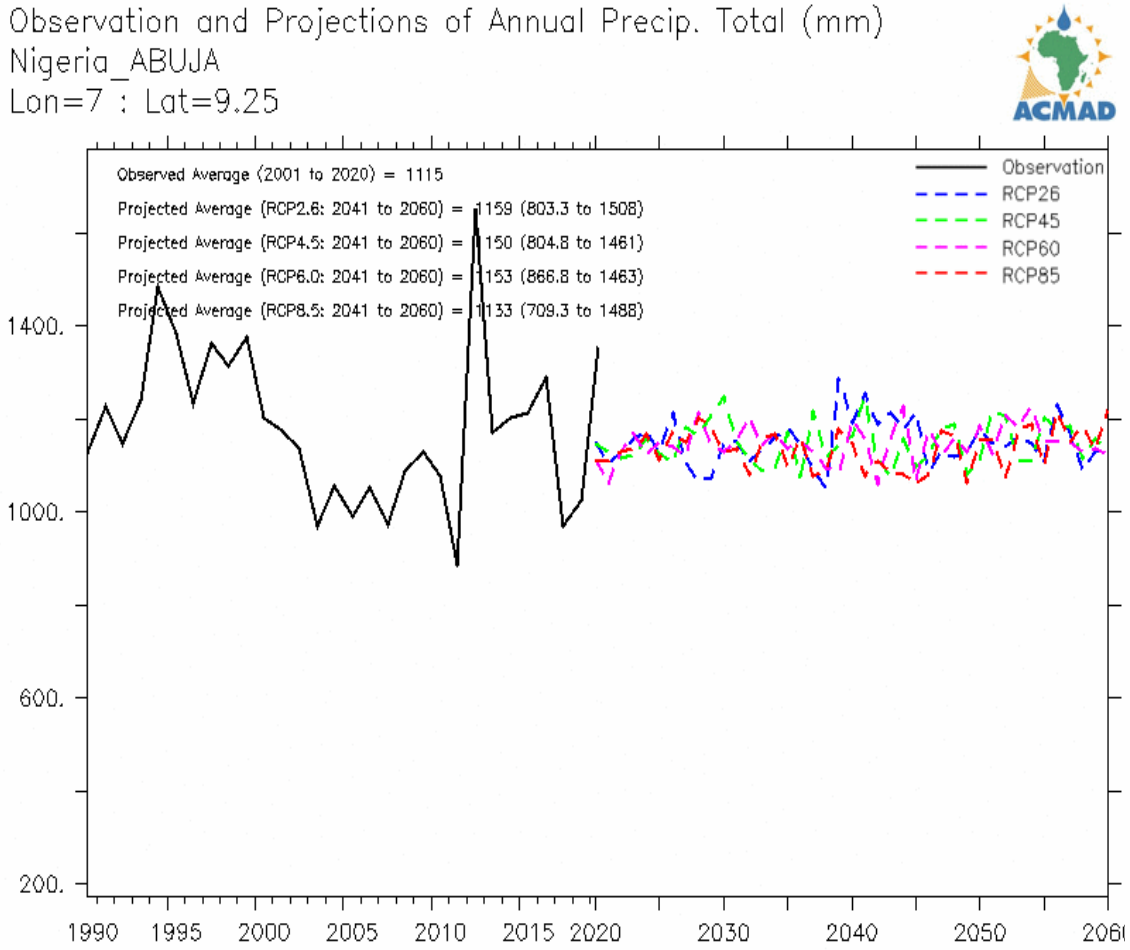
Lon=7 : Lat=9.25

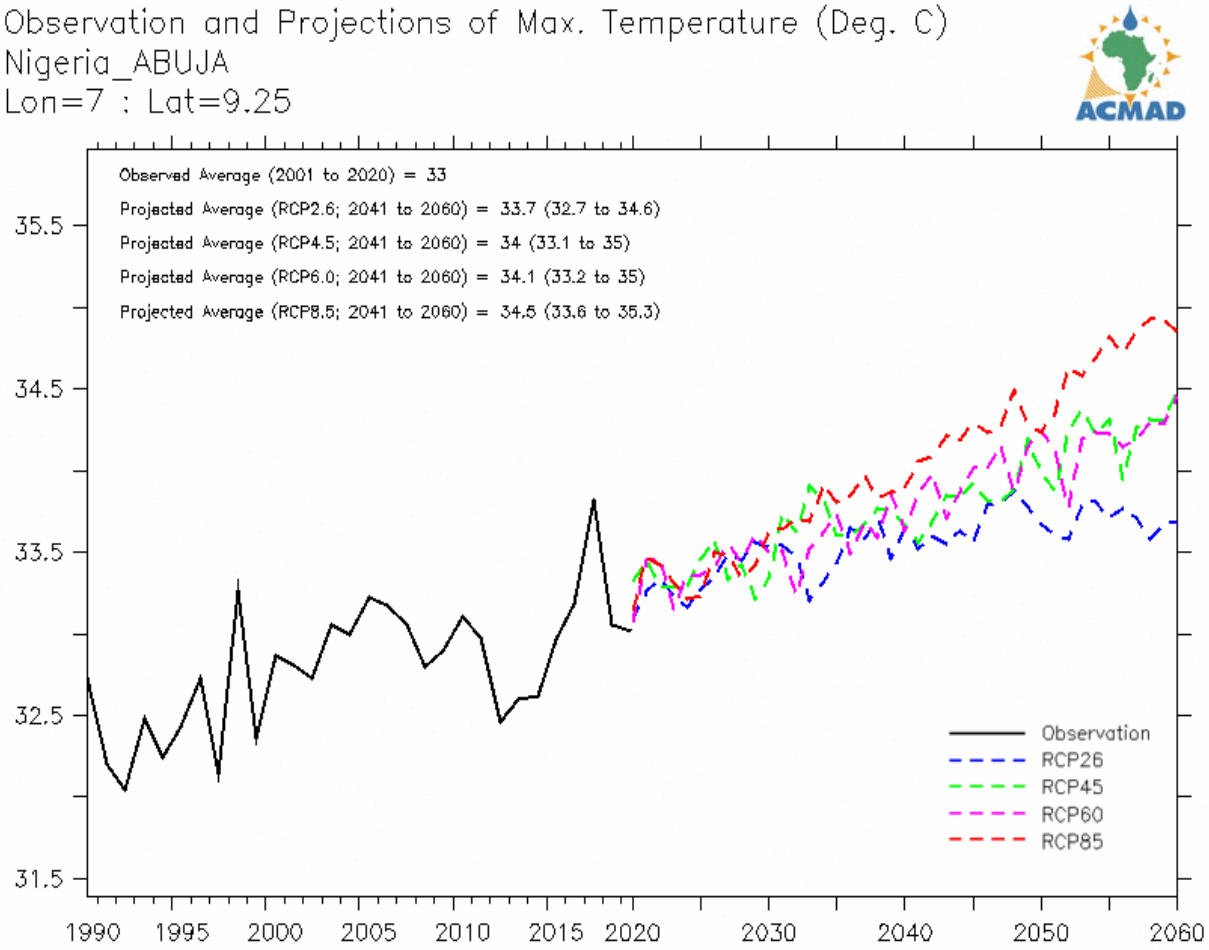


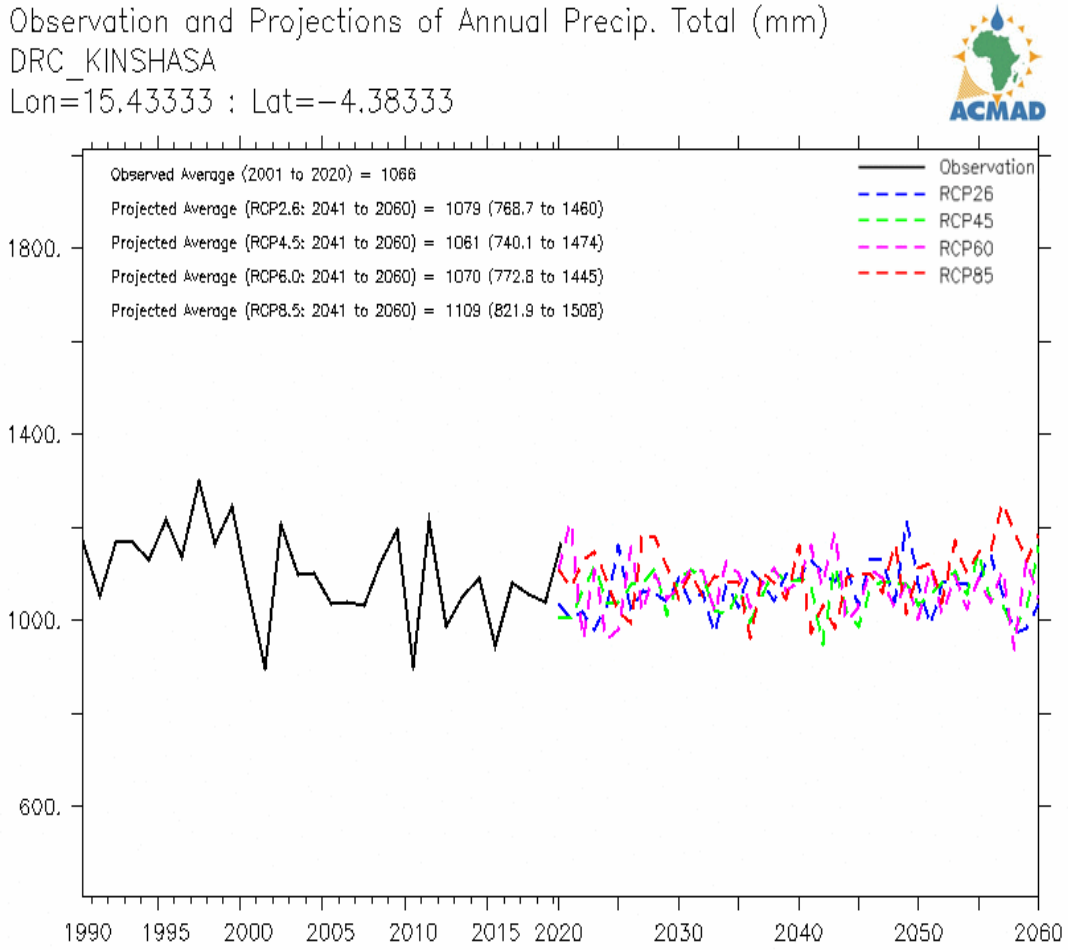
Reference Period

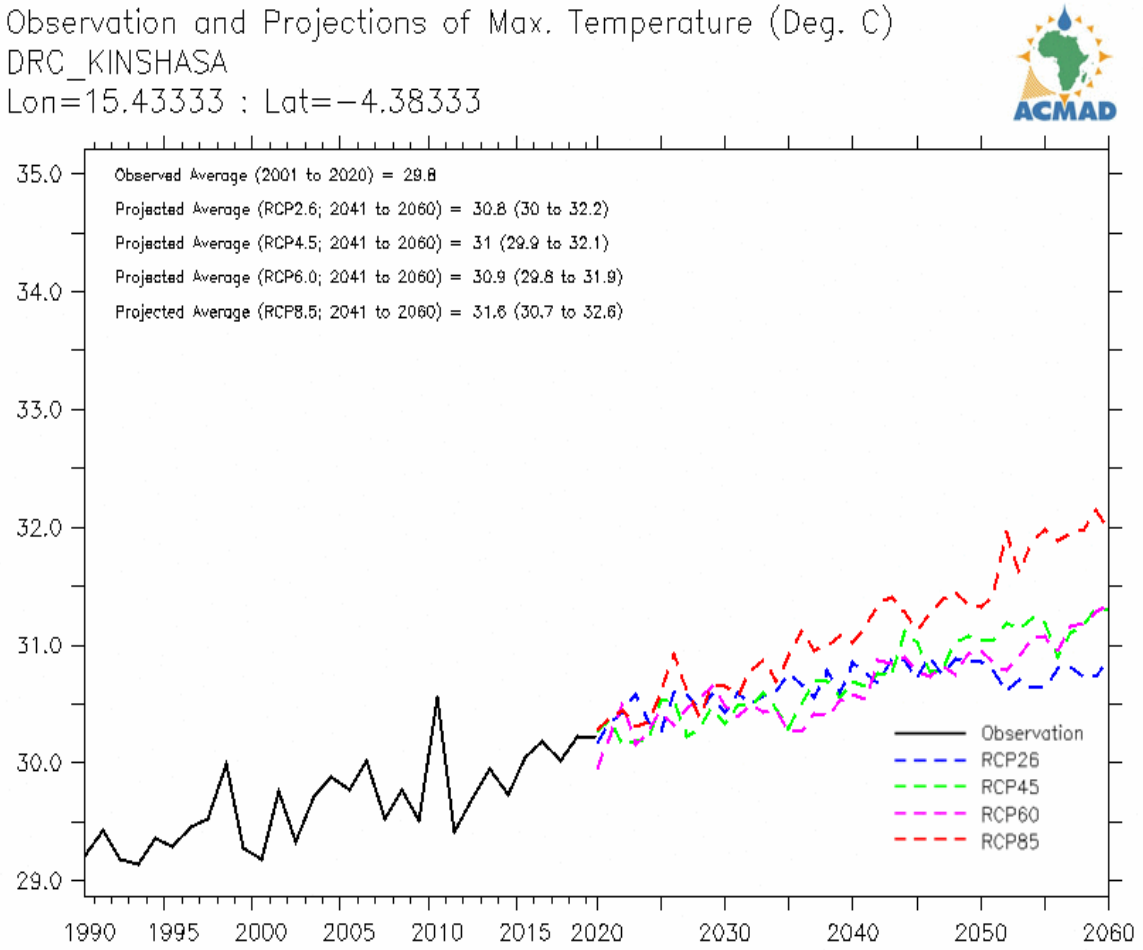
1991 to 2020

Very-Likely-Ranges are written in ( )


Observation and Projections of Annual Precip. Total (mm)
Nigeria_ABUJA
Lon=7 : Lat=9.25
Observed Average (2001 to 2020) = 1115
Projected Average (RCP2.6: 2041 to 2060) = 1159 (803.3 to 1508)
Projected Average (RCP4.5: 2041 to 2060) = 1150 (804.8 to 1461)
Projected Average (RCP6.0: 2041 to 2060) = 1153 (866.8 to 1463)
Projected Average (RCP8.5: 2041 to 2060) = 1133 (709.3 to 1488)
Observation
RCP26
RCP45
RCP60
RCP85
1400.
1000.
600.
200.
1990
1995
2000
2005
2010
2015
2020
2030
2040
2050
2060

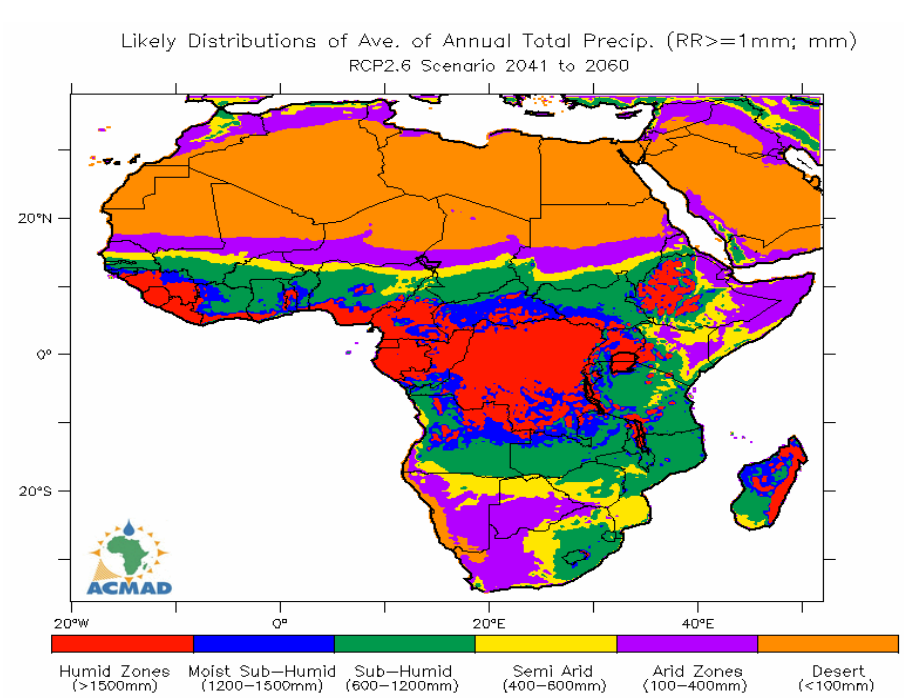

Observation and Projections of Max. Temperature (Deg. C)
Nigeria_ABUJA
Lon=7 : Lat=9.25
Observed Average (2001 to 2020) = 33
Projected Average (RCP2.6; 2041 to 2060) = 33.7 (32.7 to 34.6)
Projected Average (RCP4.5; 2041 to 2060) = 34 (33.1 to 35)
Projected Average (RCP6.0; 2041 to 2060) = 34.1 (33.2 to 35)
Projected Average (RCP8.5; 2041 to 2060) = 34.5 (33.6 to 35.3)
35.5
34.5
33.5
32.5
31.5
Observation
RCP26
RCP45
RCP60
RCP85
1990
1995
2000
2005
2010
2015
2020
2030
2040
2050
2060

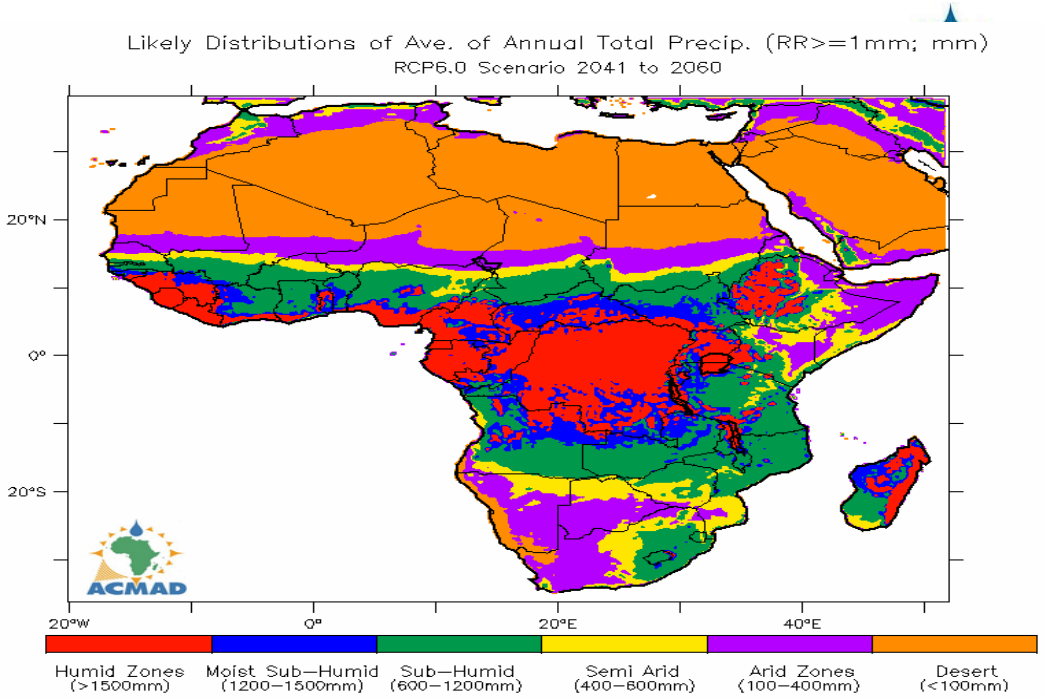

Observation and Projections of Annual Precip. Total (mm)
DRC_KINSHASA
Lon=15.43333 : Lat=-4.38333
Observed Average (2001 to 2020) = 1066
Projected Average (RCP2.6: 2041 to 2060) = 1079 (768.7 to 1460)
Projected Average (RCP4.5: 2041 to 2060) = 1061 (740.1 to 1474)
Projected Average (RCP6.0: 2041 to 2060) = 1070 (772.8 to 1445)
Projected Average (RCP8.5: 2041 to 2060) = 1109 (821.9 to 1508)
Observation
RCP26
RCP45
RCP60
RCP85
1800.
1400.
1000.
600.
1990 1995 2000 2005 2010 2015 2020 2030 2040 2050 2060

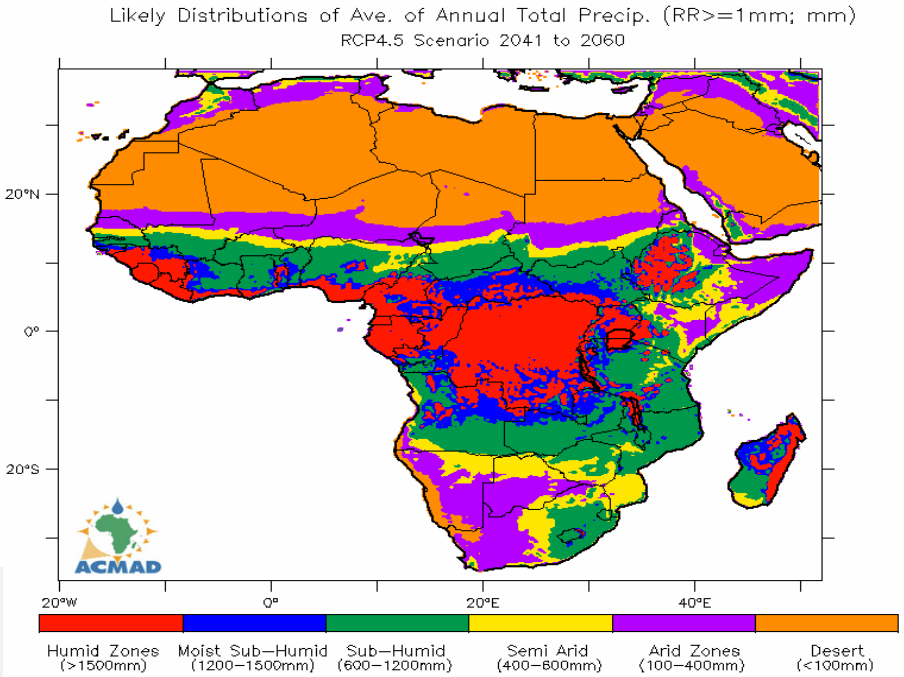

Observation and Projections of Max. Temperature (Deg. C)
DRC_KINSHASA
Lon=15.43333 : Lat=-4.38333
Observed Average (2001 to 2020) = 29.8
Projected Average (RCP2.6; 2041 to 2060) = 30.8 (30 to 32.2)
Projected Average (RCP4.5; 2041 to 2060) = 31 (29.9 to 32.1)
Projected Average (RCP6.0; 2041 to 2060) = 30.9 (29.8 to 31.9)
Projected Average (RCP8.5; 2041 to 2060) = 31.6 (30.7 to 32.6)
Observation
RCP26
RCP45
RCP60
RCP85
35.0
34.0
33.0
32.0
31.0
30.0
29.0
1990 1995 2000 2005 2010 2015 2020 2030 2040 2050 2060

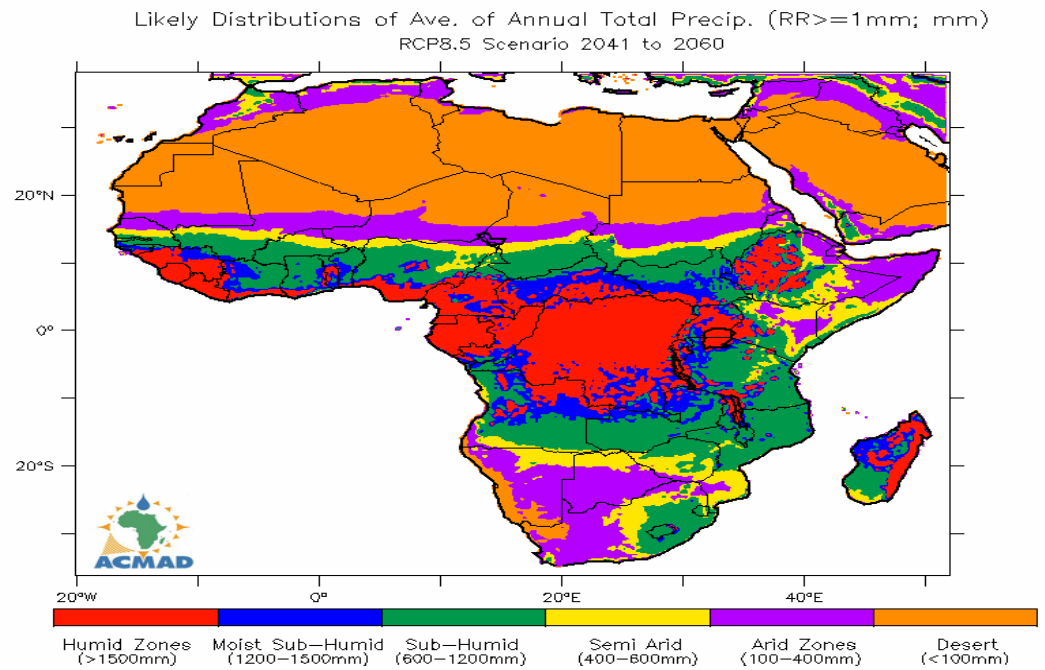
Likely spatial distributions of the near-future (2041-2060) annual average total precipitation over Africa.

Spatial correlations with observation > 0.96









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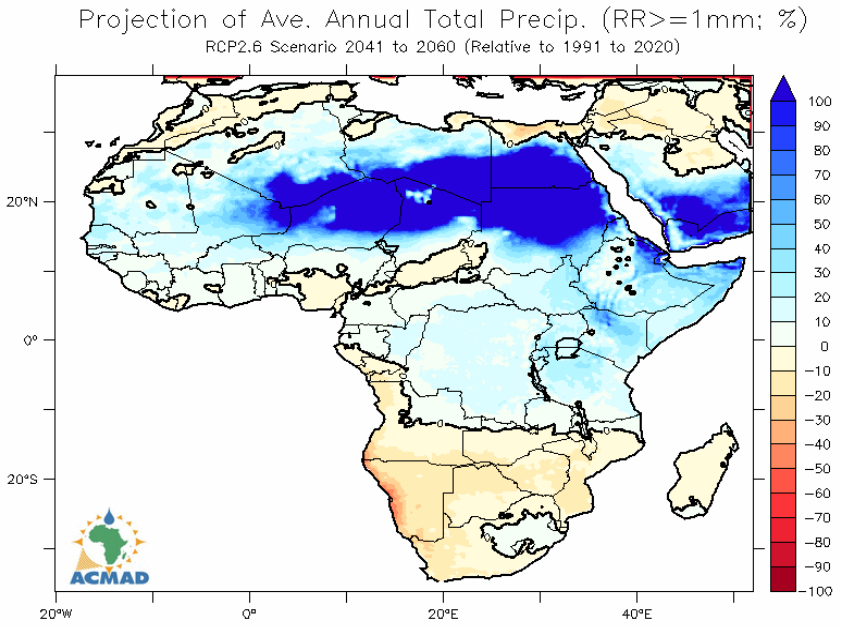
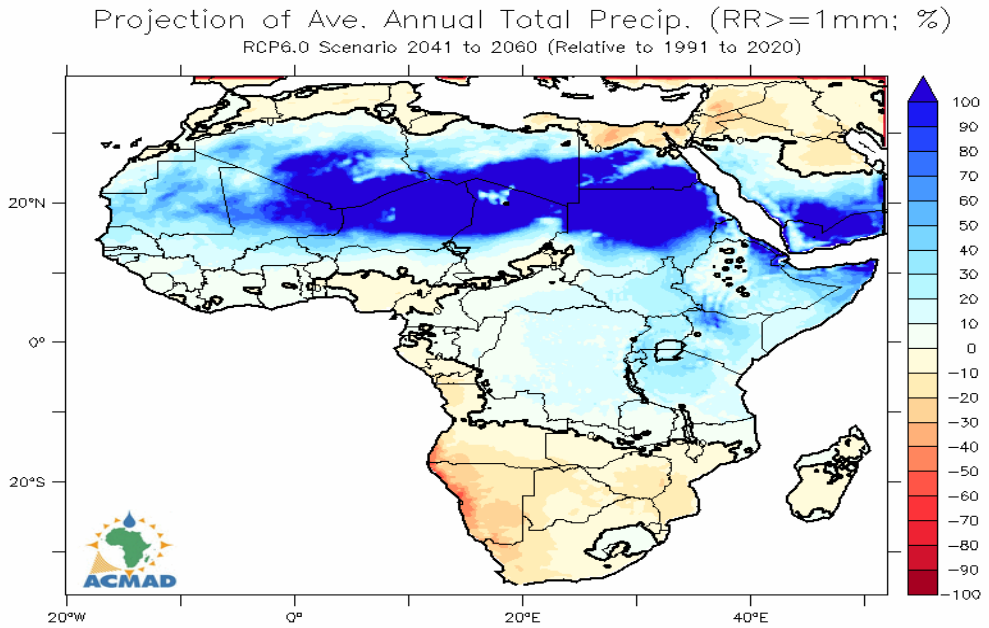
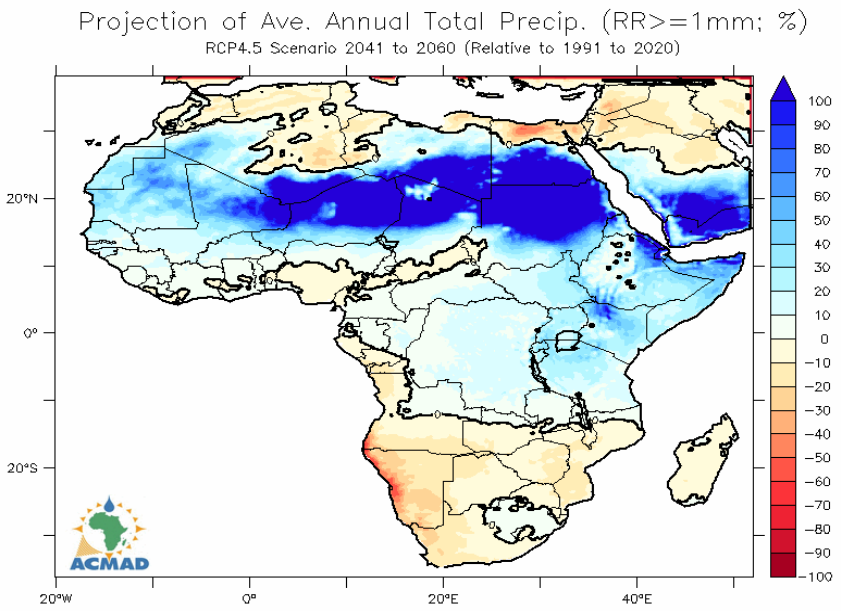
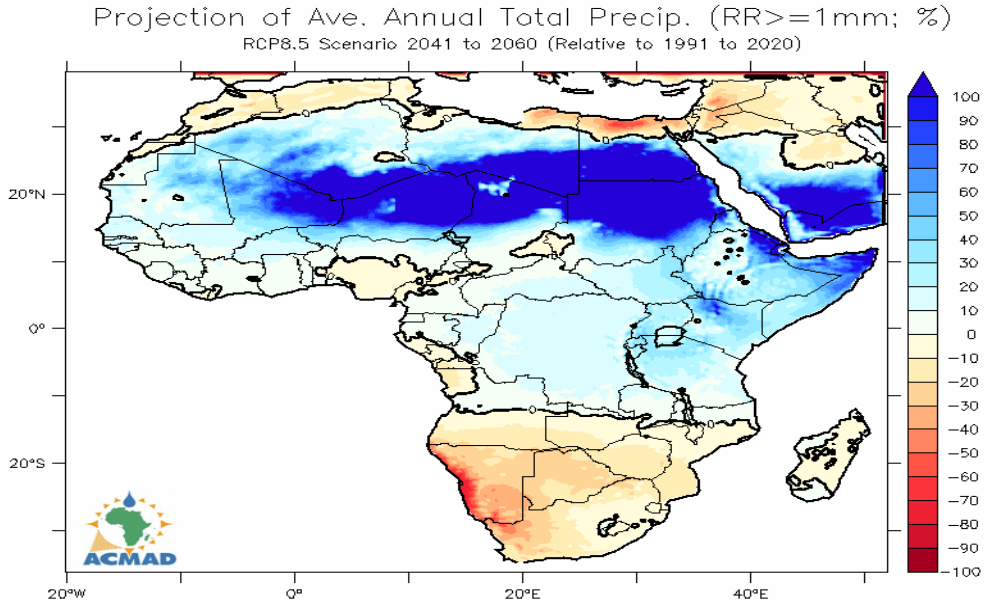
Spatial distributions of the projected departures of the near-future (2041-2060) annual total precipitation over Africa, relative to 1991-2020 climatology









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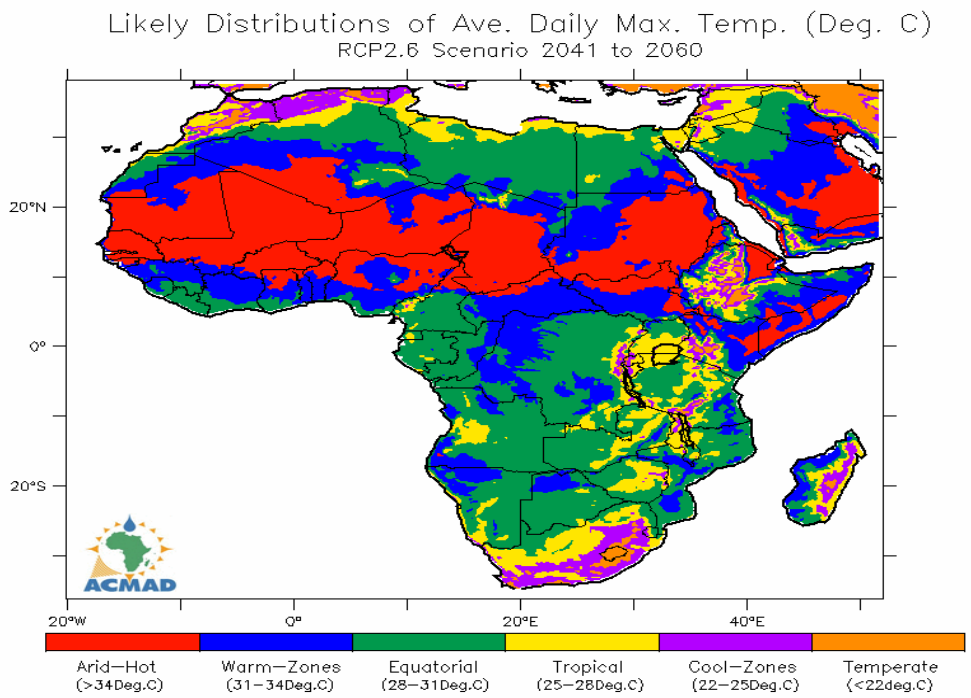
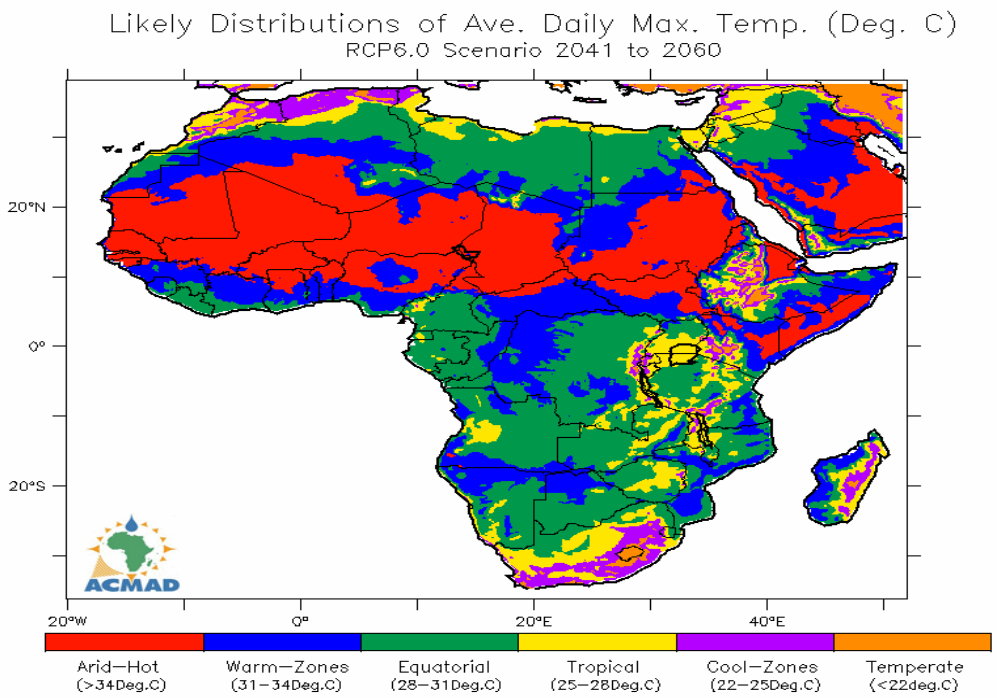
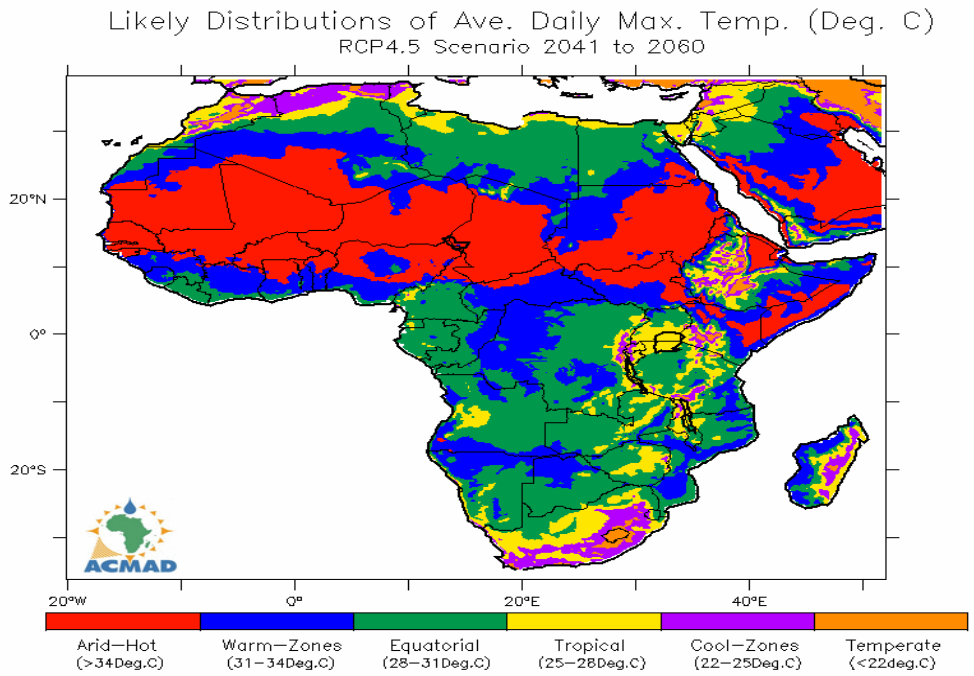
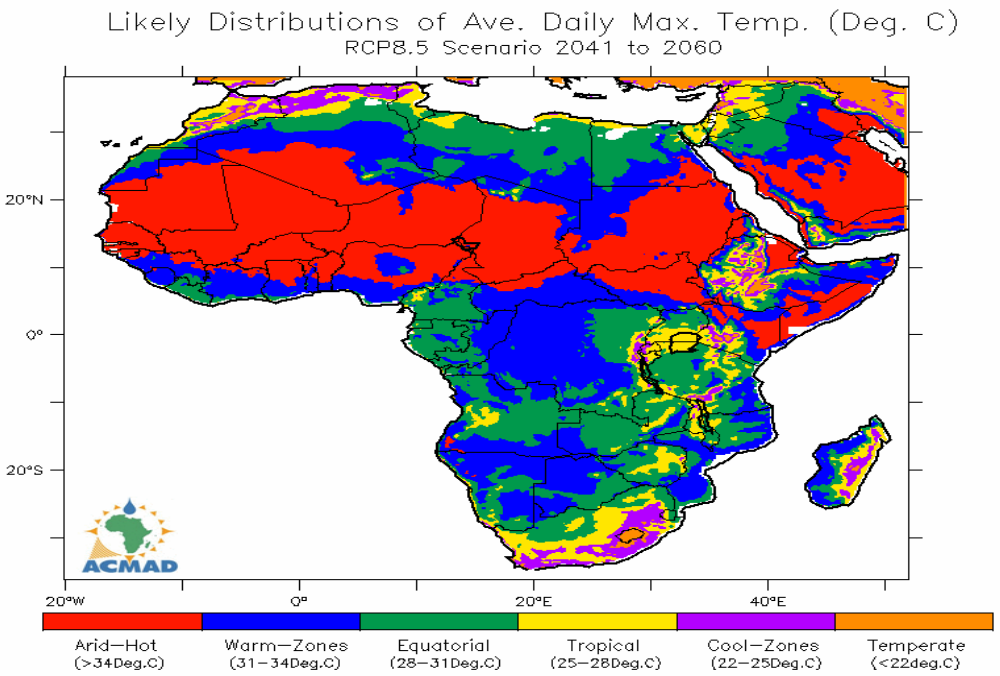
Likely spatial distributions of the near-future (2041-2060) annual average max. temp. over Africa.

Spatial correlations with observation < 0.65



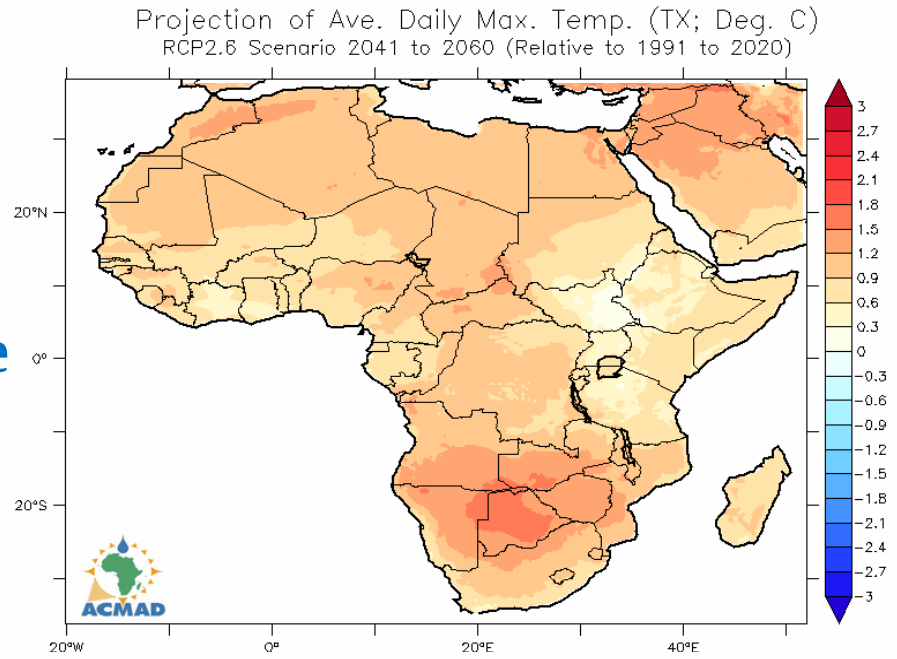


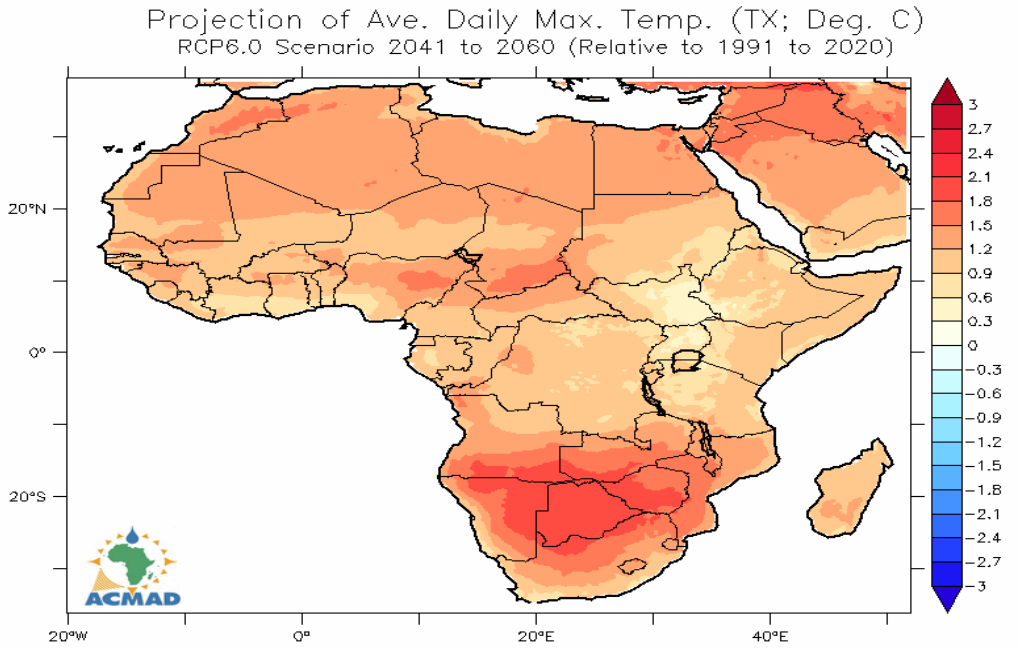


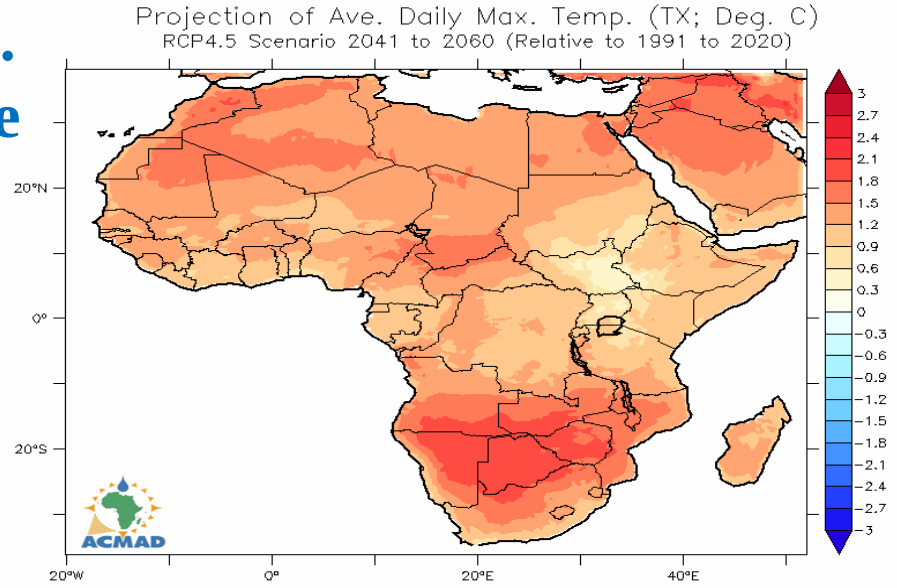


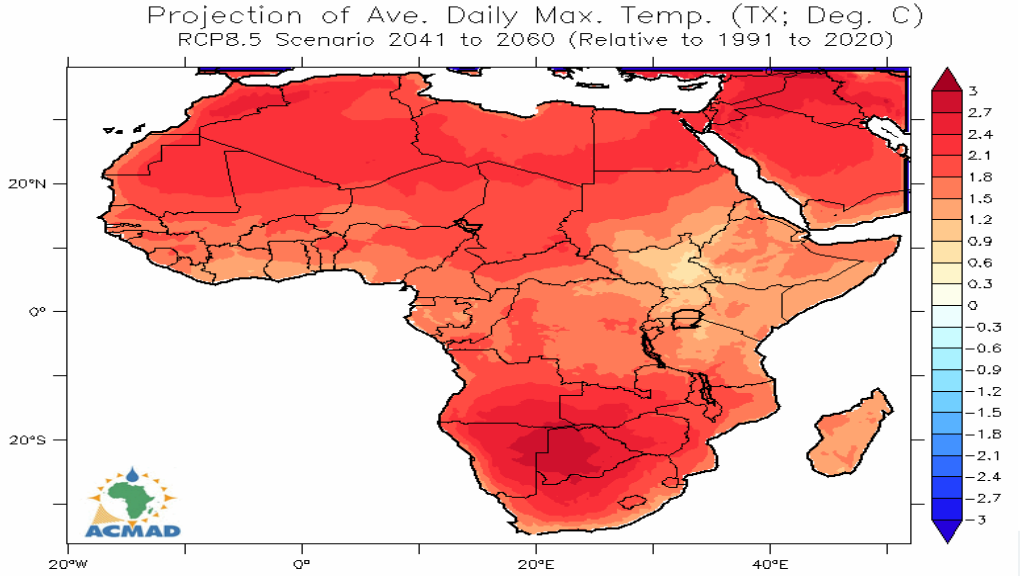
ClimSA

Spatial distributions of the projected departures of the near-future (2041-2060) annual average max. temp. over Africa, relative to 1991-2020 climatology









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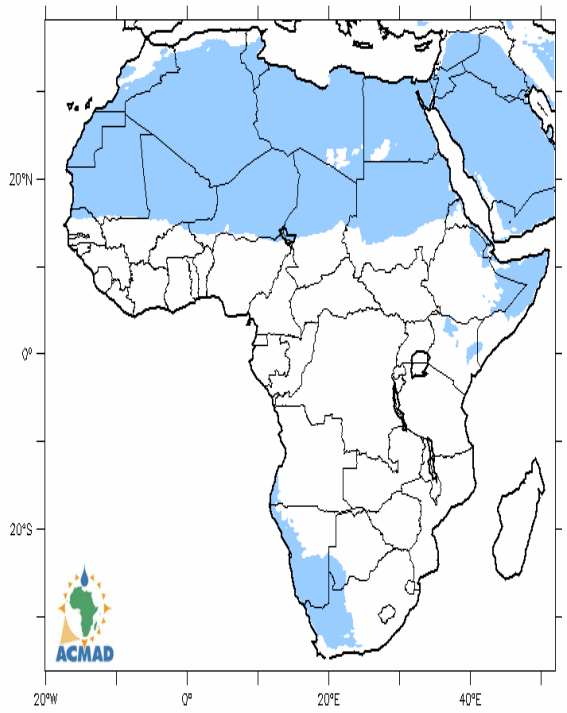
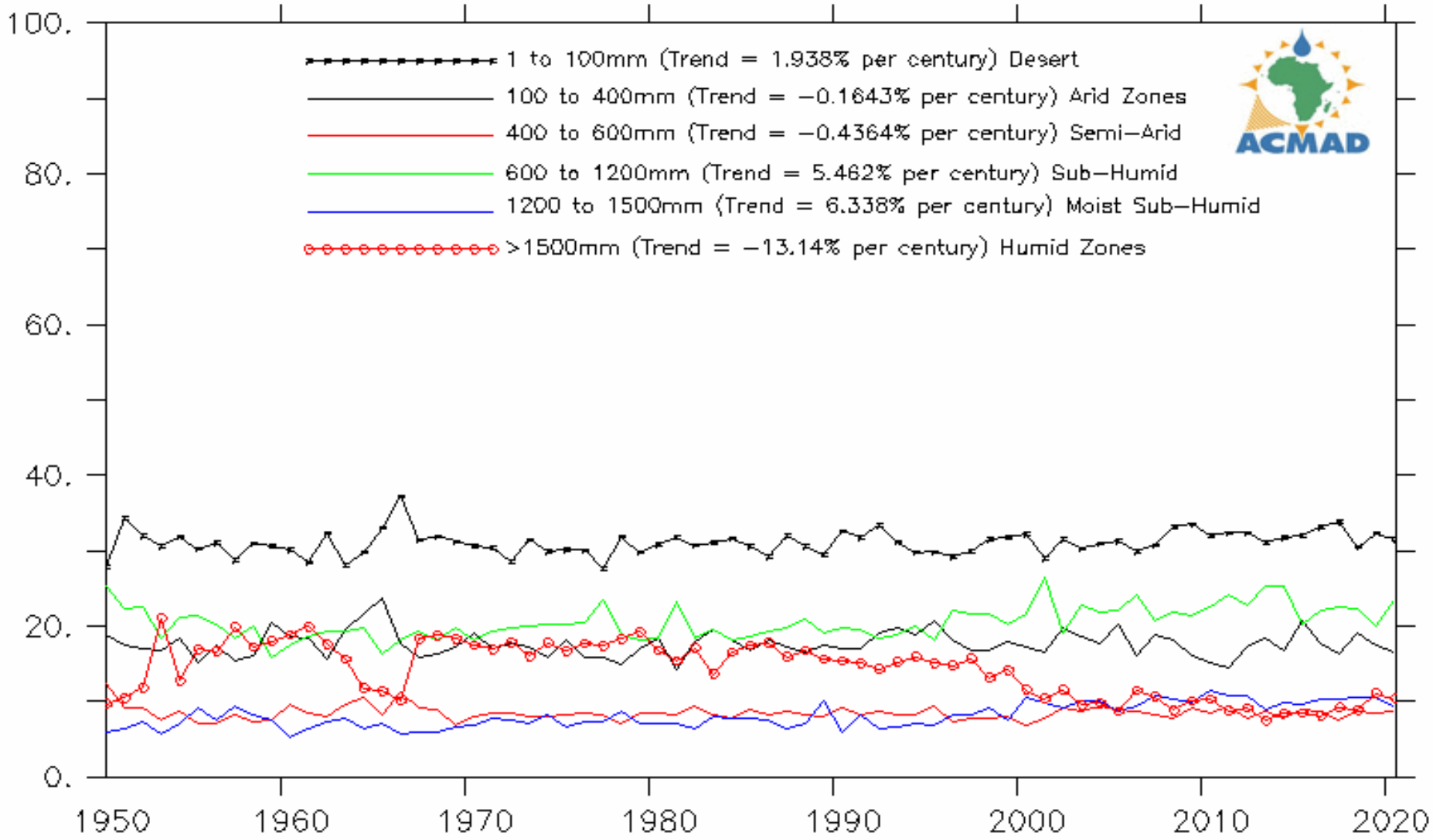
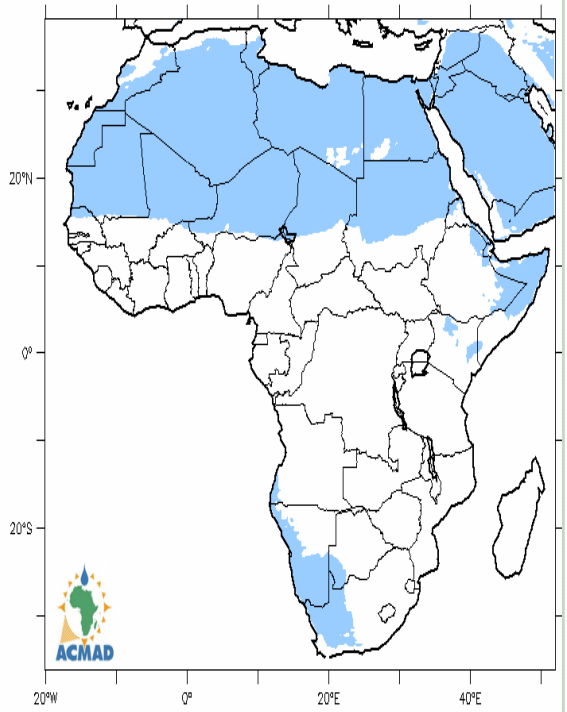
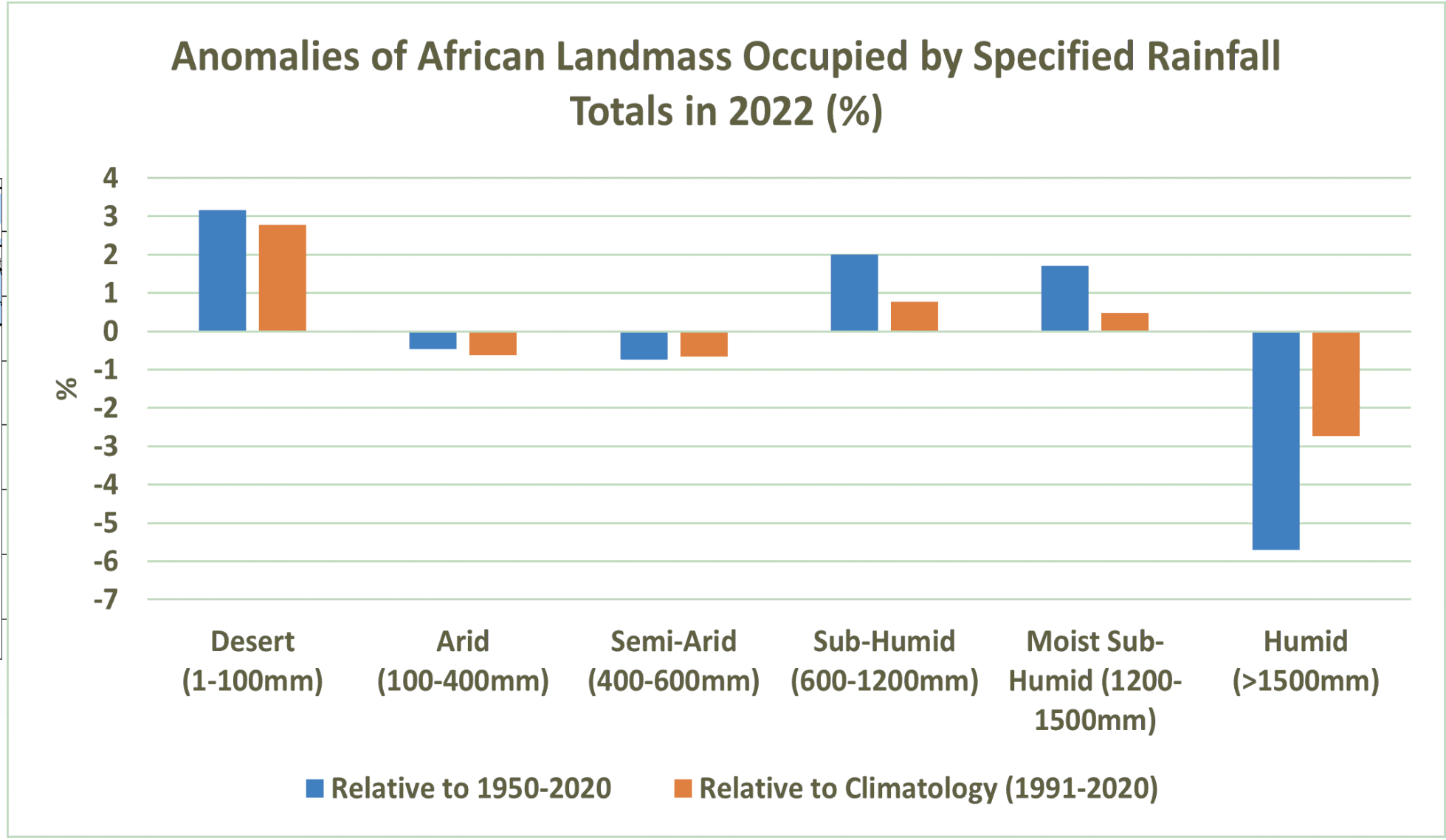
Annual African Landmass Occupied by Specified Rainfall Totals and their Trends





Anomalies of African Landmass Occupied by Specified Rainfall Totals in 2022



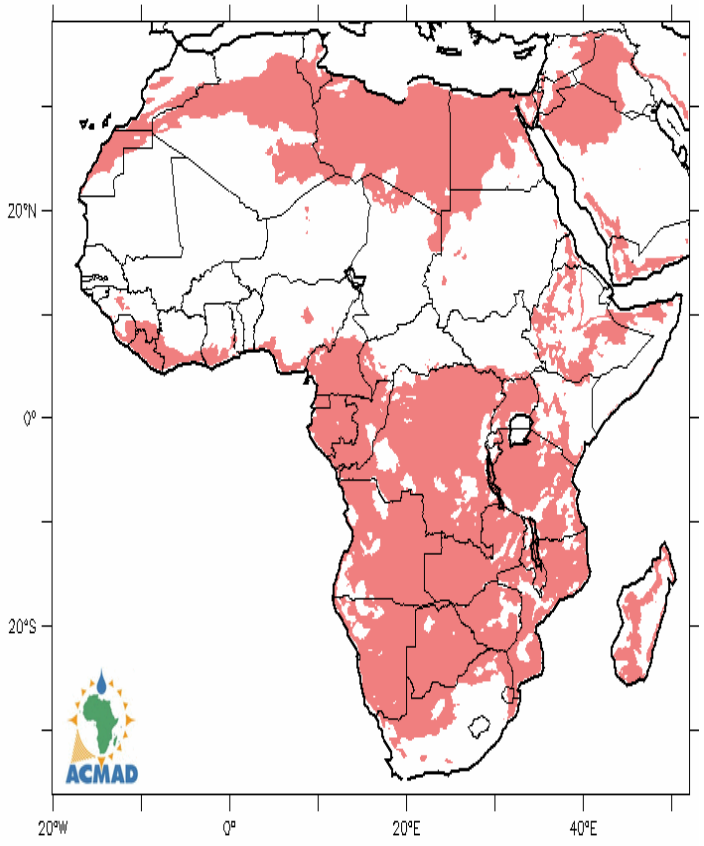


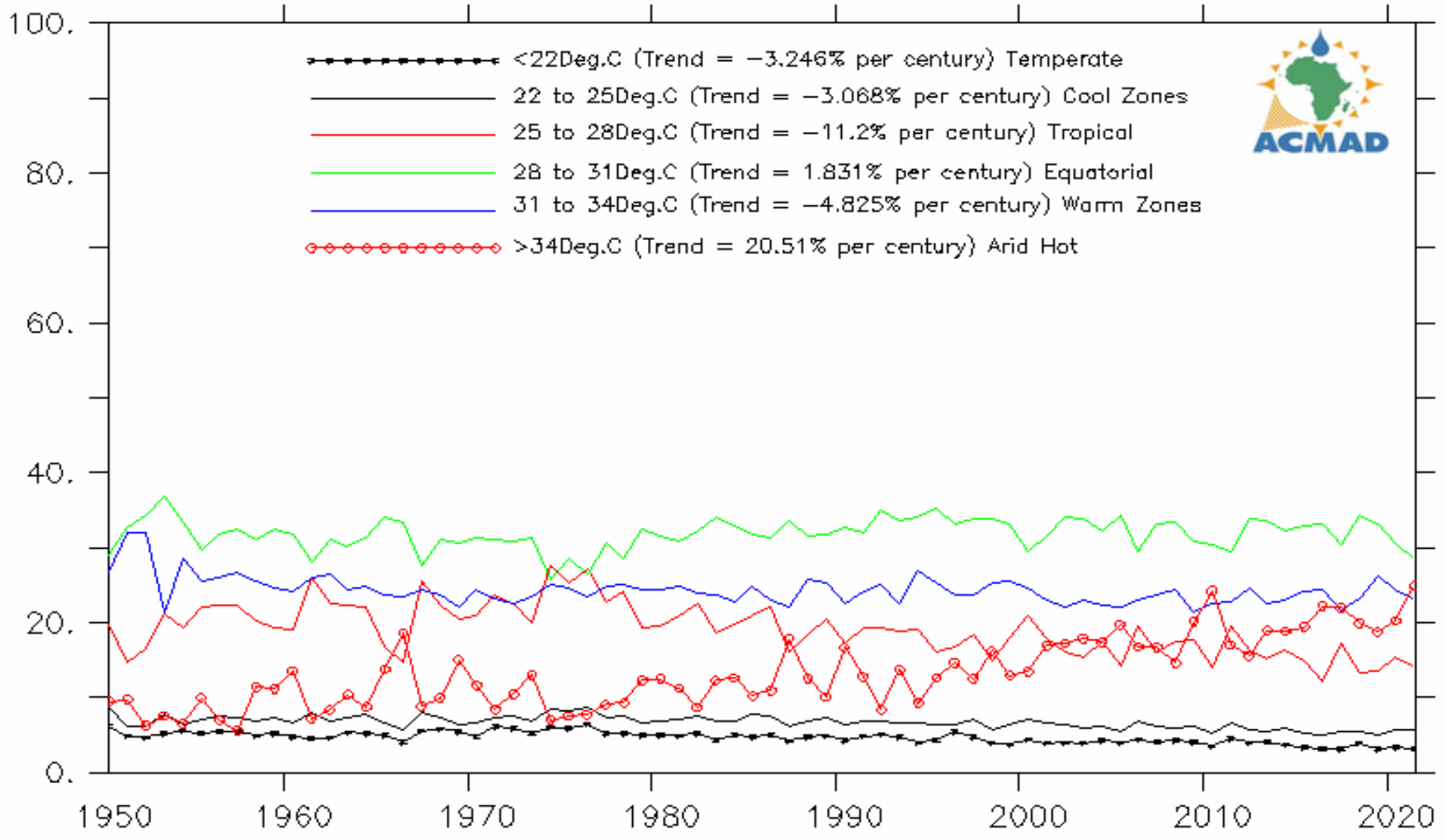
African Landmass occupied by Desert Zones (1mm<=RR<100mm) are expanding while those of humid zones (RR>=1500mm) are shrinking.

In 2022 – Landmass occupied by Desert Zones (1mm<=RR<100mm) expanded by about 3% above normal while humid zones (RR>=1500mm) shrank by about 3-6% below normal.

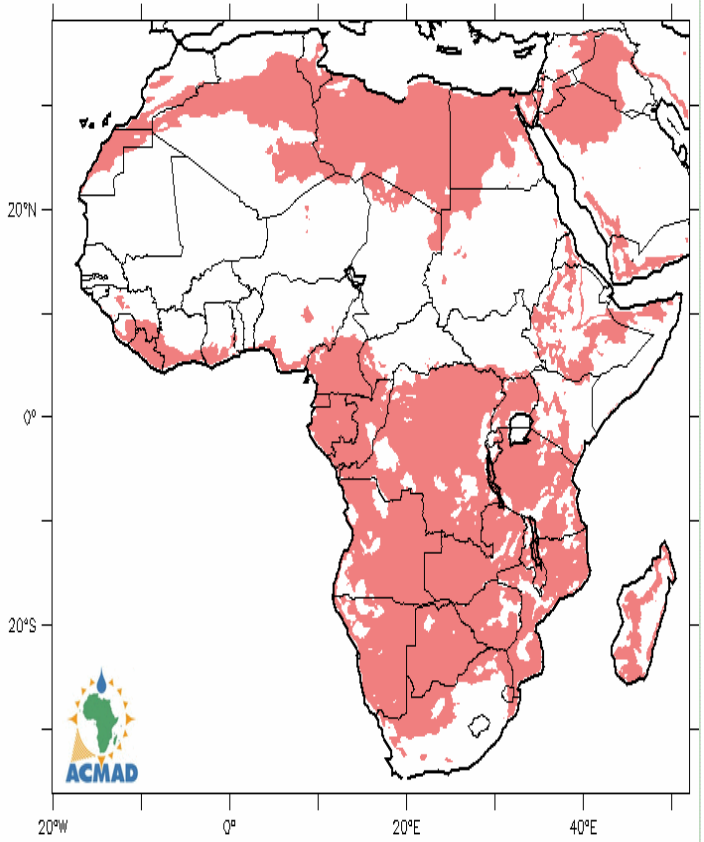
More places got lesser rainfall in 2022

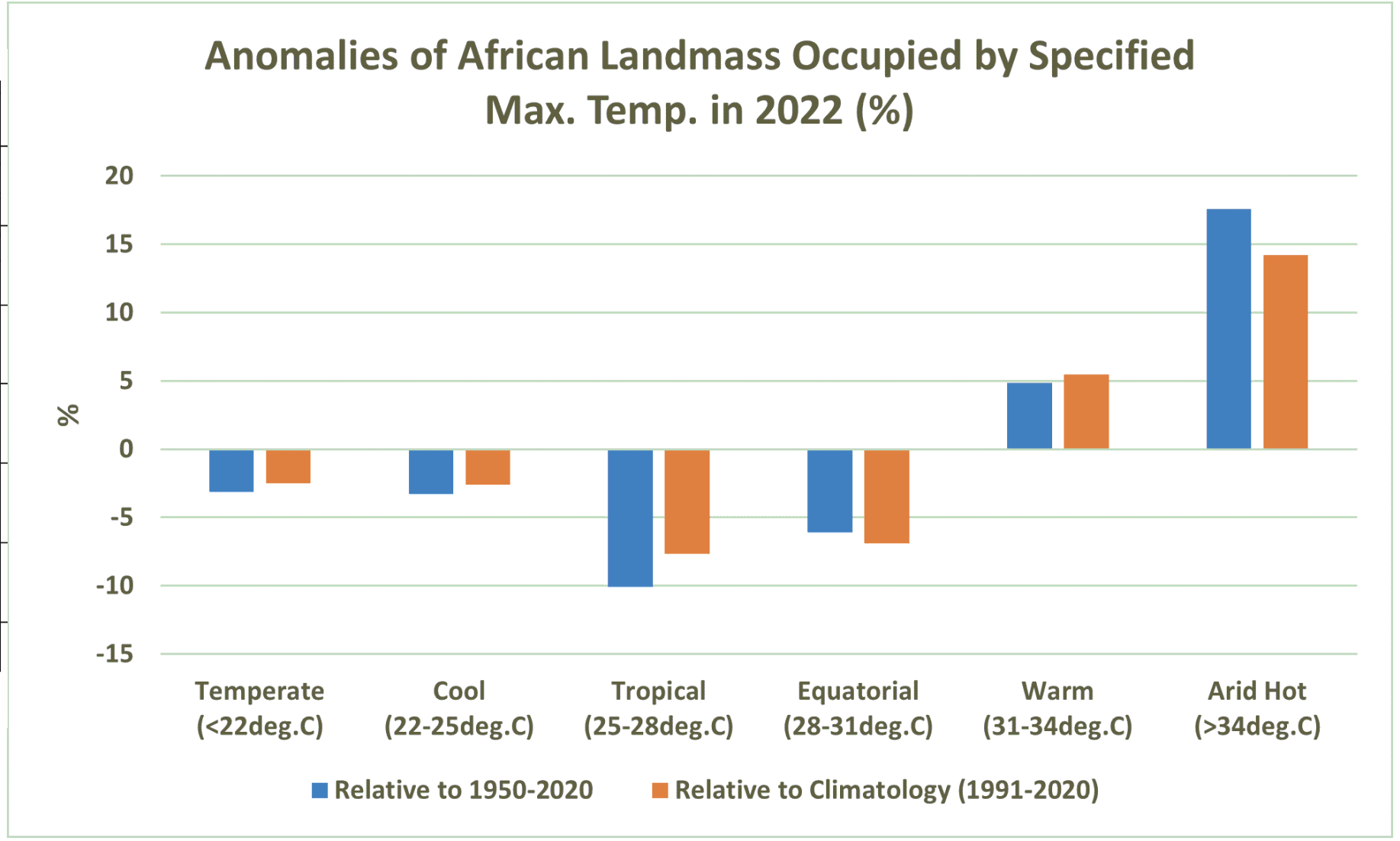
Annual African Landmass Occupied by Specified Max. Temp. and their Trends





Anomalies of African Landmass Occupied by Specified Max. Temp. in 2022



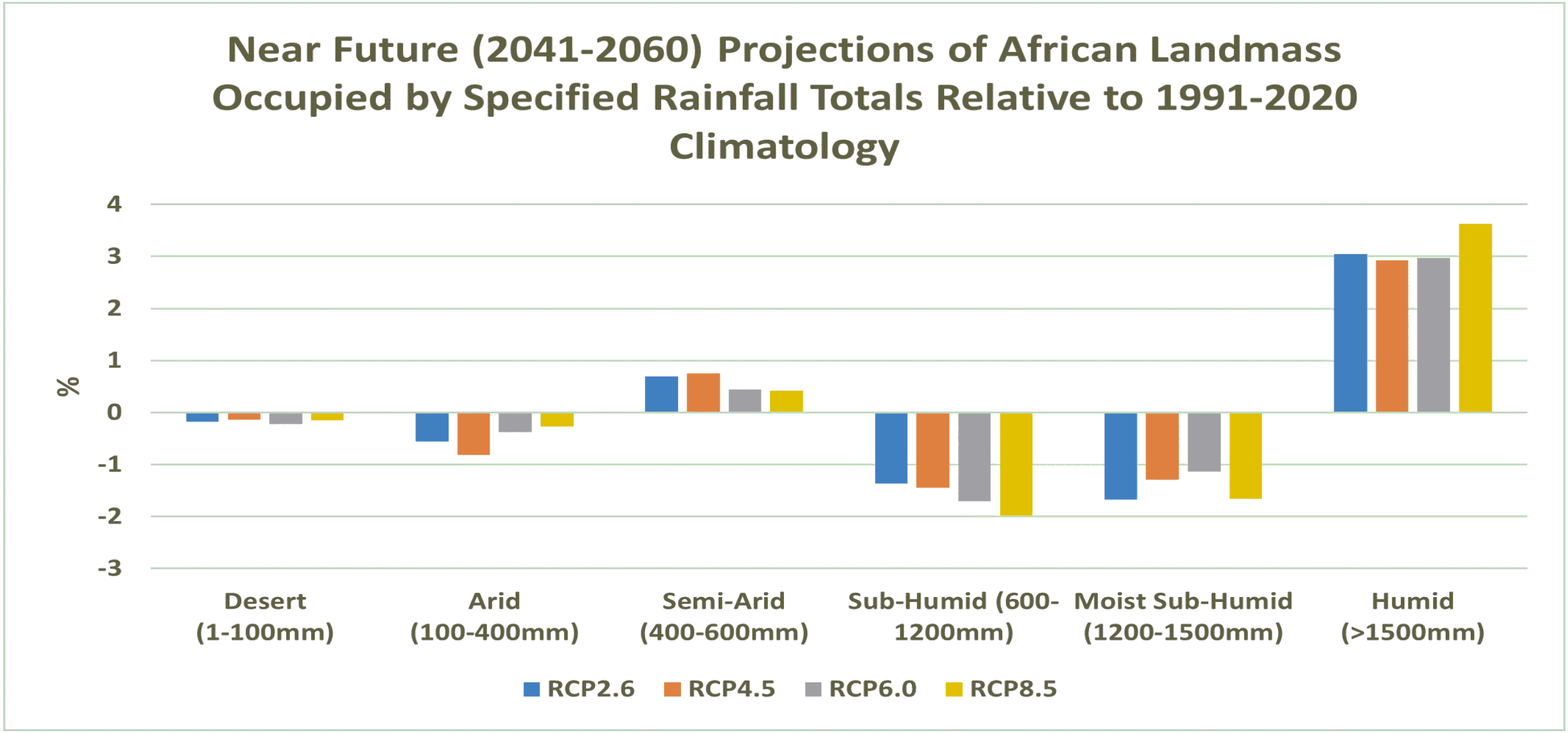


African Landmass occupied by max. temp. >34deg.C are expanding rapidly while those of max. temp. that are <28deg.C are shrinking.

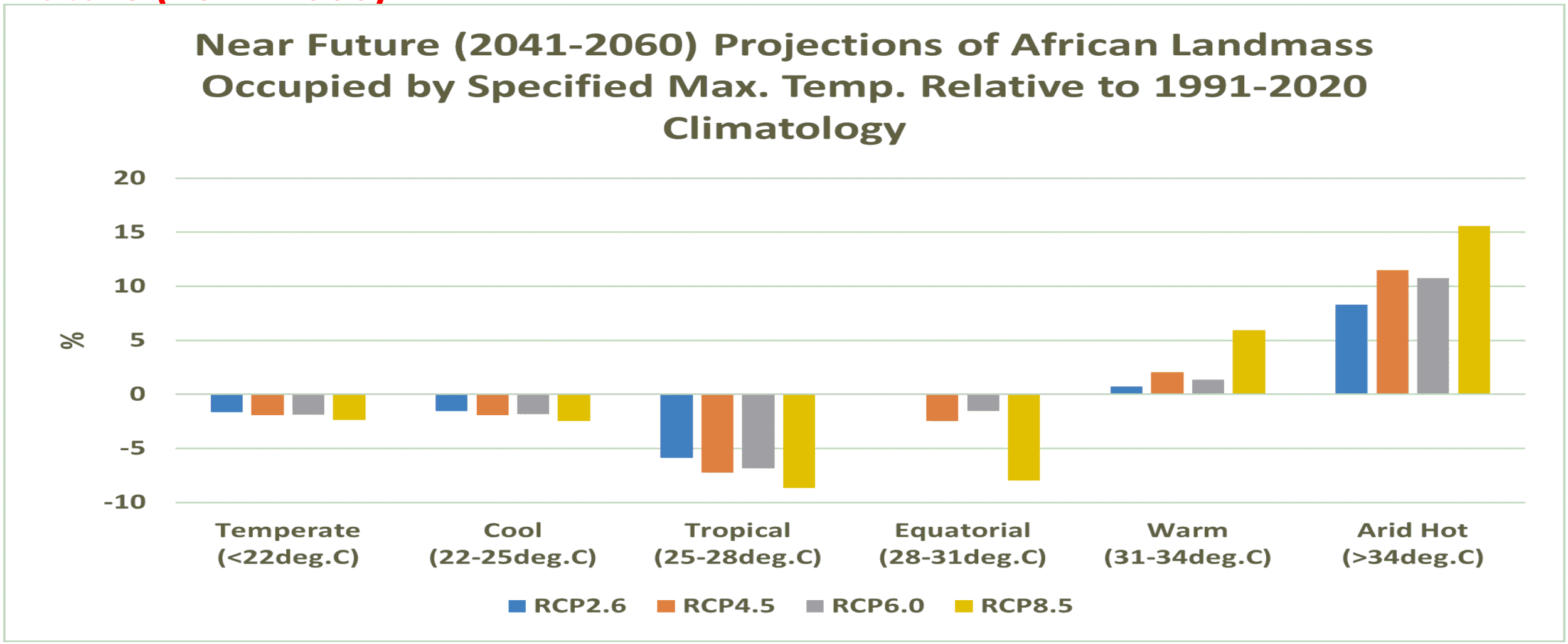
In 2022 – Landmass occupied by max. temp. >31deg.C expanded by 5 – 17% above normal while max. temp. that are <31deg.C shrank by 3-10% below normal.

More places got warmer in 2022

Humid Zones (RR>=1500mm) are likely to expand by about 3% in the Near Future (2041-2060)



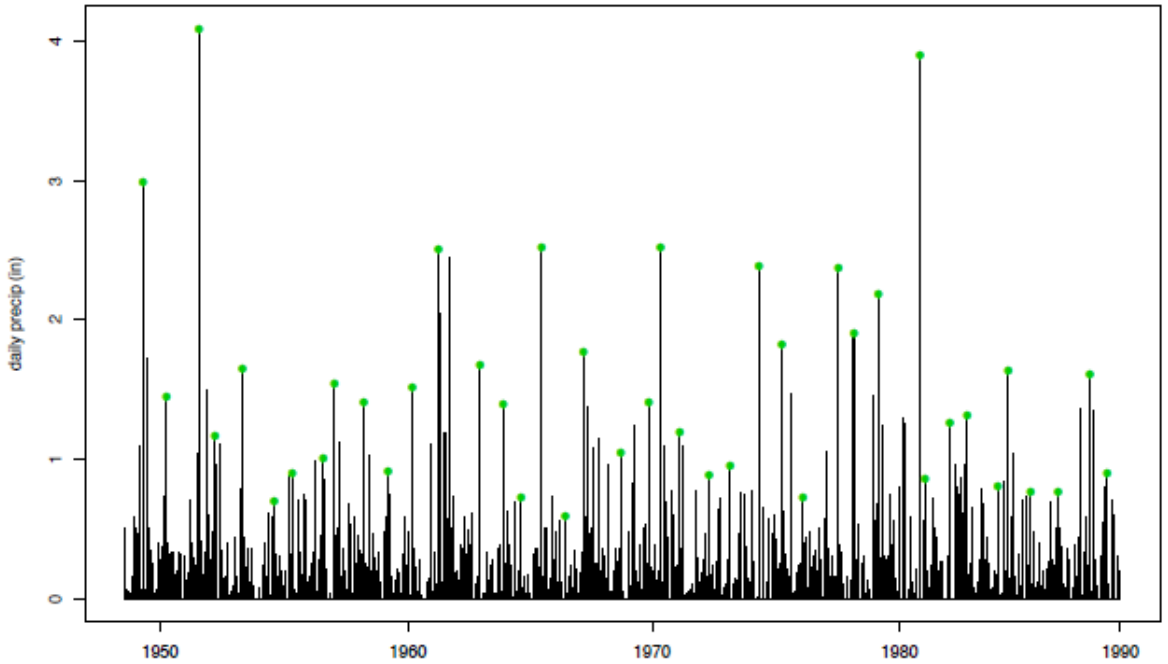
Warm (31-34deg.C) and Arid-Hot (>34deg. C) Zones are likely to expand by 5-15% while landmass occupied by cooler areas (<28deg. C) are likely to shrink by up to 8% in the Near Future (2041-2060)

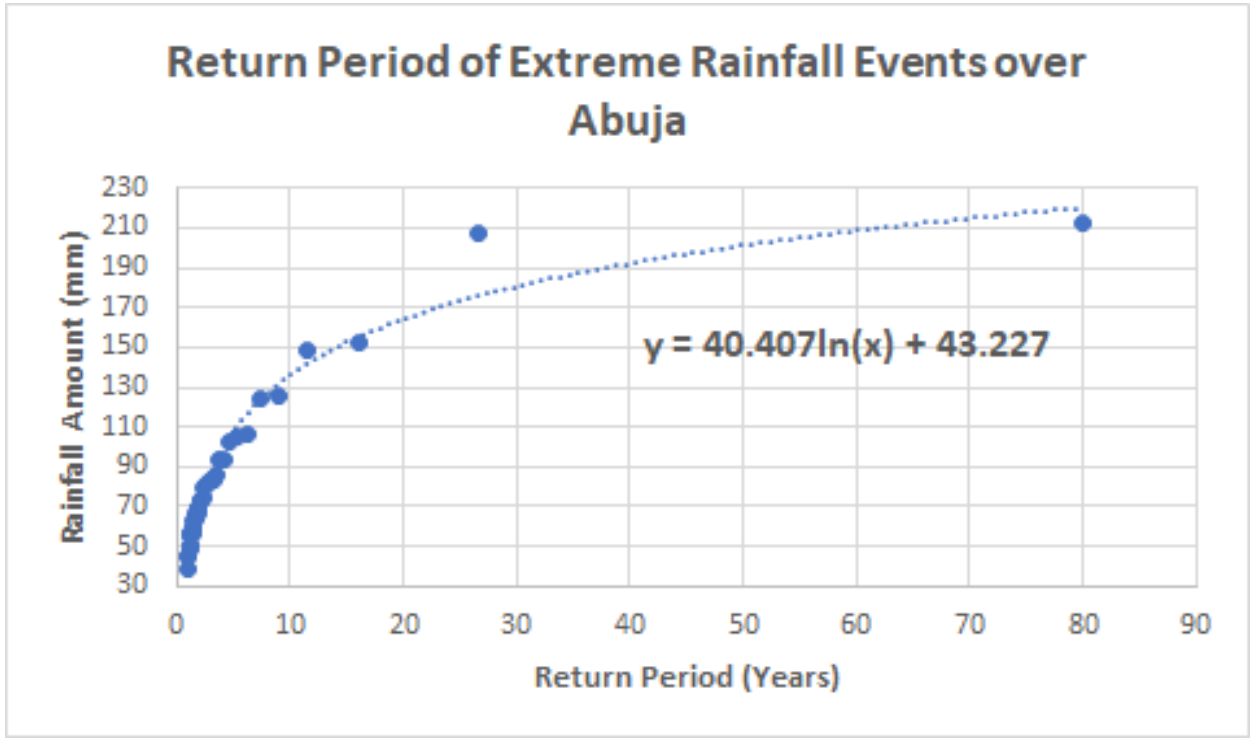


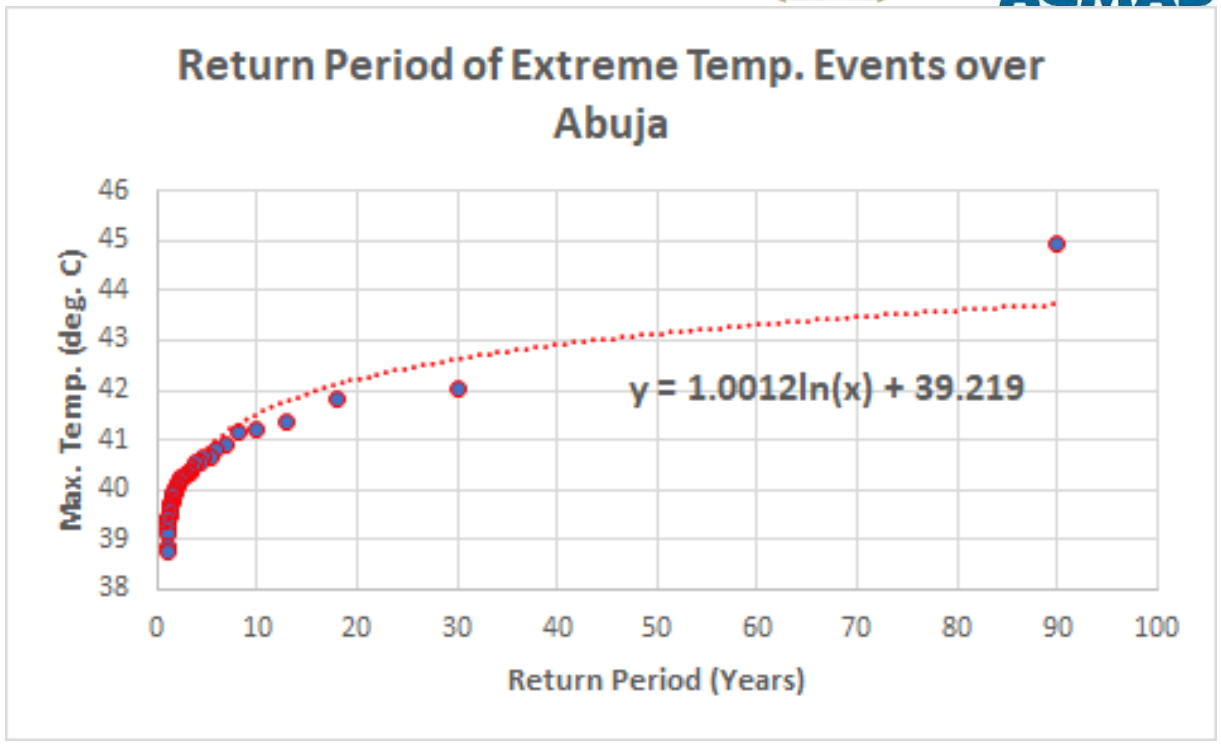
How exactly often are these extreme events likely to keep occurring?

Here, we calculate and display, graphically, the "Return Periods" - an estimated average time between events. Also known as a **recurrence interval** or **repeat interval.**

Approach used – extraction of annual maxima and fitting a model.





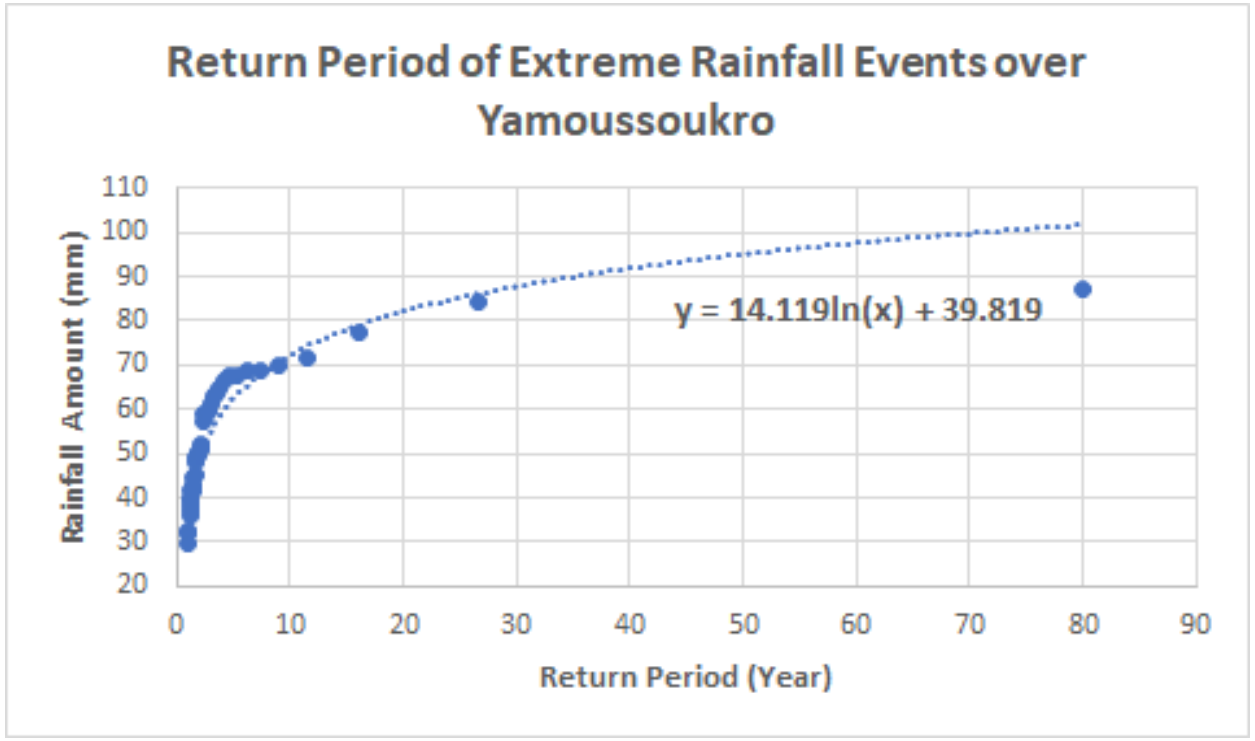


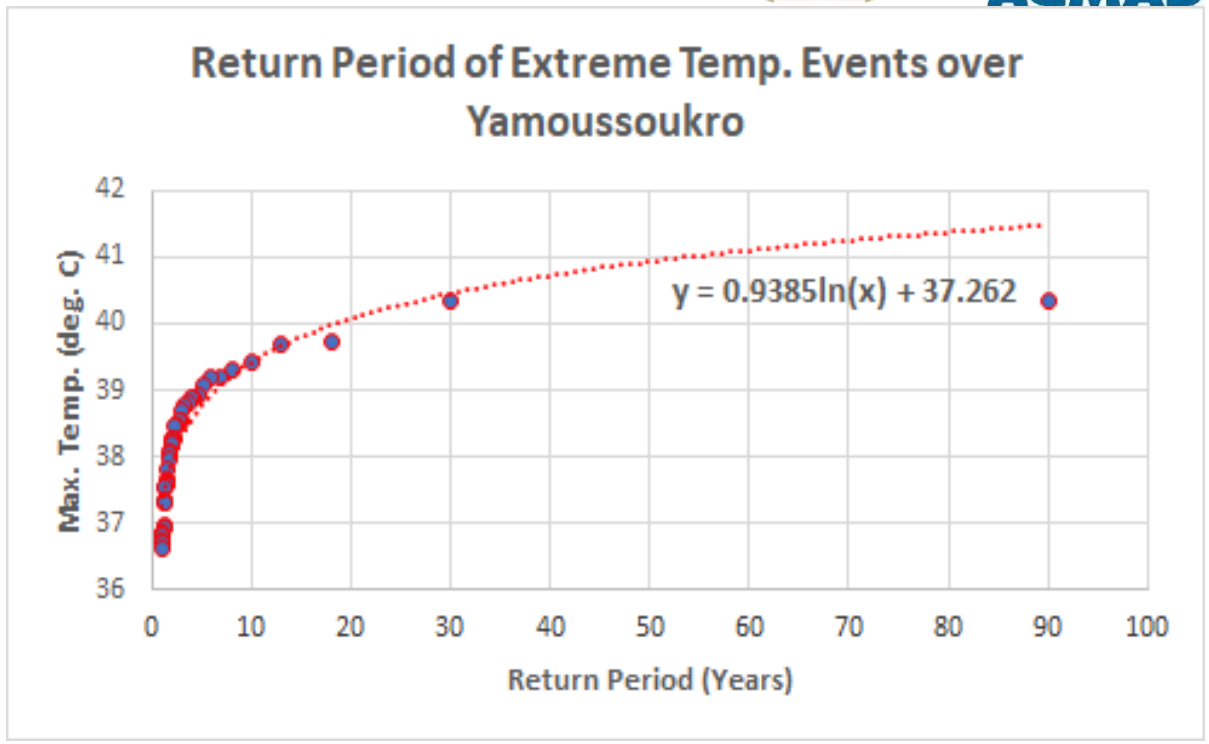
40 - 50mm daily rainfalls may likely become annual events.

50 - 130mm daily rainfalls may likely be reoccurring every 2 - 10years.

Daily temperatures of 38 – 40 deg. C are fast becoming annual events.

40 – 42 deg. C daily temperatures may likely be reoccurring every 3 - 30years.



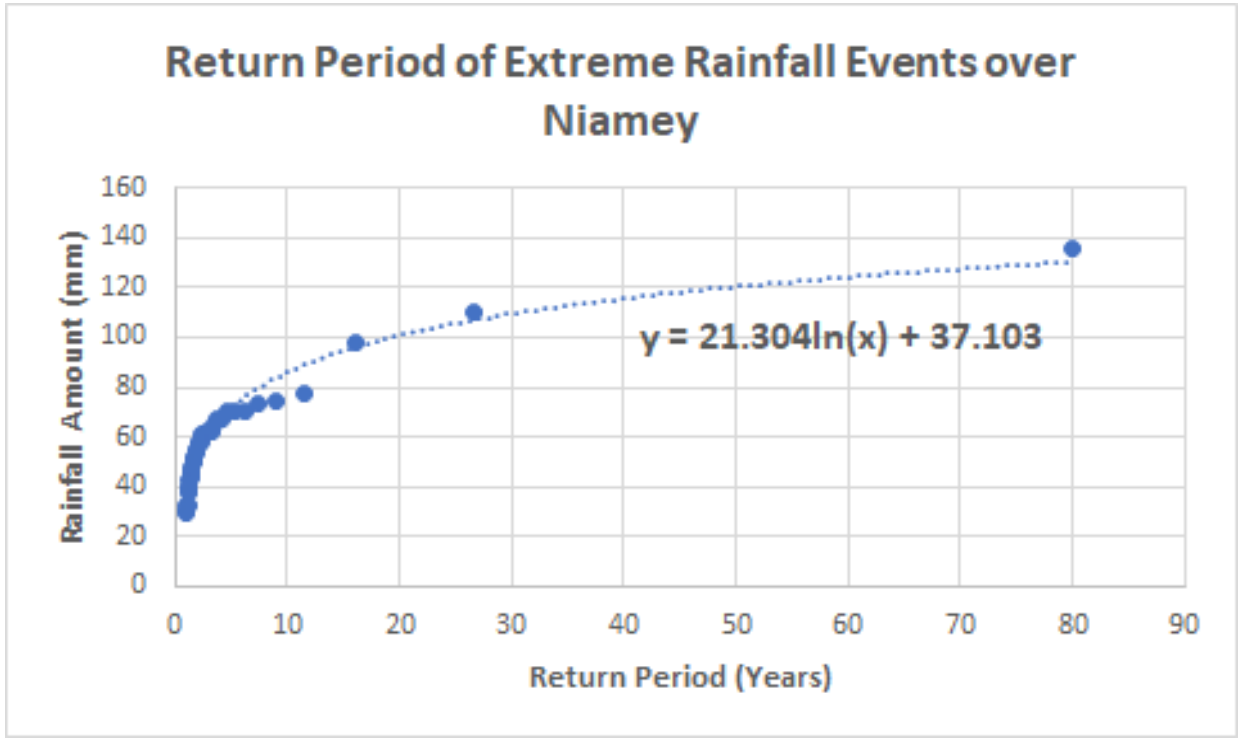


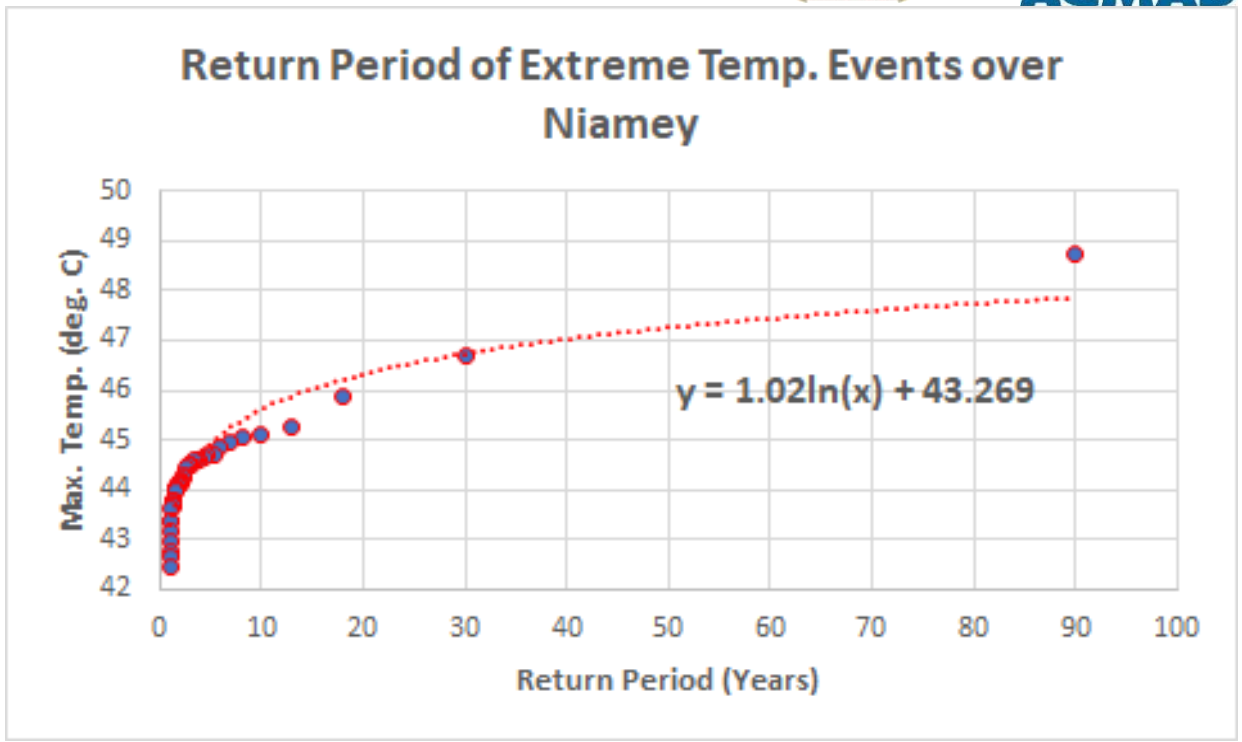
30 - 50mm daily rainfalls may likely become annual events.

60 - 80mm daily rainfalls may likely be reoccurring every 4 - 20years.

Daily temperatures of 36 – 38 deg. C are fast becoming annual events.

38 – 40 deg. C daily temperatures may likely be reoccurring every 3 - 20years.





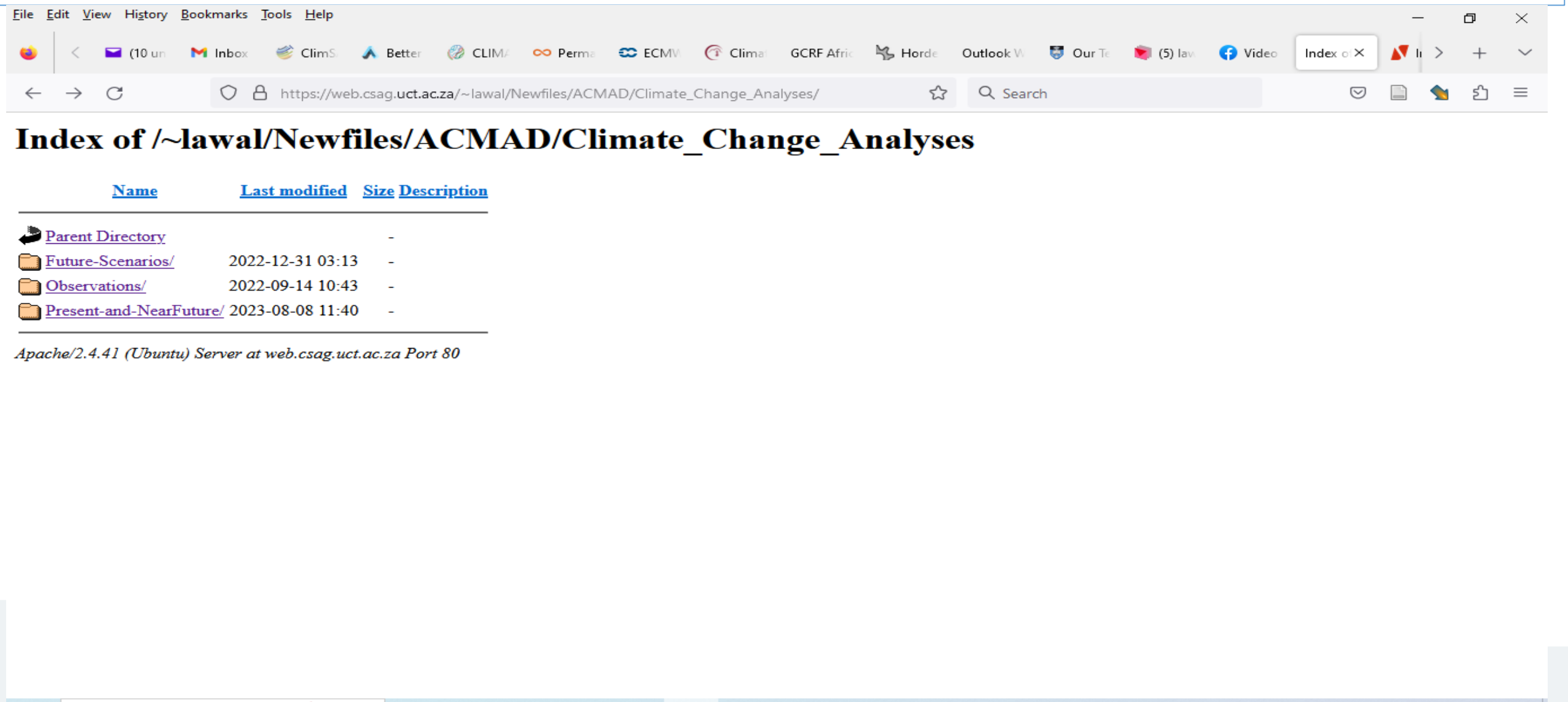
30 - 60mm daily rainfalls may likely become annual events.

60 - 80mm daily rainfalls may likely be reoccurring every 2 - 12years.

Daily temperatures of 42 – 44 deg. C are fast becoming annual events.

44 – 46 deg. C daily temperatures may likely be reoccurring every 2 - 18years.

https://web.csag.uct.ac.za/~lawal/Newfiles/ACMAD/Climate_Change_Analyses/



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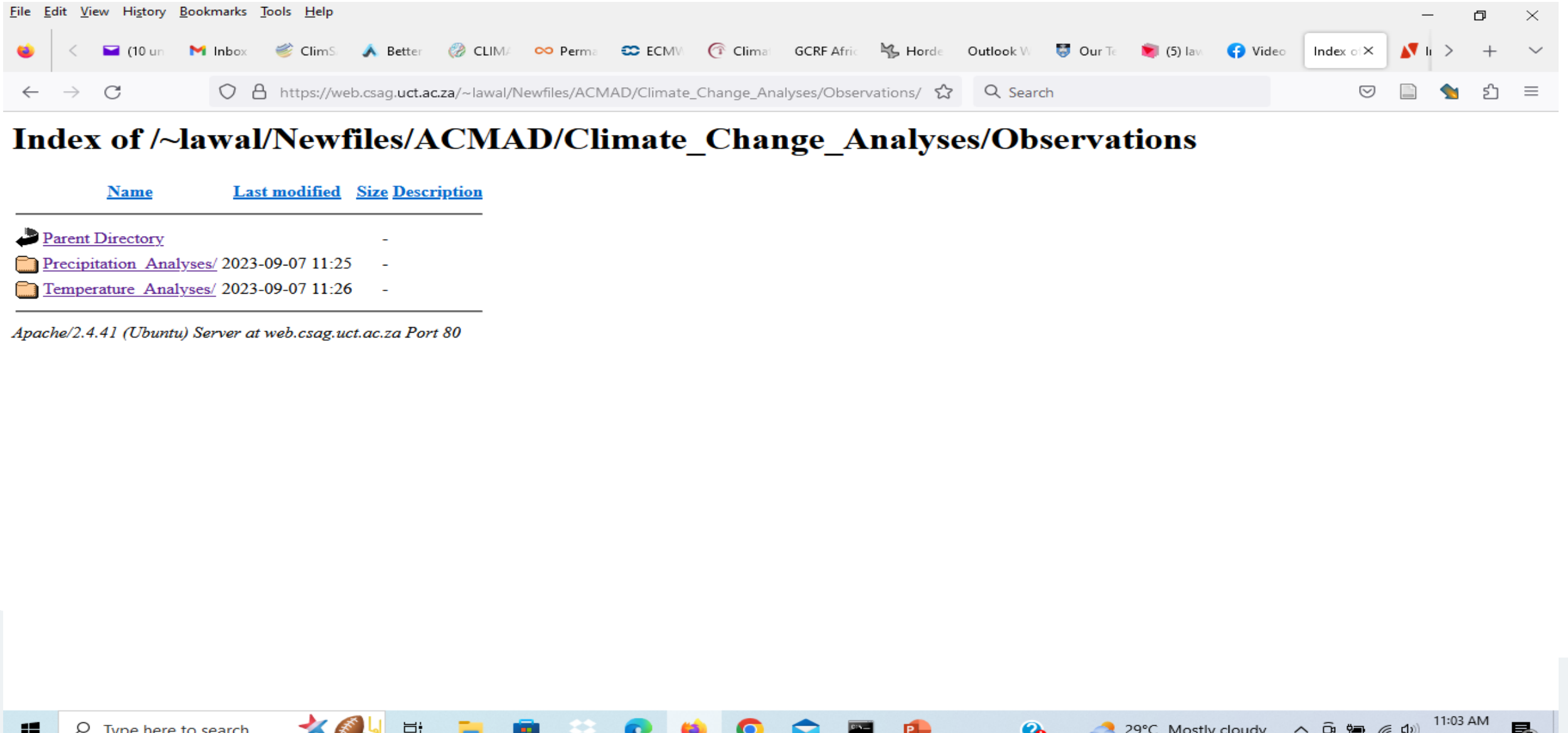
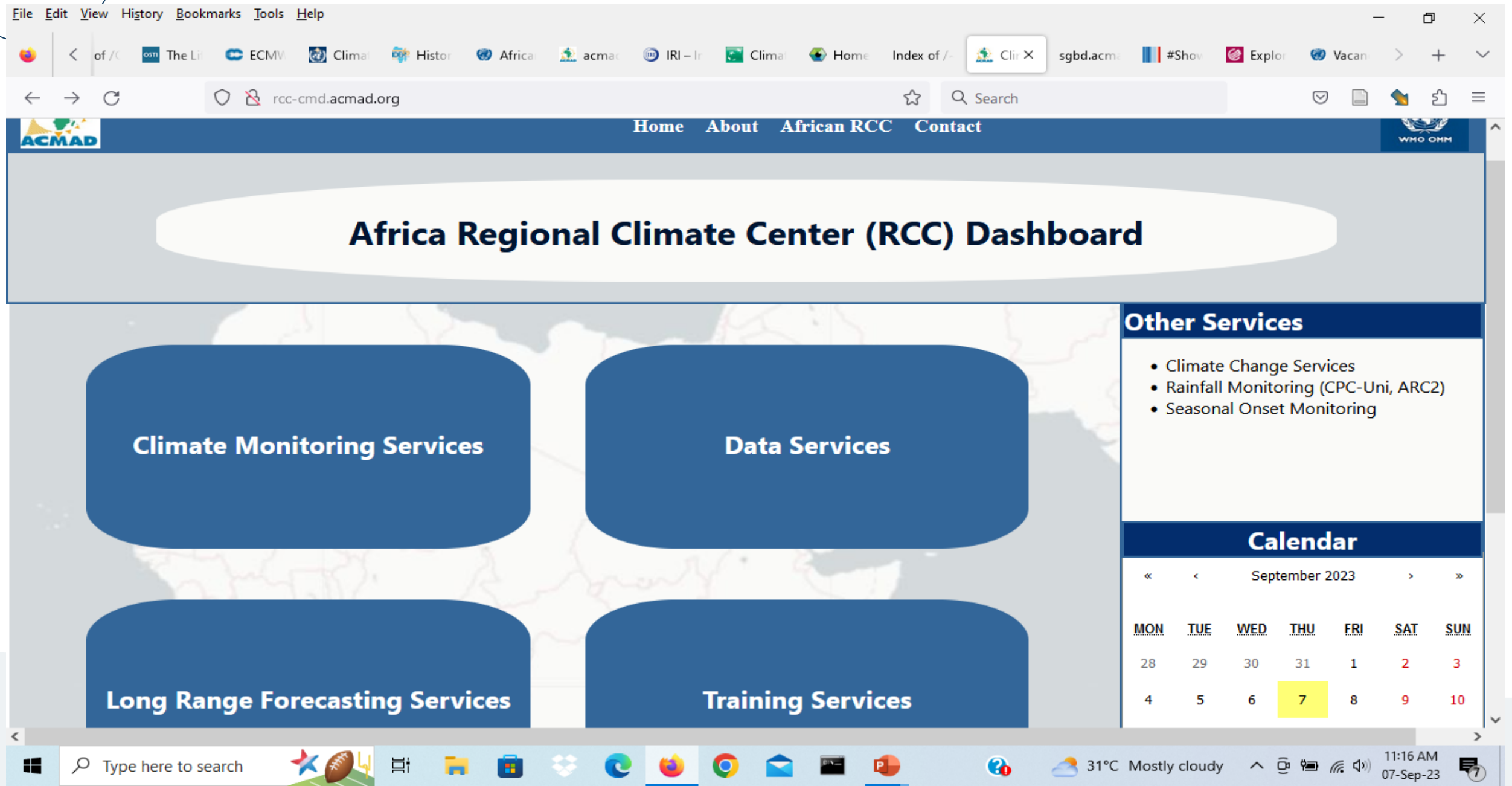
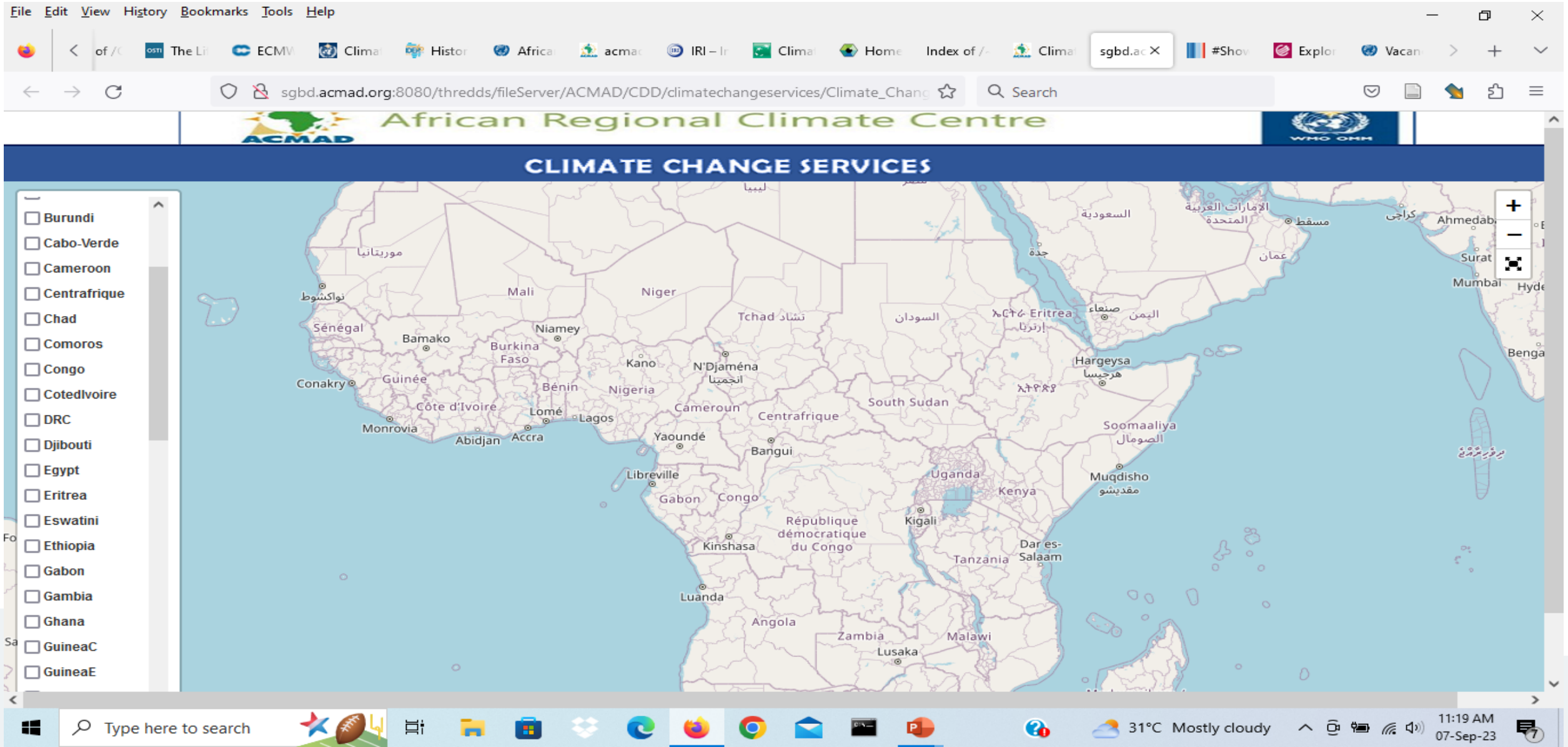


http://rcc-cmd.acmad.org/



http://sgbd.acmad.org:8080/thredds/fileServer/ACMAD/CDD/climatechangeservices/Climate_Change_Indexes/climate_change_indexes.html



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Likely Effects of Extreme Climates on Infrastructures

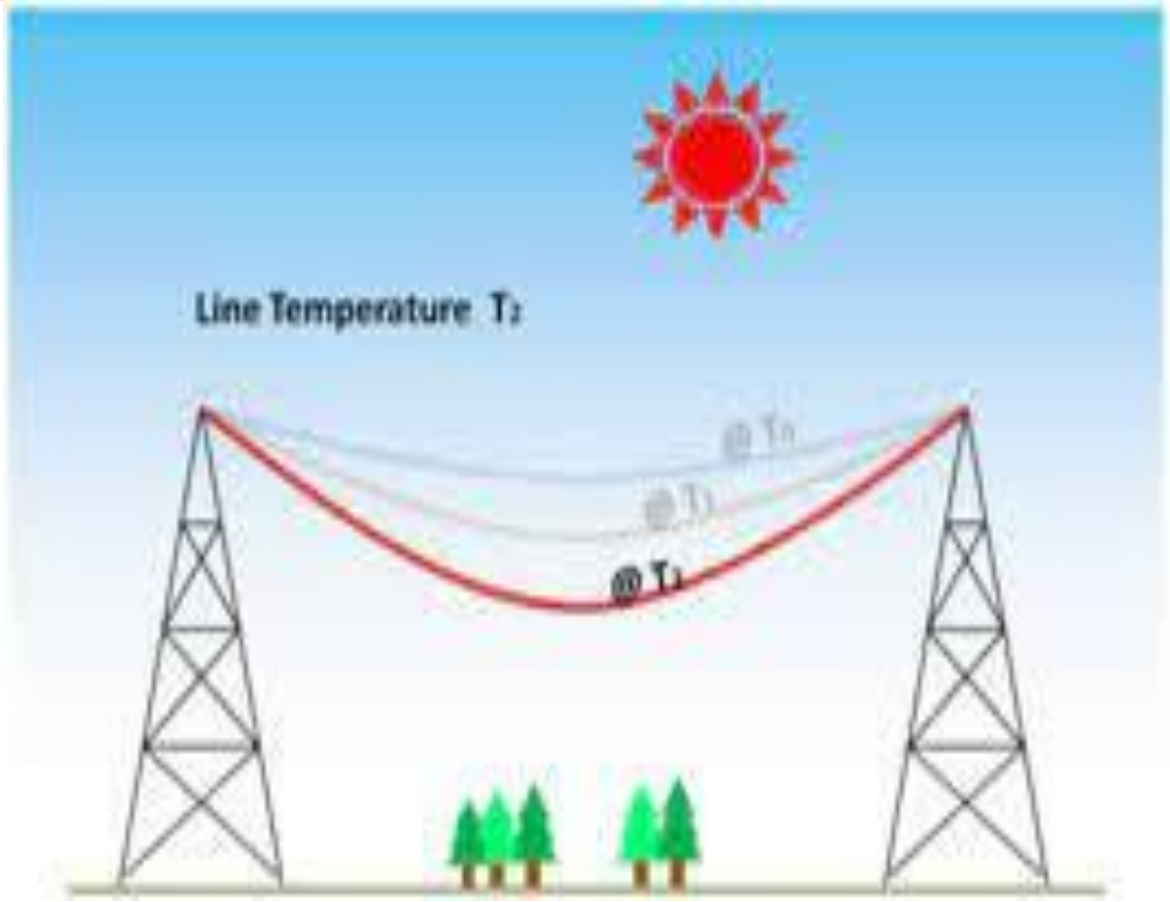
Likely effects of extreme temperature events on infrastructures

Rail lines may buckle and bend under high temperatures (Source: BBC)

Likely effects of extreme temperature events on infrastructures

Asphalts / bitumen may deteriorate and melt under high temperatures (Source: Times of India)

Likely effects of extreme temperature events on infrastructures



Power lines may sag under high temperatures, thereby increasing electrocution risks (Source: BBC)

Likely effects of extreme rainfall events on infrastructures

Bridges under threats of being washed away by flood (Source: Presenter)

Likely effects of extreme rainfall events on infrastructures

A flooded village (Source: Presenter)

Likely effects of extreme rainfall events on infrastructures

Bridges under threats of being washed away by flood (Source: Presenter)

A three-storey building about to be swallowed by gully erosion at Omagbe Estate, Onitsha (Source: News Agency of Nigeria, 2011)

Likely effects of extreme rainfall events on infrastructures

Stagnant water on the roof can enter into the structure through cracks and joints, ultimately damaging the structural strength (Source: Presenter)

A three-storey building about to be swallowed by gully erosion at Omagbe Estate, Onitsha (Source: News Agency of Nigeria, 2011)

01

02

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06

Conclusions

Though resilient infrastructures need:

- Drainage
- Coastal preventions
- Waste management
- Water management
- Protection against flood and drought, etc.;

However, we need the following weather and climate products, usually customized or tailored and on demand:

- Wind speed and direction
- Soil and near surface temperatures
- Rainfall (amounts, intensity, duration, etc.), Humidity
- Sunlight (duration, angle and intensity)
- Historical and projected intensity, duration and frequency of extremes at the infrastructure project sites

Summary

- ✓ Climate crisis are, in fact, becoming national security crisis in African countries (e.g. shrinking lakes and drying rivers are aiding migration).

- ✓ Climatic effects on critical national infrastructures and ecosystems are becoming more and more negative (e.g. maintenance becomes more costly).

- ✓ Therefore, development of more weather and climate products are encouraged (e.g. massive capacity building, co-production and critical reasoning).

- ✓ We also advocate the development and use of Early Warning and Early Action for all (e.g. legal encouragement for the uptake of weather and climate products).

Merci beaucoup

Thank You

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