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1945-3

Conference on African Drought: Observations, Modeling, Predictability, Impacts

2 - 6 June 2008

Predictability of African Drought Part III: Evaluation of NCAR/CSM and UK Metoffice/PRECIS models

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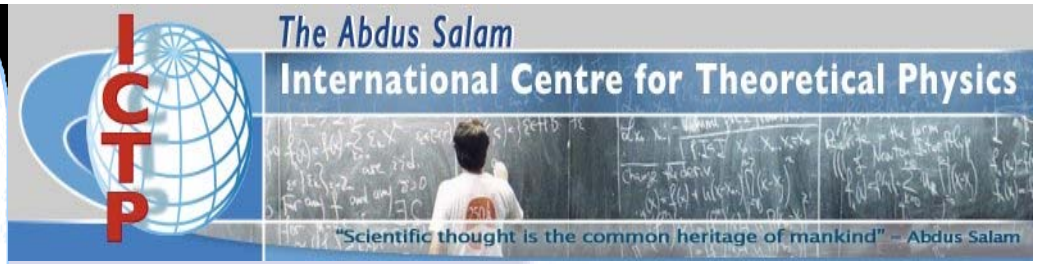


Predictability of the African Drought.
Part III: Evaluation of NCAR/CSM and UK Metoffice/PRECIS models

Dr. Andre KAMGA Foamouhoue

ICTP/ African Drought Conference- June 2008

Motivation

- **Economic and social development in Africa rely quite significantly on rainfall (eg. GDP loss in Mozambique due to the severity of tropical cyclones related floods in 2000, 10 Billions CFA aid for 2008 to the Agriculture community following very late start of the 2007 summer monsoon in Senegal)**

- **It is therefore crucial for Africa's sustainable development to capitalize on substantial investments made by the international community to monitor and predict weather phenomena and particularly rainfall**

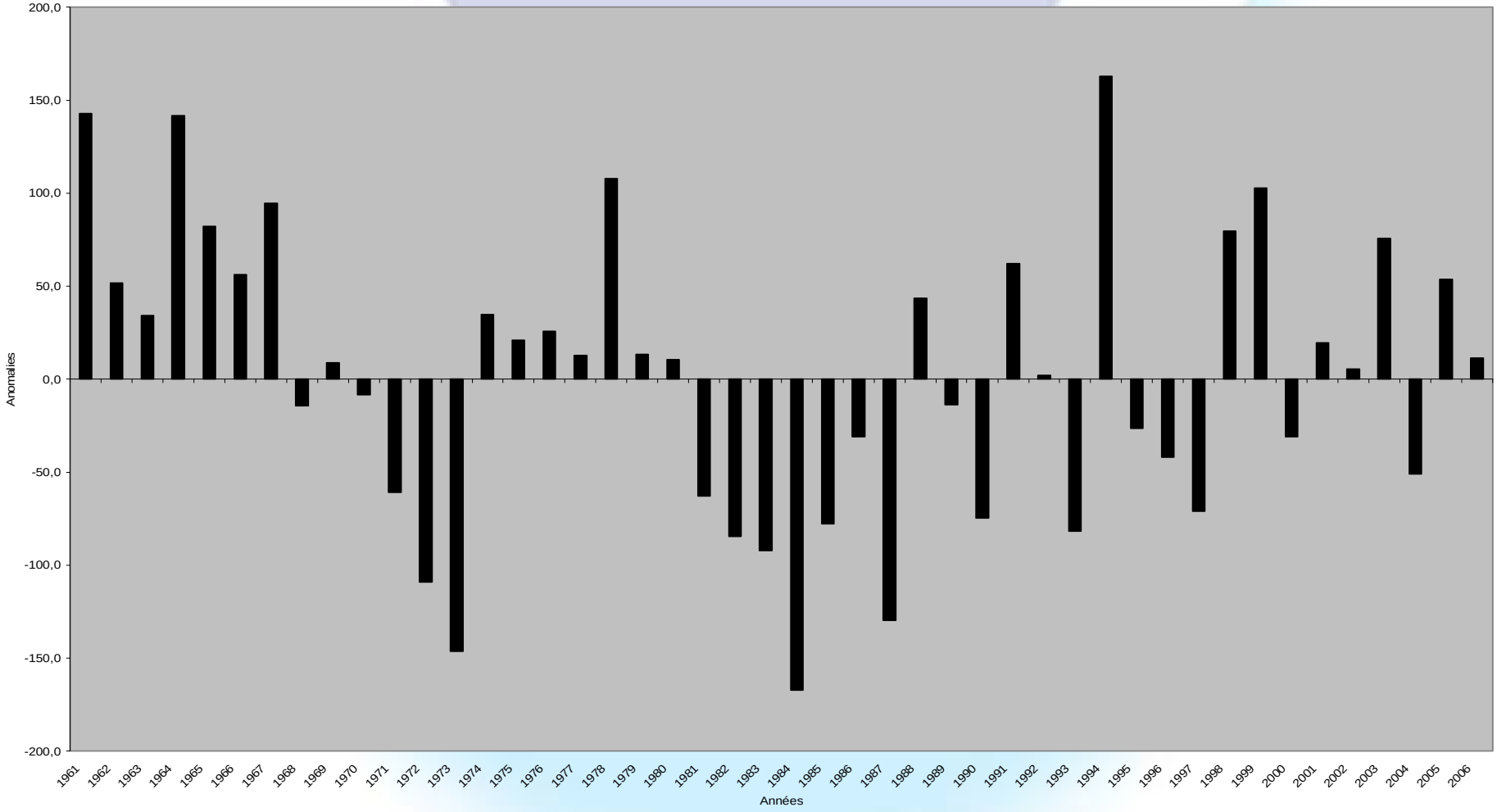
Objectives

- **Highlight strengths and weaknesses of climate models over parts of Africa**
- **Suggest approach to handle these deficiencies when using models for forecasting and projections**
- **Discuss future research agenda for climate model development/interpretation over region.**

Some evidences of climate variability

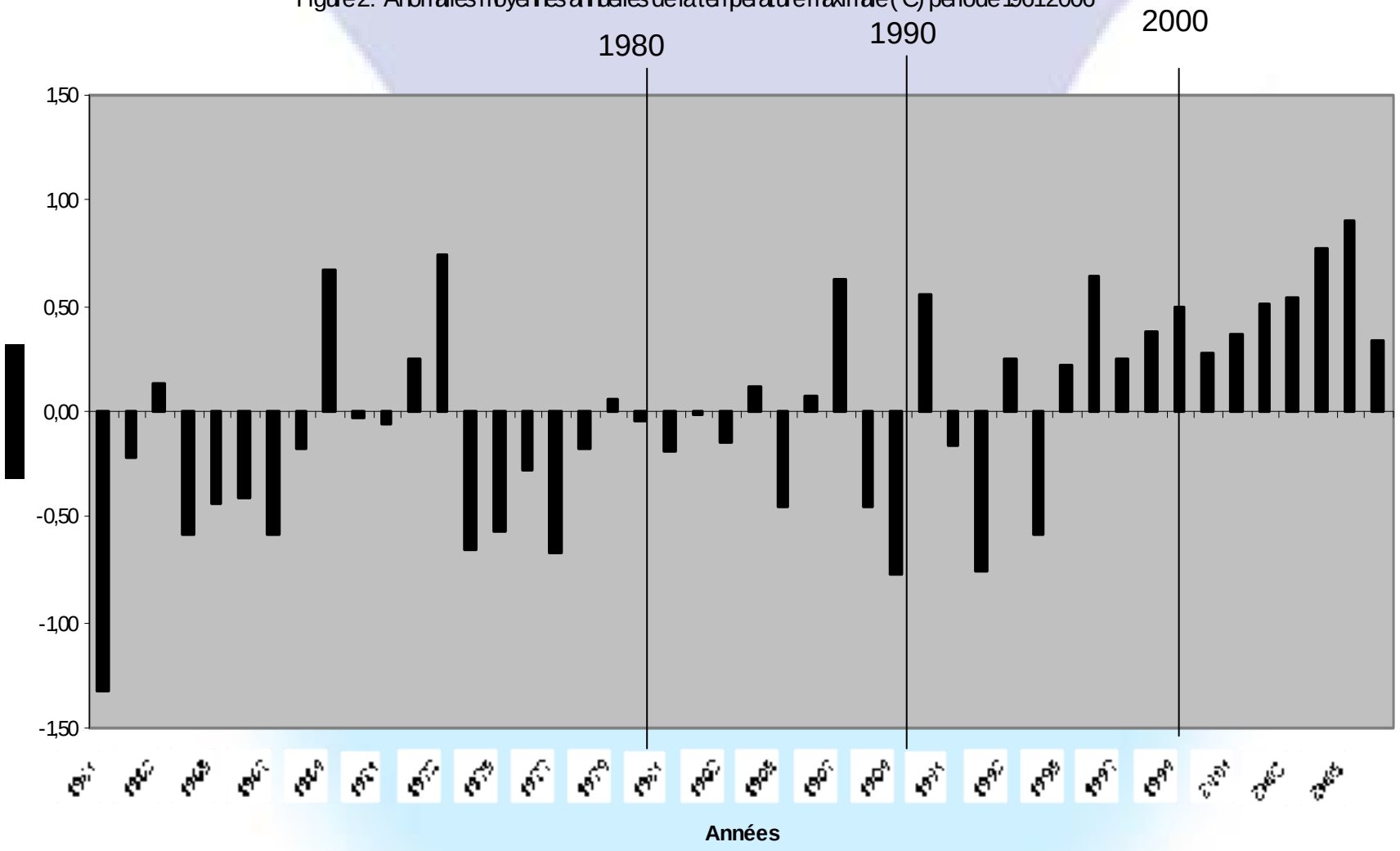
Rainfall anomalies for Niger (average of 59 stations between 1961 and 2006)

Figure 1 : Anomalies moyennes annuelles de la pluviométrie (en mm) période 1961 2006



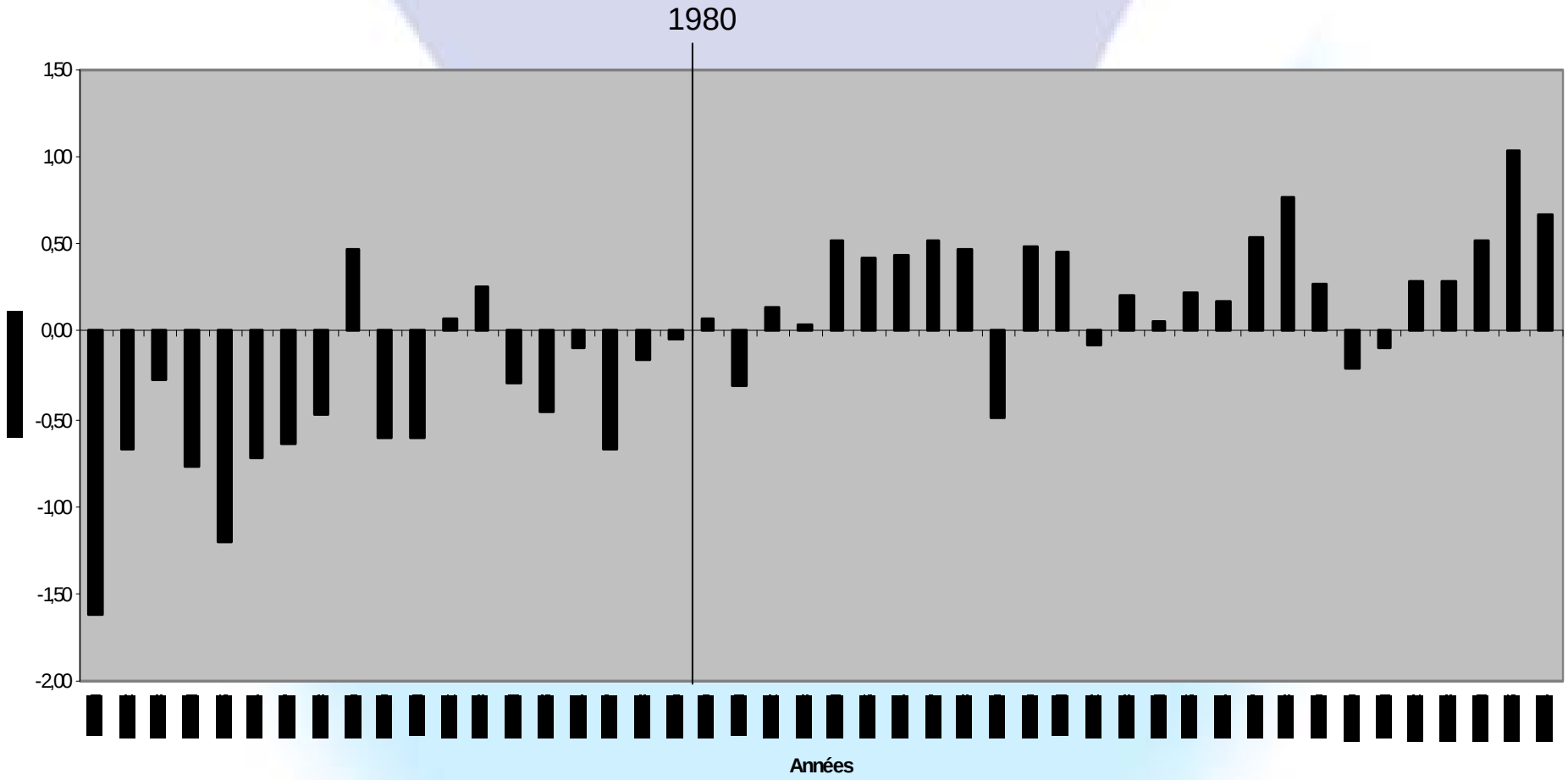
Tmax anomalies

Figure 2: Anomalies moyennes annuelles de la température maximale (°C) période 1961-2006

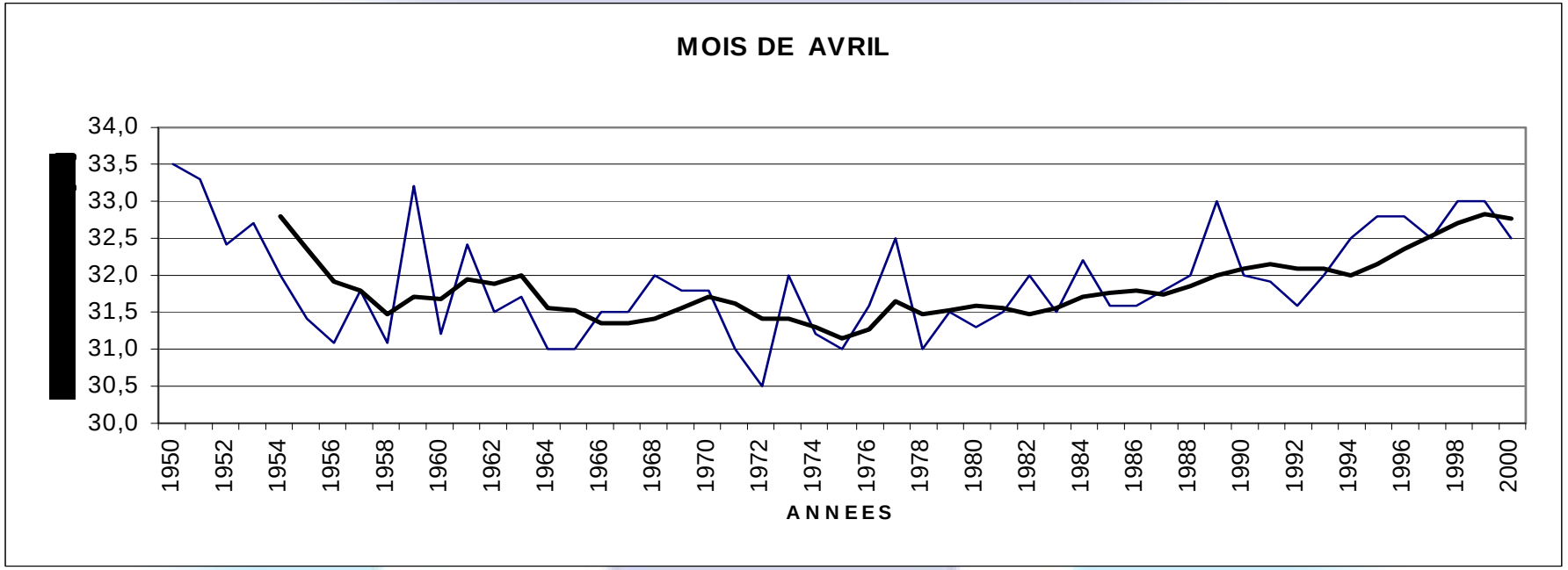


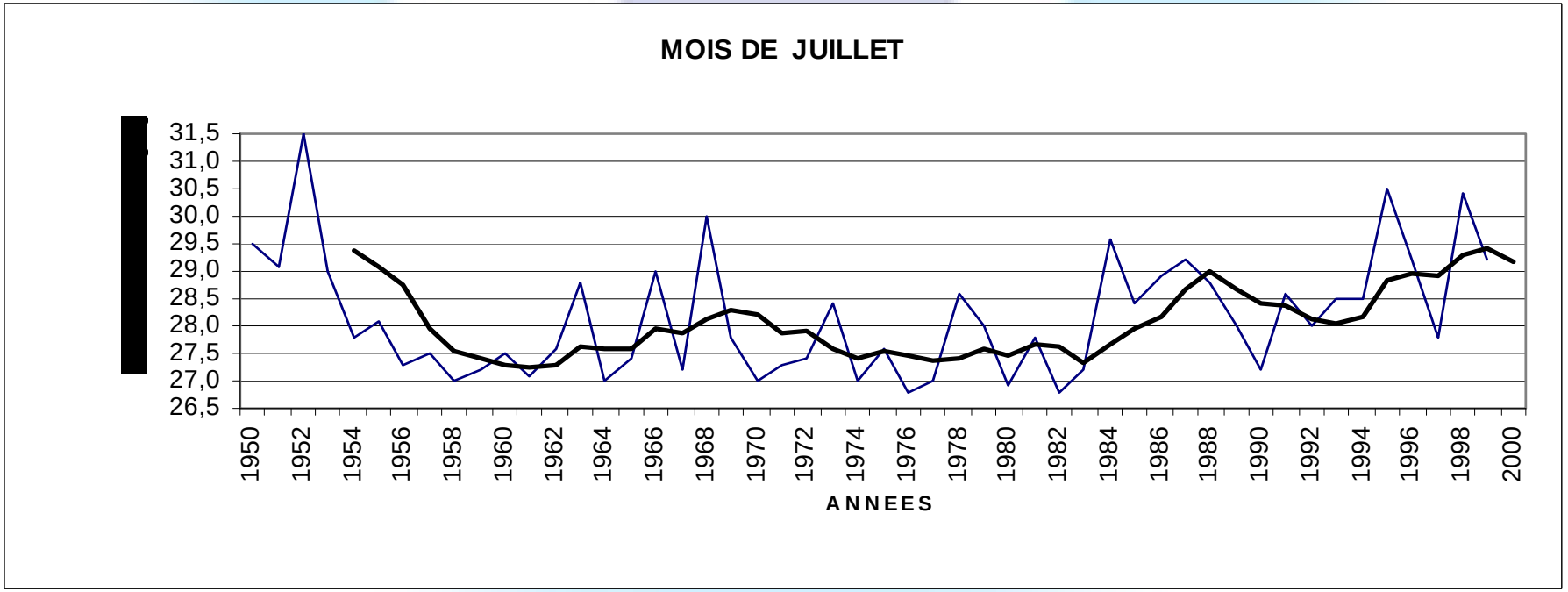
Tmin Anomalies

Figure 3: Anomalies moyennes annuelles de la température minimale (°C) période 1961-2006

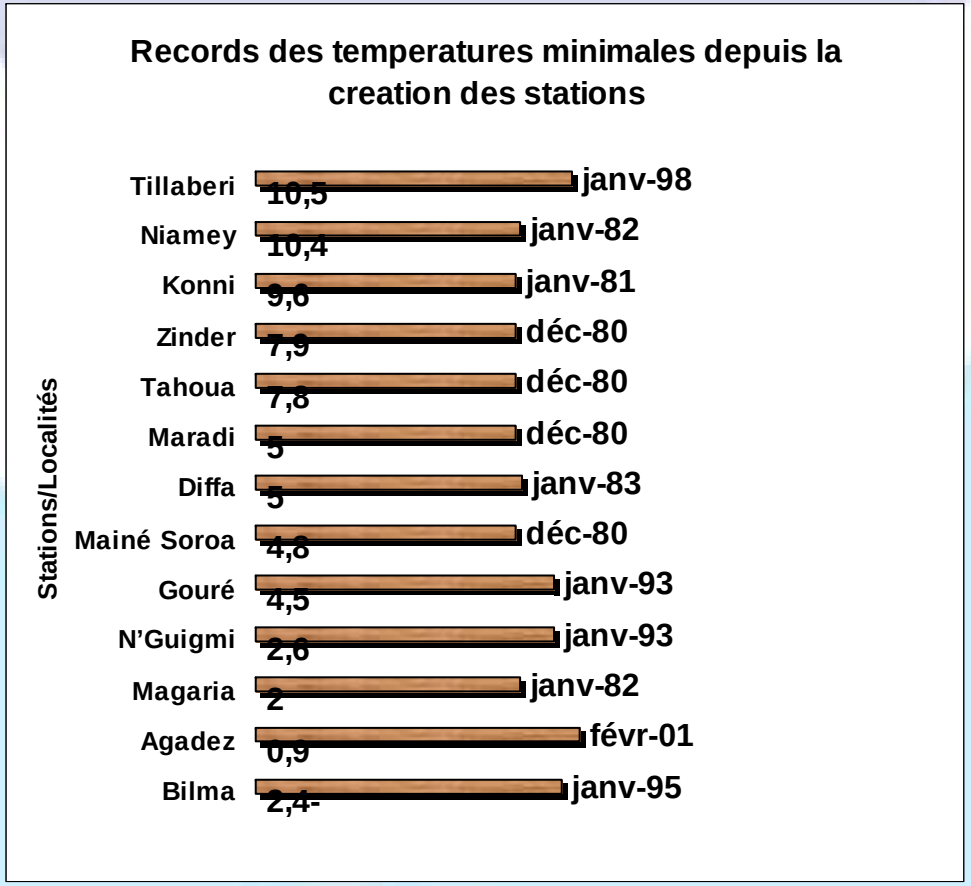


Monthly Tmax for April and July for Libreville-Gabon



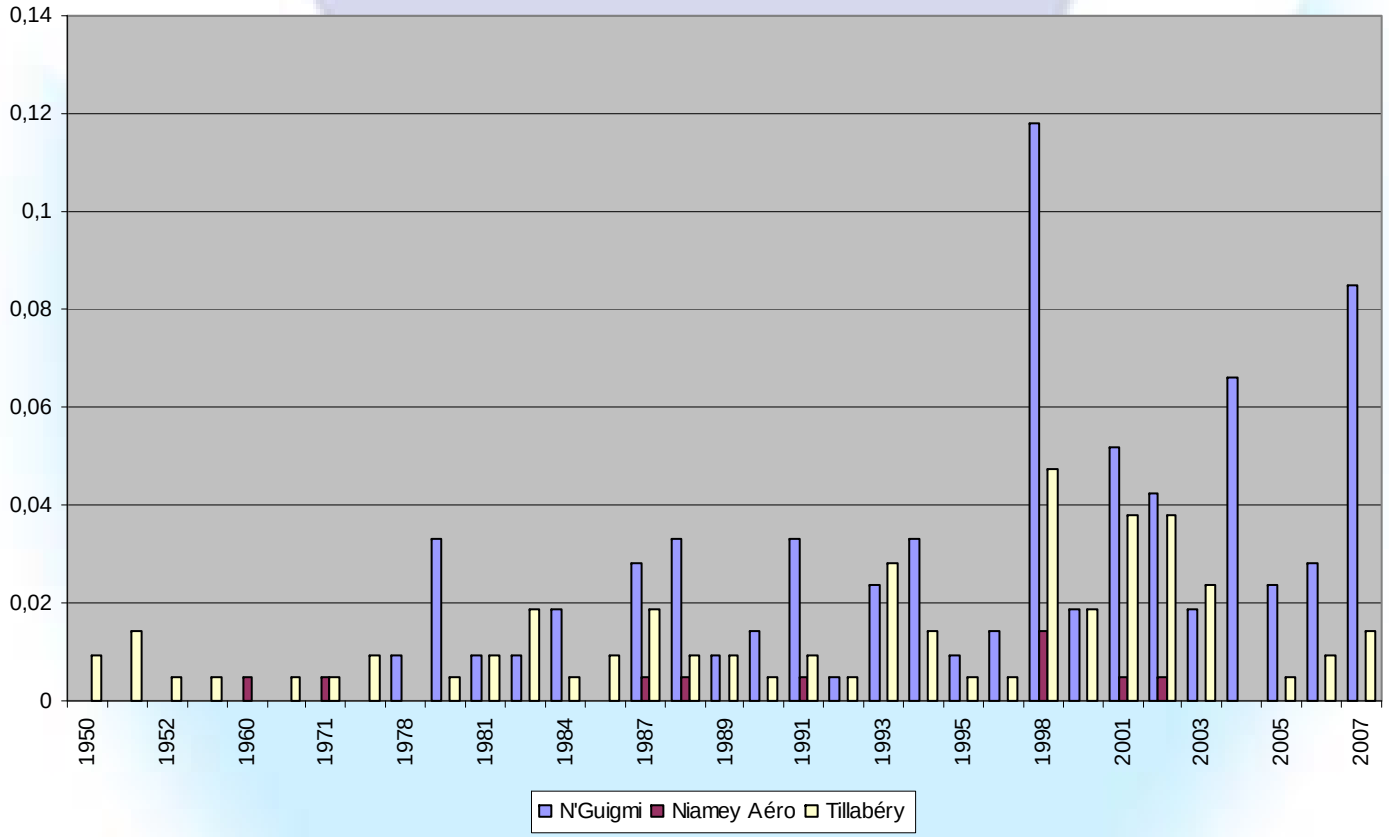


Record Tmin mostly observed during the 80s and 90s

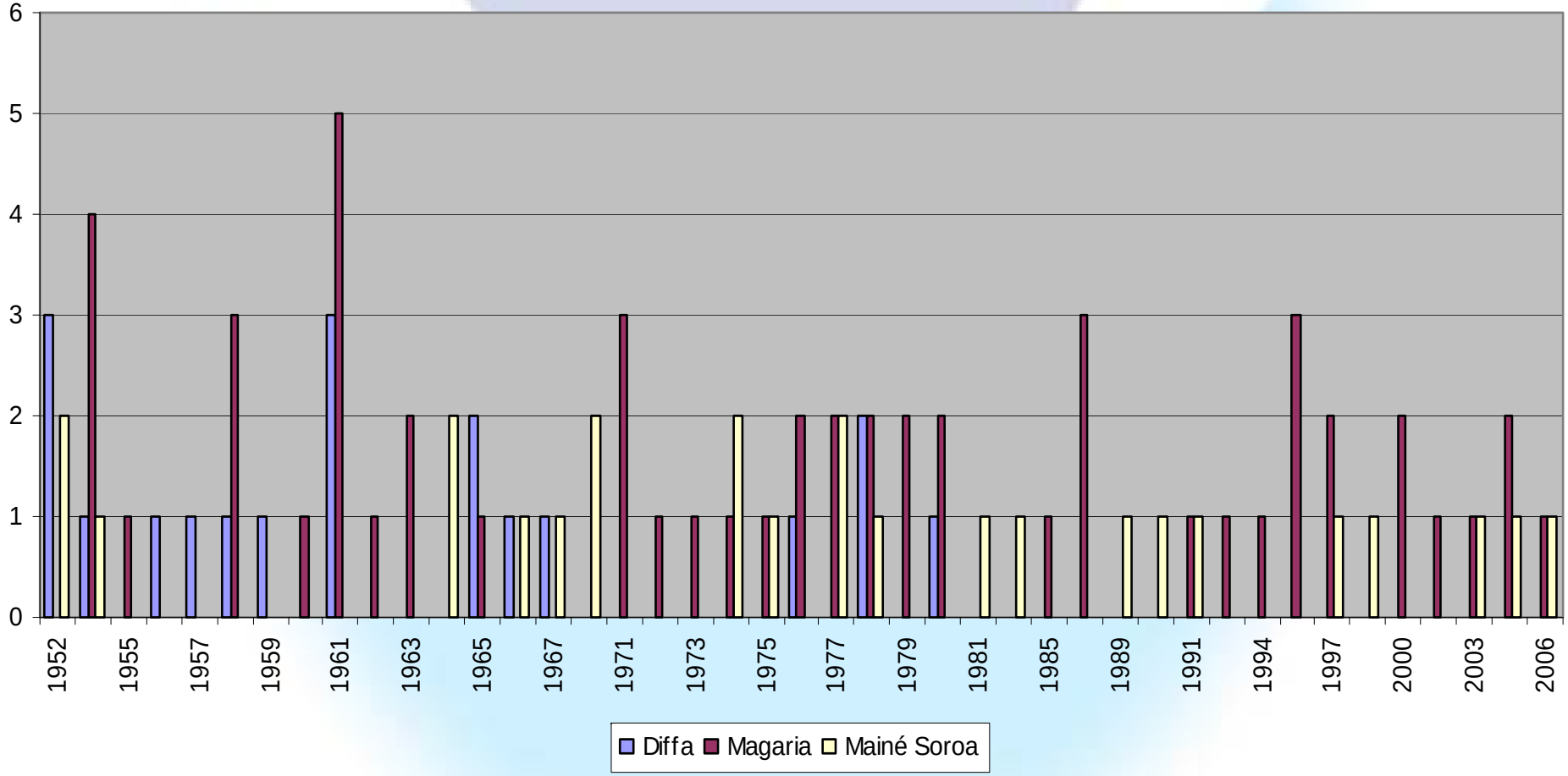


Record Tmax mostly during the 90s

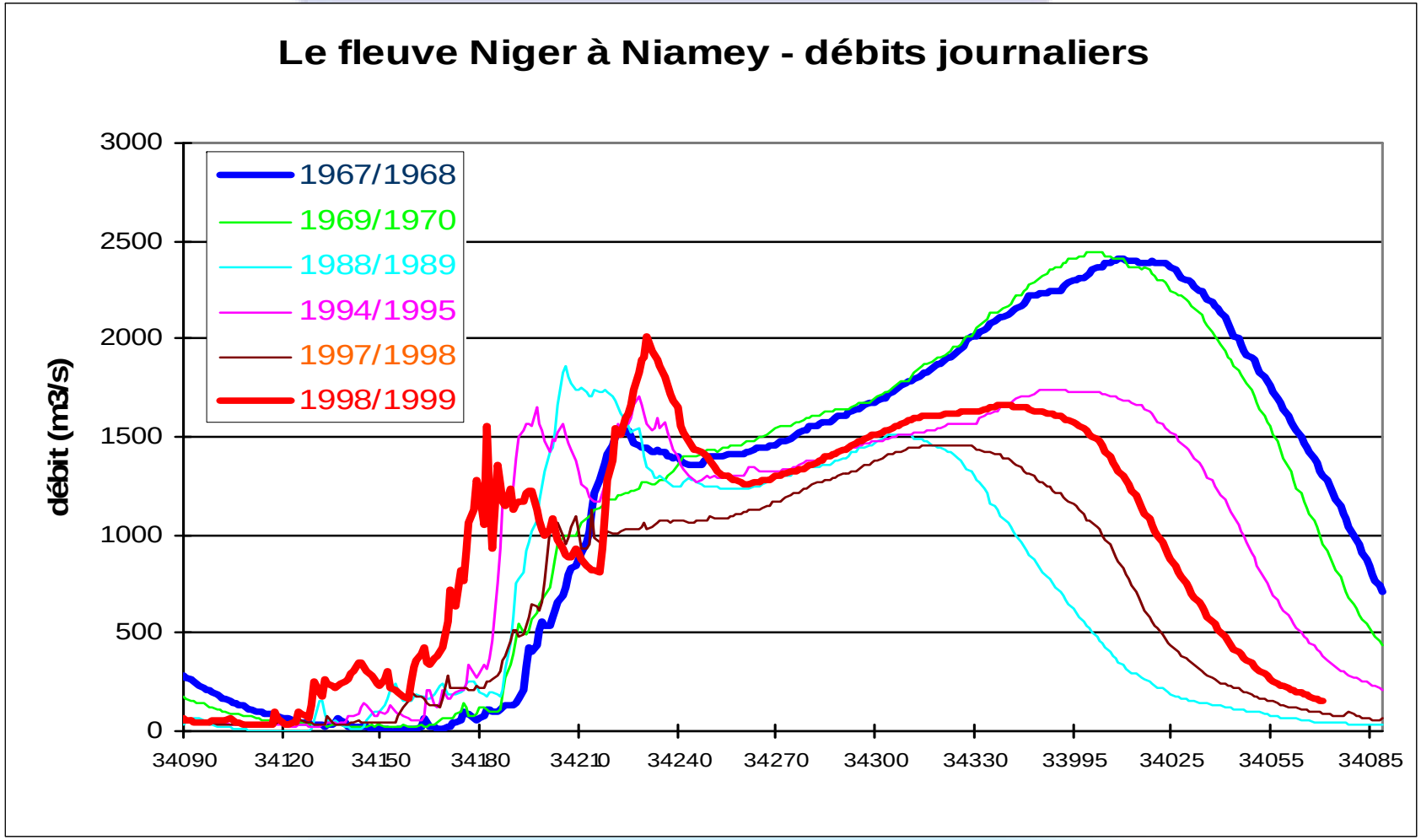
Number of very hot days/365: More hot days since the 80s.



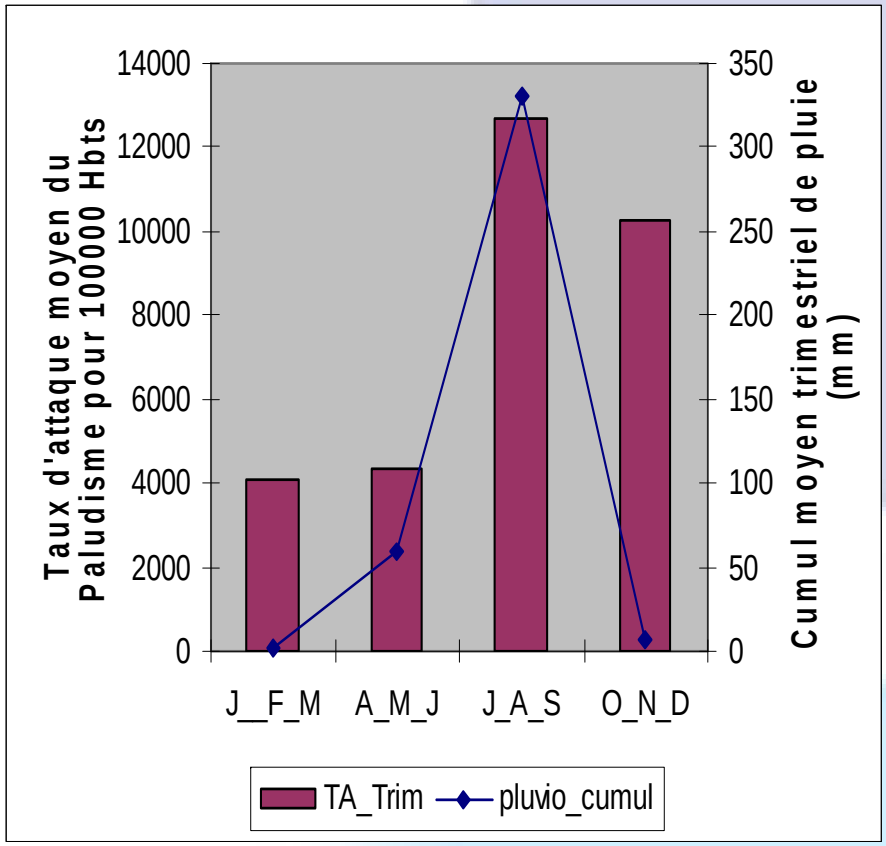
Number of extreme rain events > 60 mm

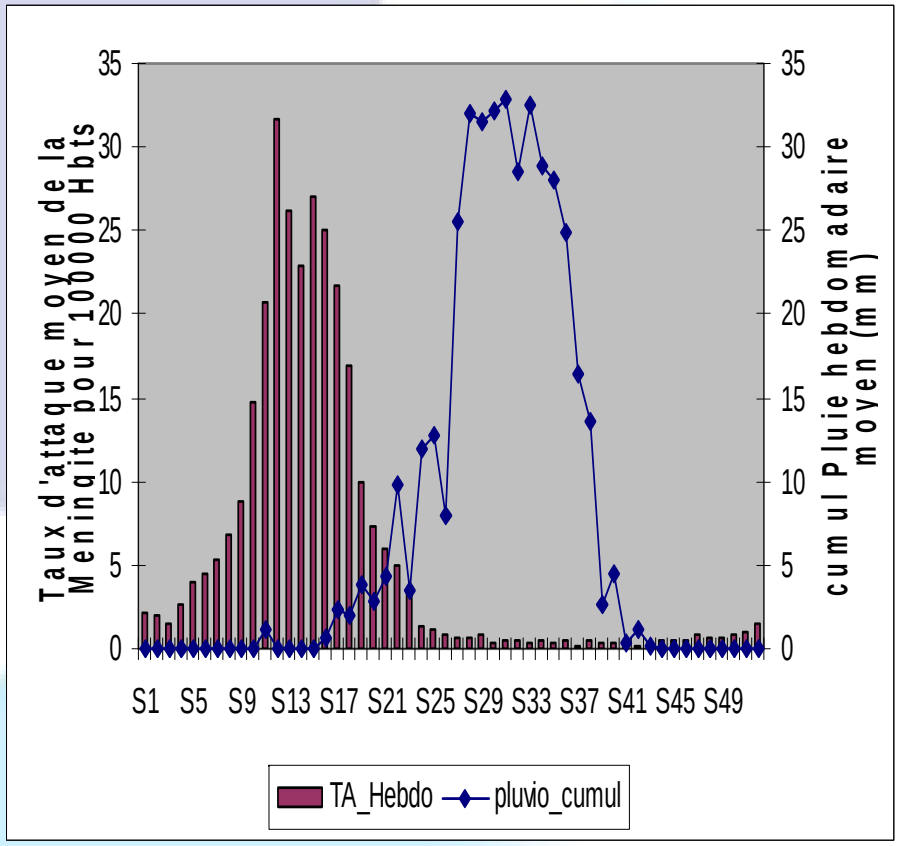


Changes on discharge annual cycle – River Niger in Niamey (number 3 in Africa)



Rainfall, malaria and meningitis in Niger





Expected global impacts (IPCC reports)

Table SPM.3. Examples of possible impacts of climate change due to changes in extreme weather and climate events, based on projections to the mid- to late 21st century. These do not take into account any changes or developments in adaptive capacity. The likelihood estimates in column 2 relate to the phenomena listed in column 1. {WGII Table SPM.1}

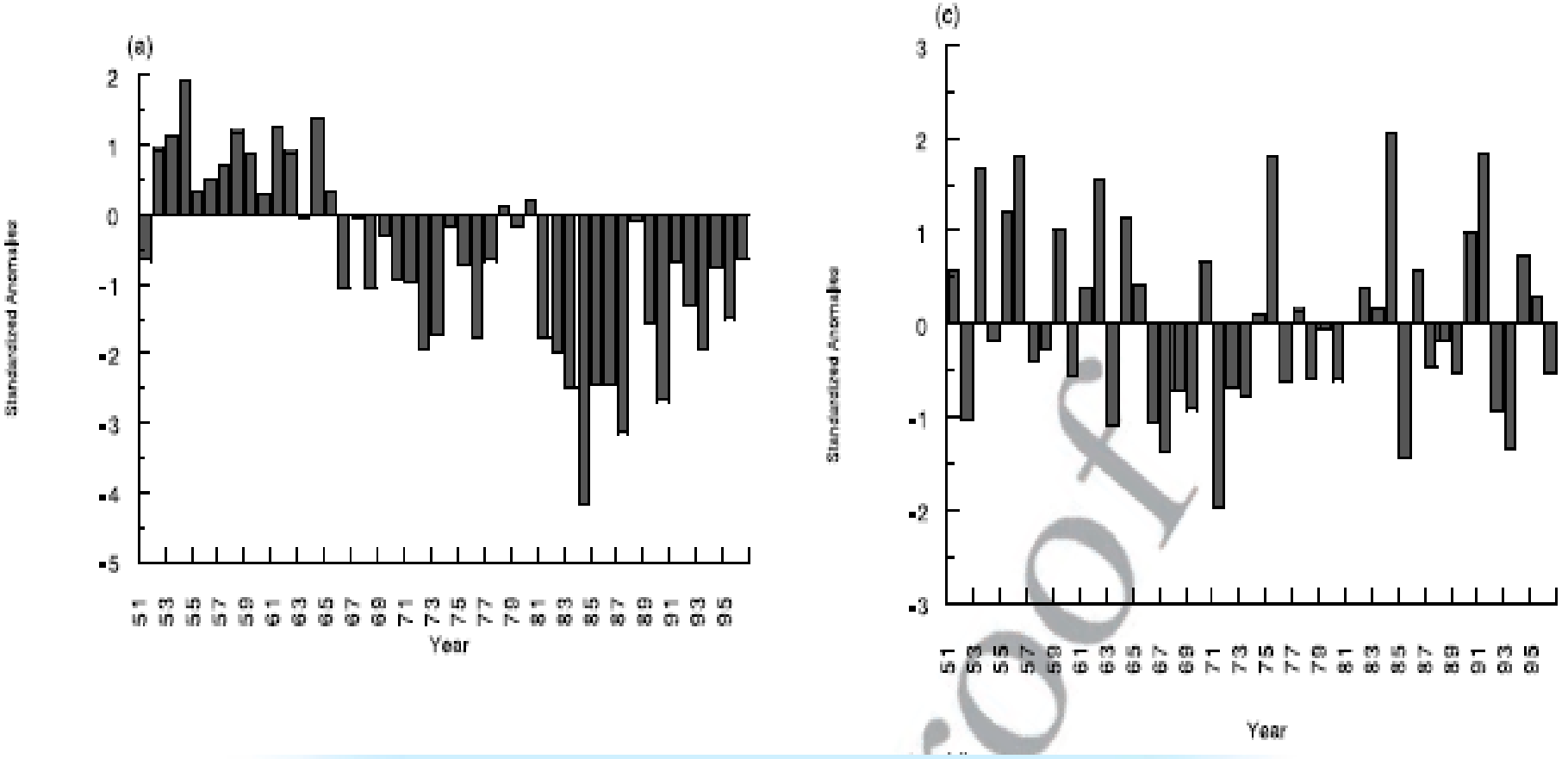
Phenomenon[a] and direction of trend	Likelihood of future trends based on projections for 21st century using SRES scenarios	Examples of major projected impacts by sector			
		Agriculture, forestry and ecosystems {WGII 4.4, 5.4}	Water resources {WGII 3.4}	Human health {WGII 8.2, 8.4}	Industry, settlement and society {WGII 7.4}
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	*Virtually certain*[b]	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snowmelt; effects on some water supplies	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves. Frequency increased over most land areas	*Very likely*	Reduced yields in warmer regions due to heat stress; increased danger of wildfire	Increased water demand; water quality problems, e.g. algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor
Heavy precipitation events. Frequency increases over most areas	*Very likely*	Damage to crops; soil erosion, inability to cultivate land due to waterlogging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding: pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	*Likely*	Land degradation; lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water-and food-borne diseases	Water shortage for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	*Likely*	Damage to crops; windthrow (uprooting) of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of deaths, injuries, water- and food- borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers, potential for population migrations, loss of property
Increased incidence of extreme high sea level (excludes tsunamis)[c]	*Likely*[d]	Salinisation of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drowning in floods; migration-related health effects	Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure; also see tropical cyclones above

Notes:

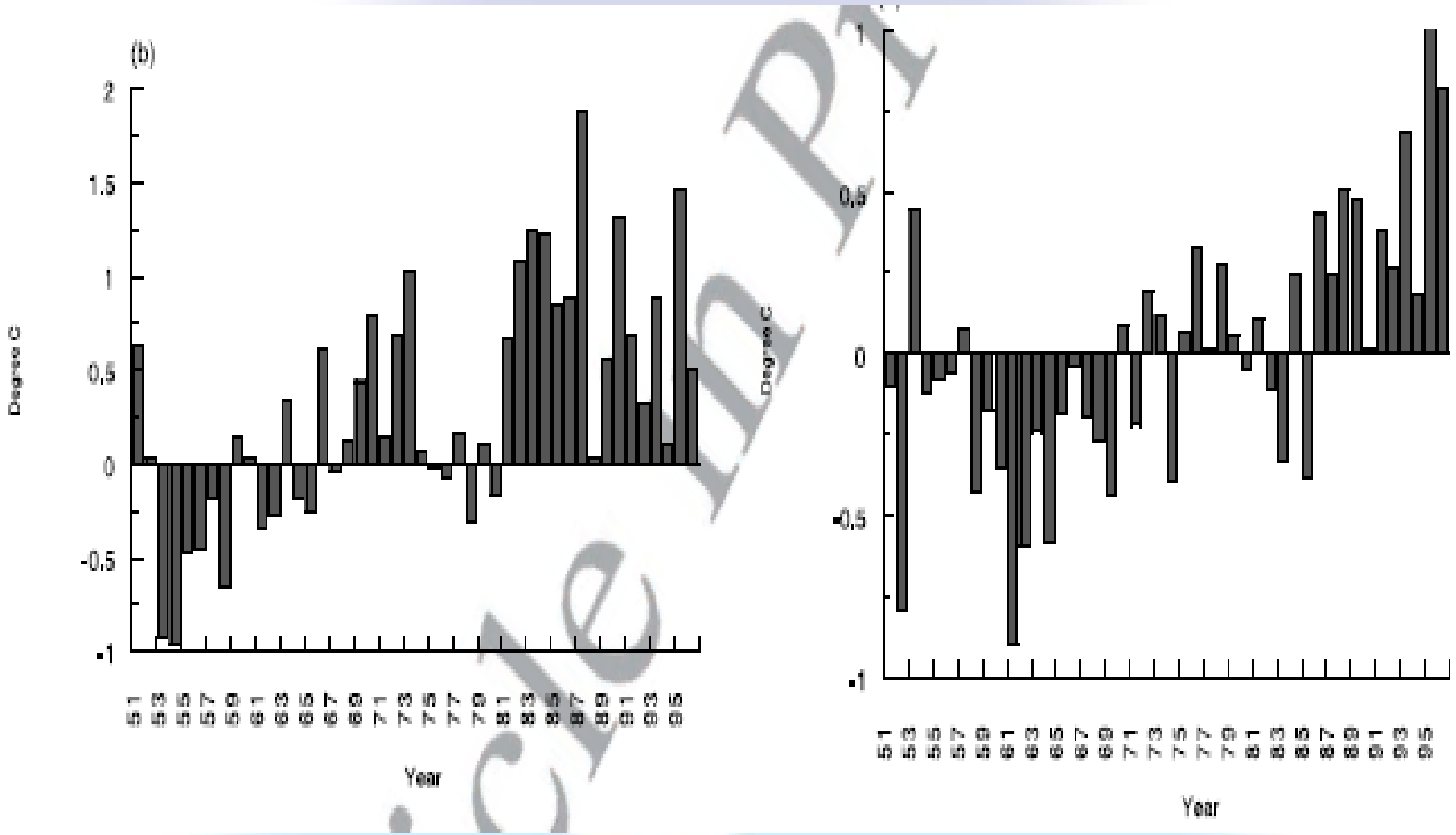
Verification of Climate projections

- **Global Model (NCAR/CSM)**
- **Regional Model (HADRM3 or PRECIS)**

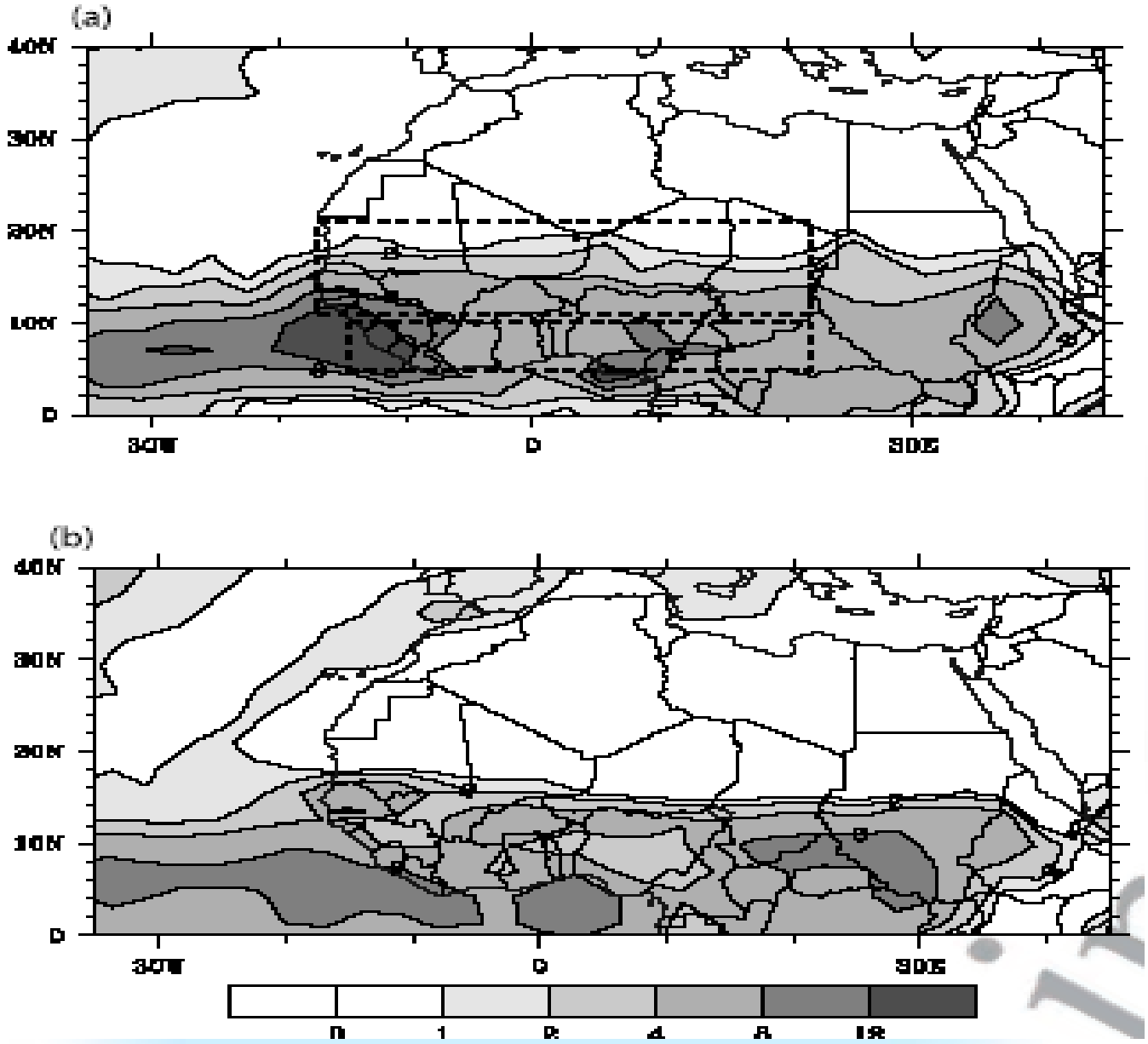
NCAR/CSM v1.3 described by Blackmon et al.(2001)



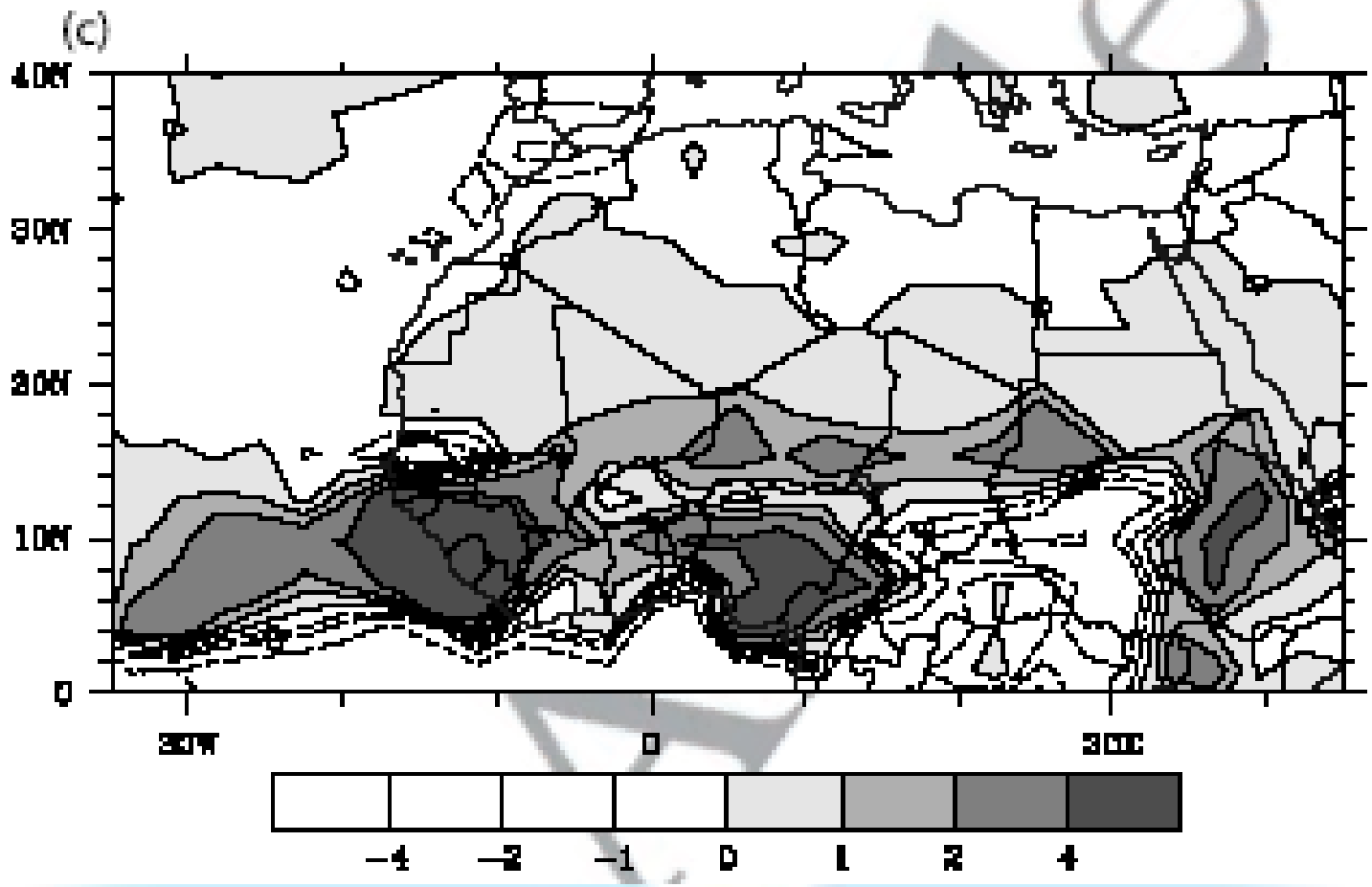
- **JJA sahelian observed precip anom(left) and CSM simulated anom(rigth).**
- **Base period 1951-1980**



Same as previously but forTemperature anomalies. Quite frequent warm years since early 80s in the obs and mid 80s in CSM.

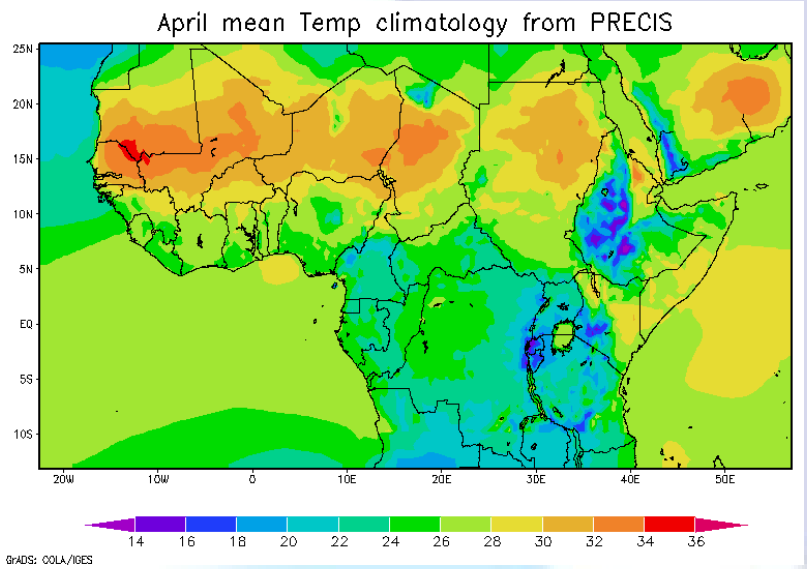


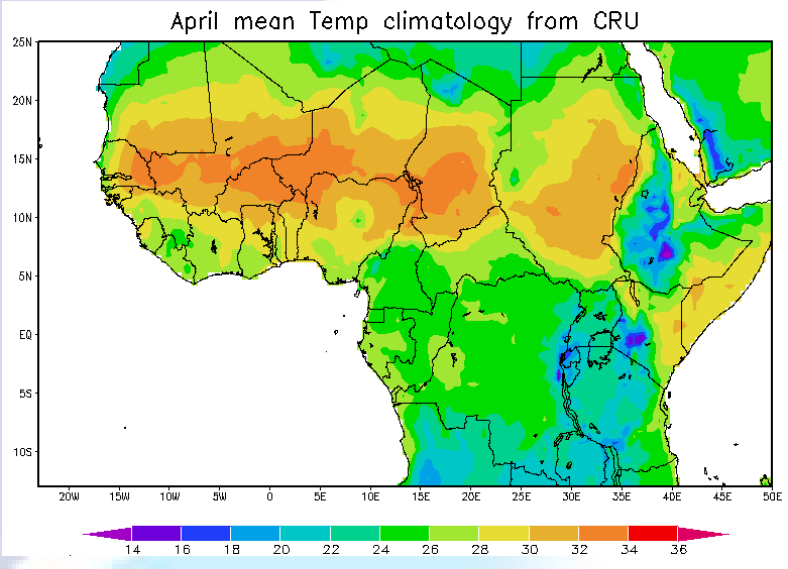
JJA observed (above) and simulated (below) precip rates (mm/day)

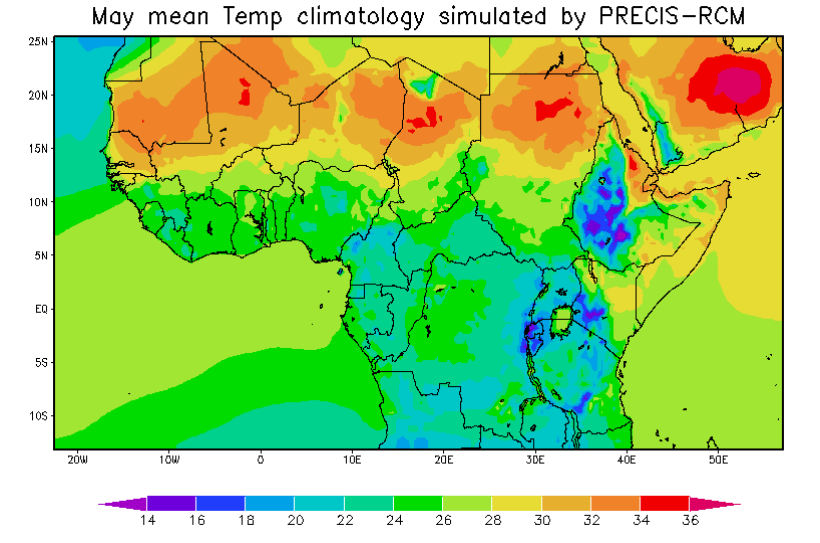


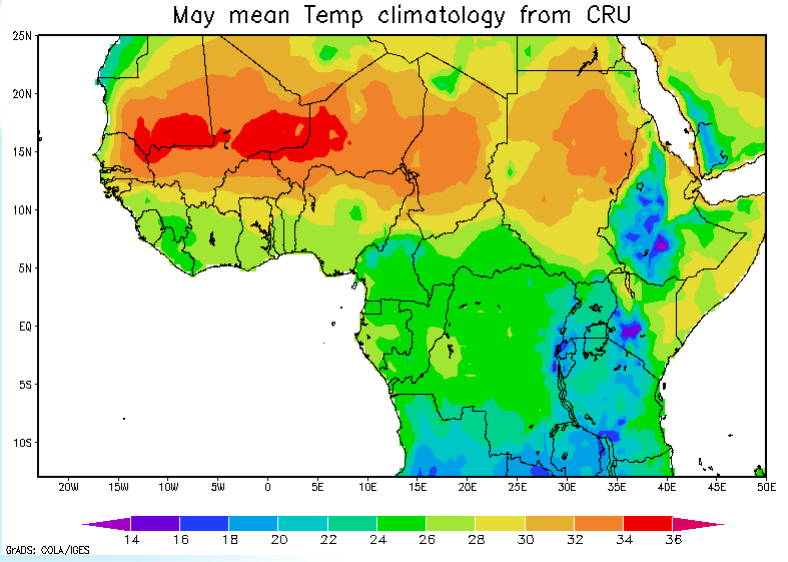
- **Observed minus simulated precip rates. More rainfall in the CSM over the much of Sahel and the Highlands (<u>Guinean highlands, Jos plateau,and Cameroon mountains, Ethiopian Highlands and its extension probably up to the Drakensberg in South Africa</u>) .**

PRECIS under predicts extreme temperatures.









NCAR/CSM cooling up to 6°K

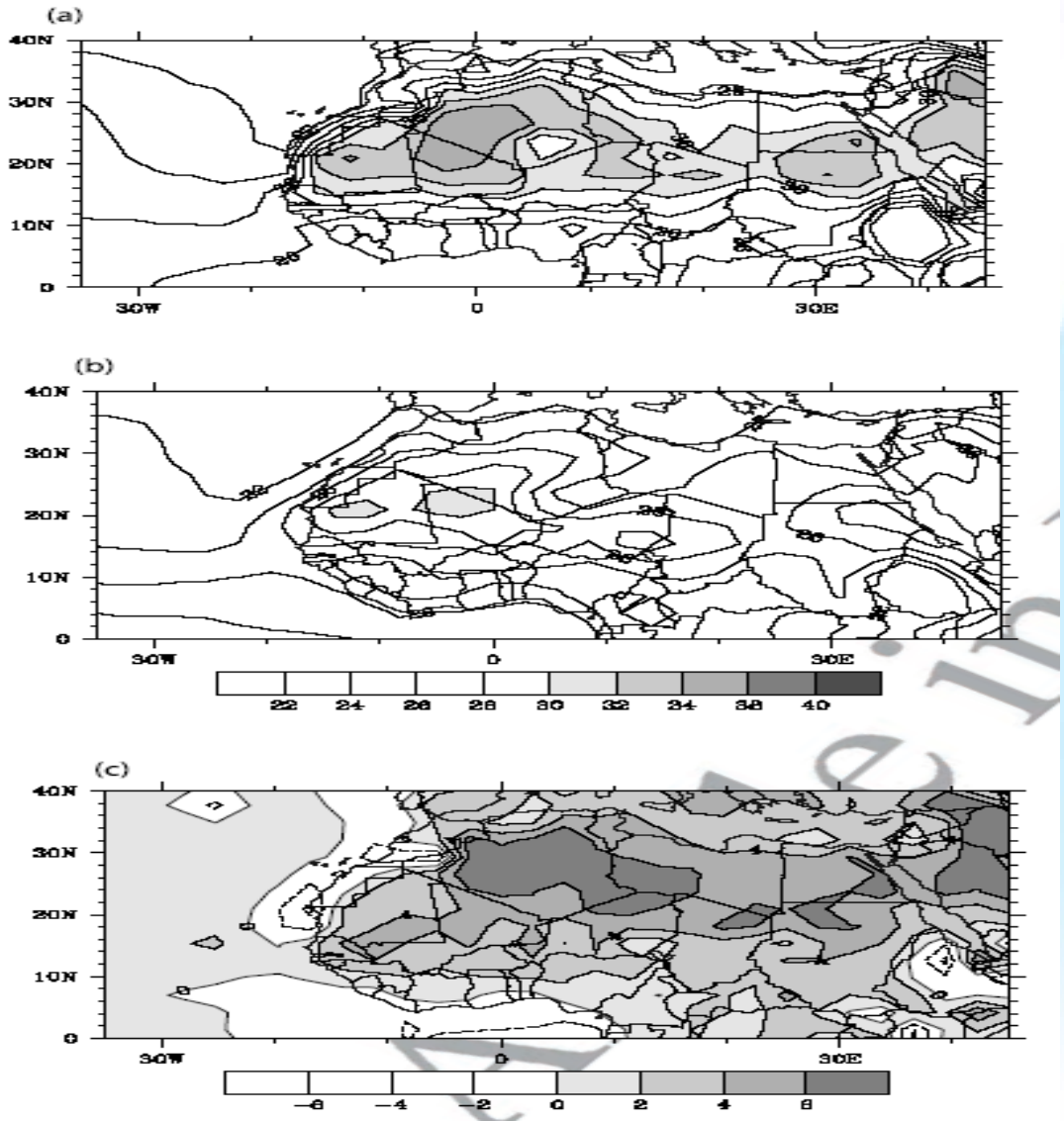
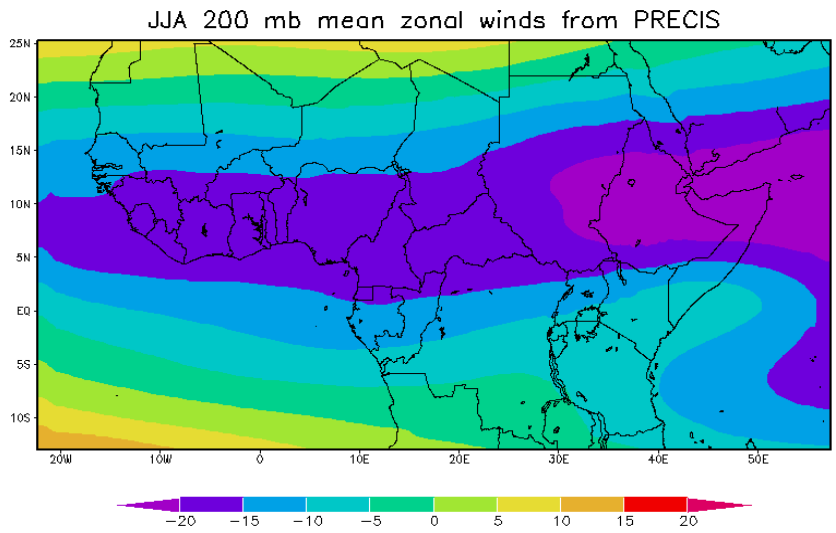
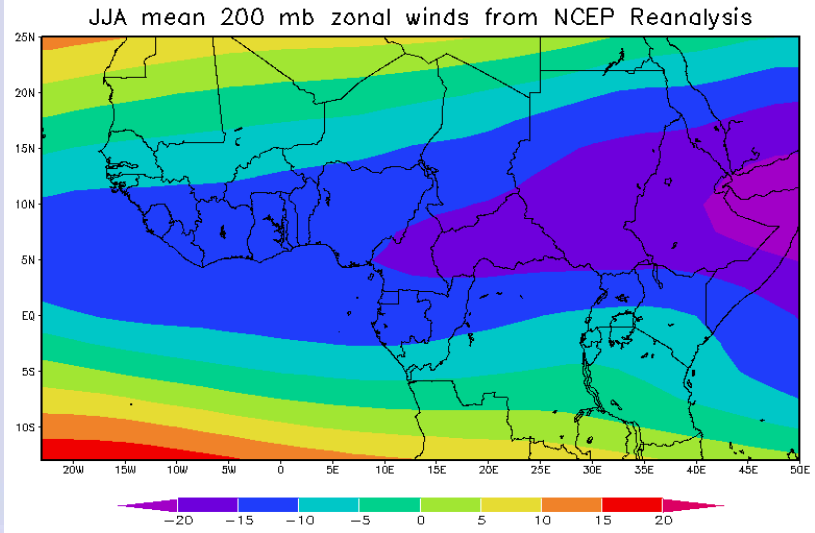


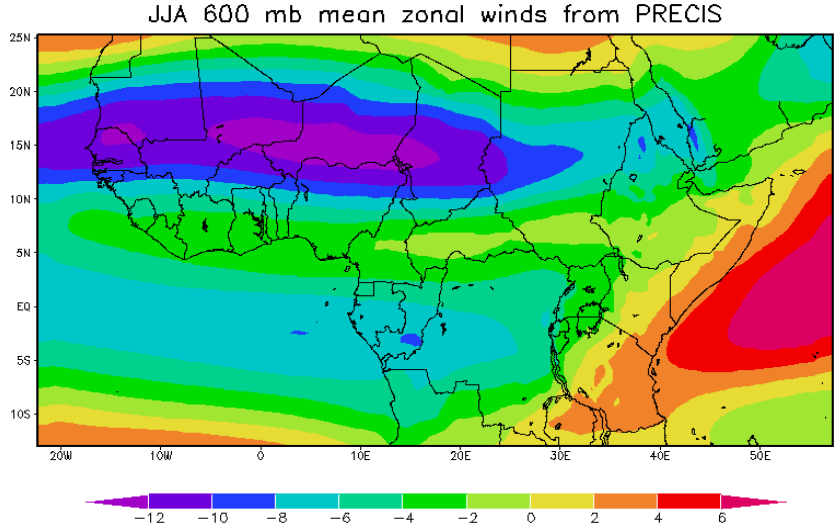
Figure 4. JJA observed and CSM 2 m air temperatures. (a) Observed, (b) simulated, and (c) observed minus CSM. Negative values are denoted by dashed curves. Dark shading denotes temperature differences >6 K.

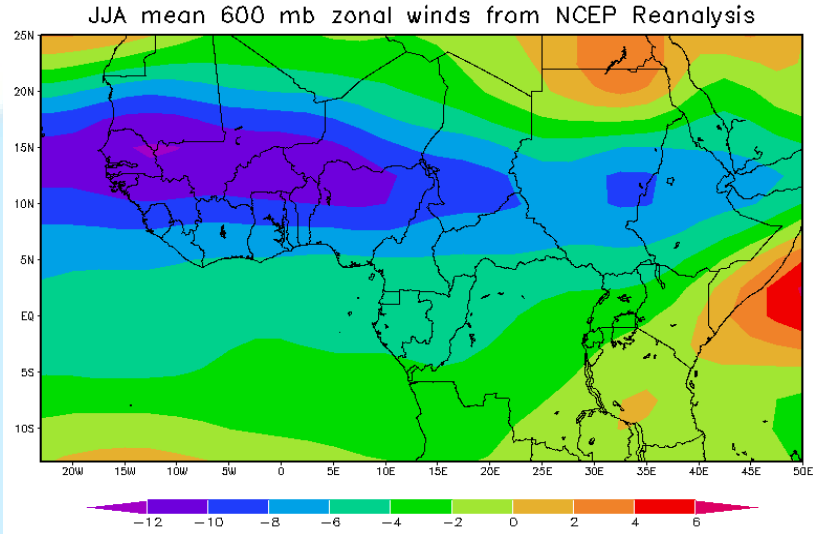
Comparaison PRECIS – NCEP Analyses
Zonal wind at 200hPa et 600hPa

Simulated AEJ and TEJ stronger than observed

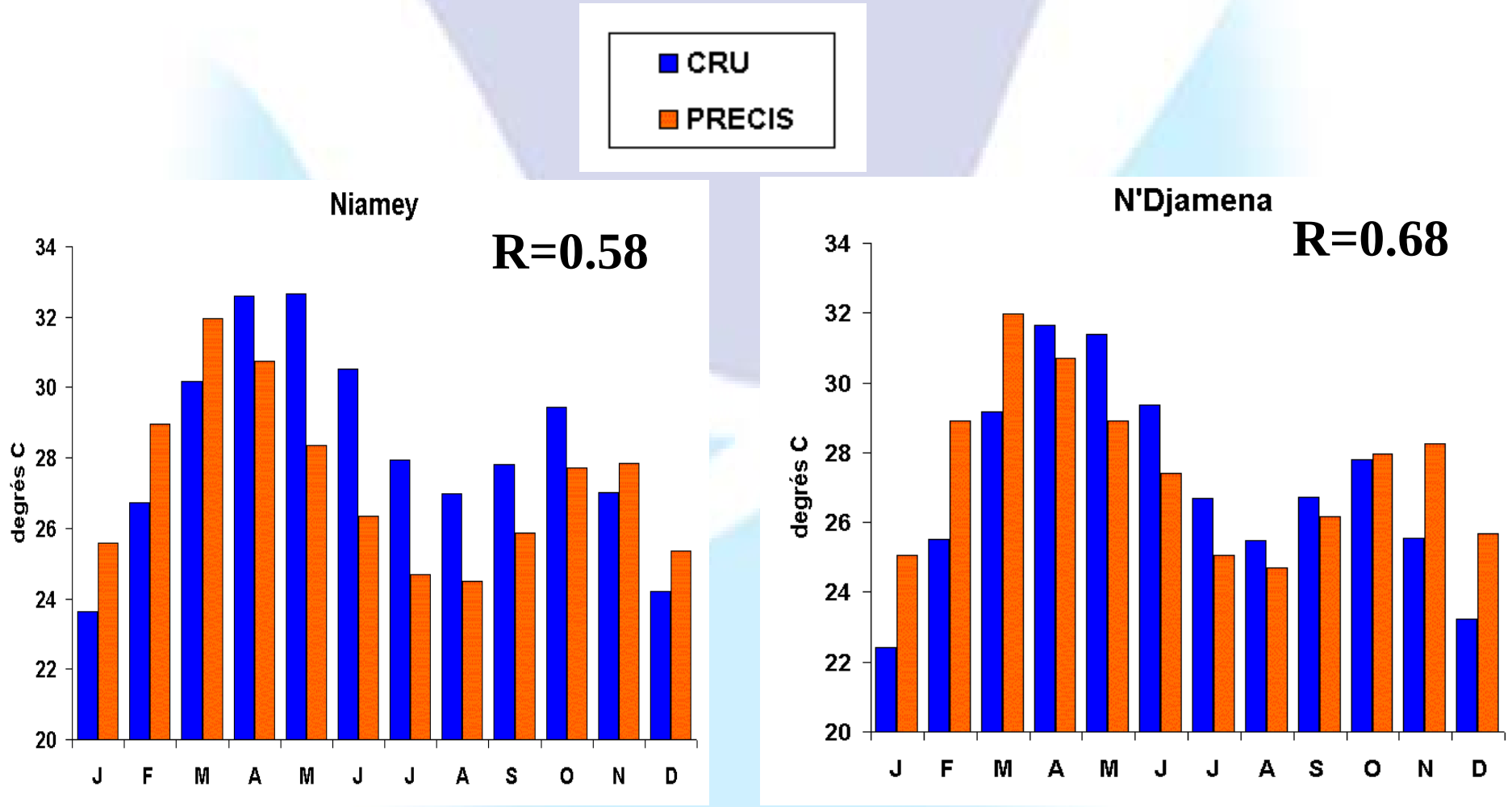




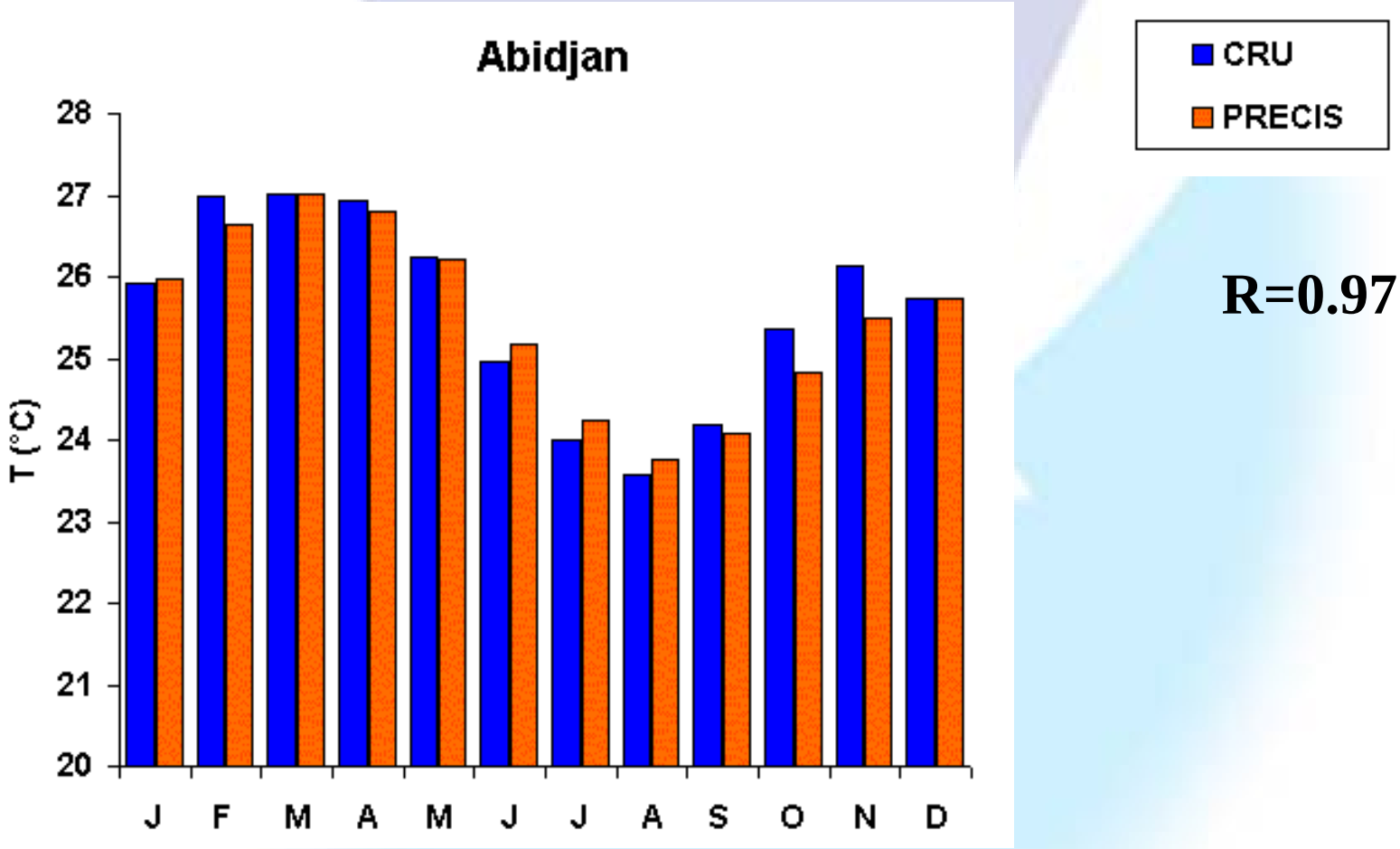




Annual cycle of temperature
Observations(blue); simulations (red).
Nov-Mars(Model warming); April-Oct (Model cooling) Tmax in March instead of April in the Obs



Annual cycle of Temperature
Simulation and observations quite similar



R=0.97

Systematic Cool bias in the NCAR/CSM

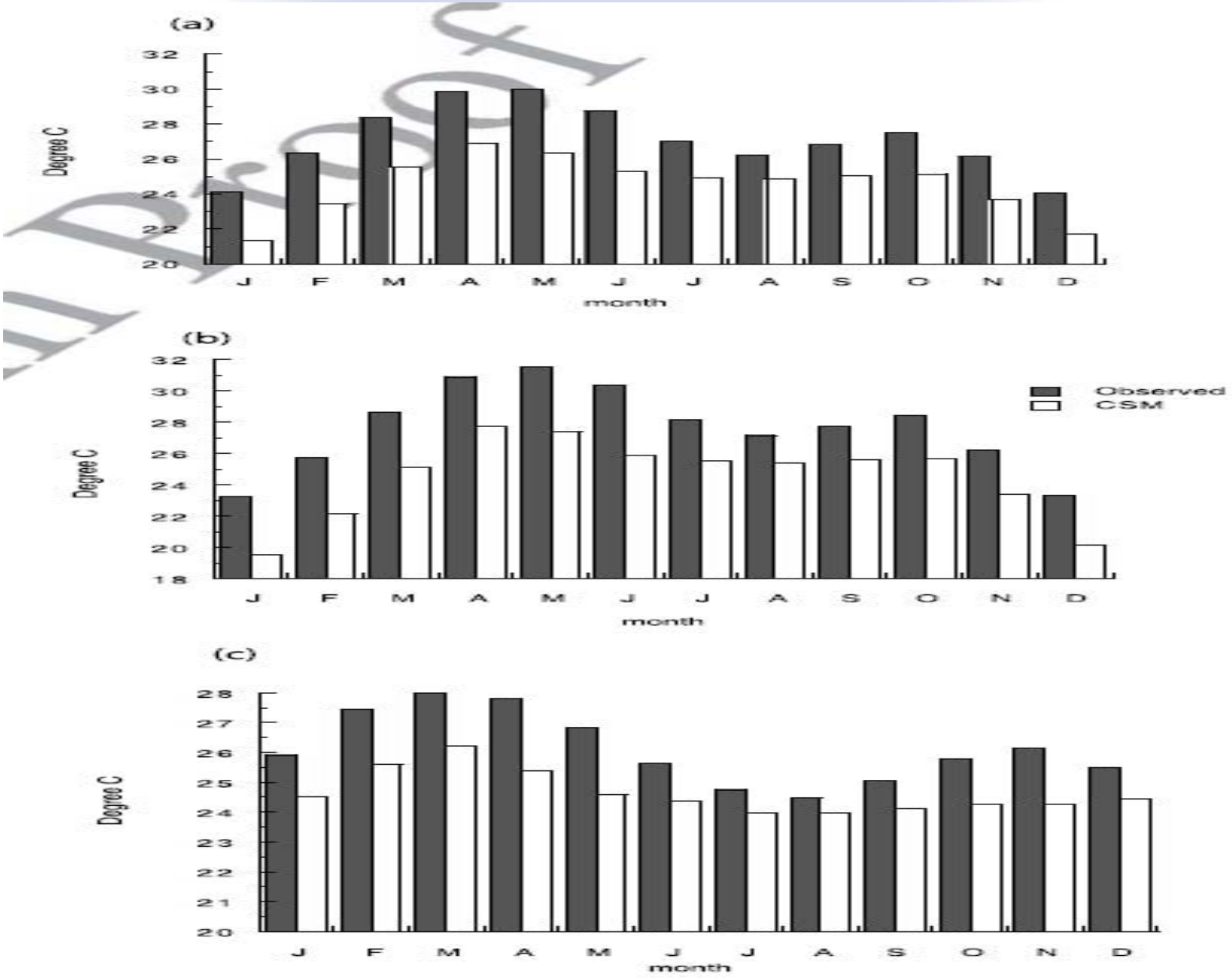
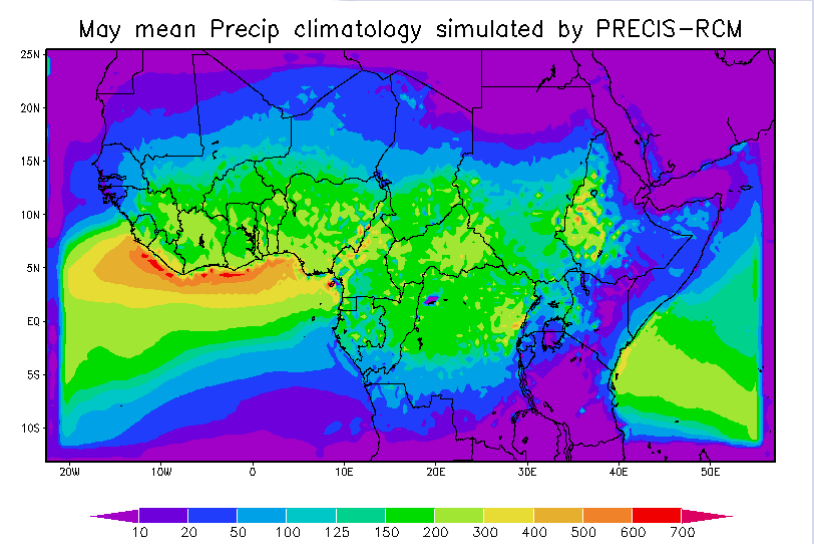
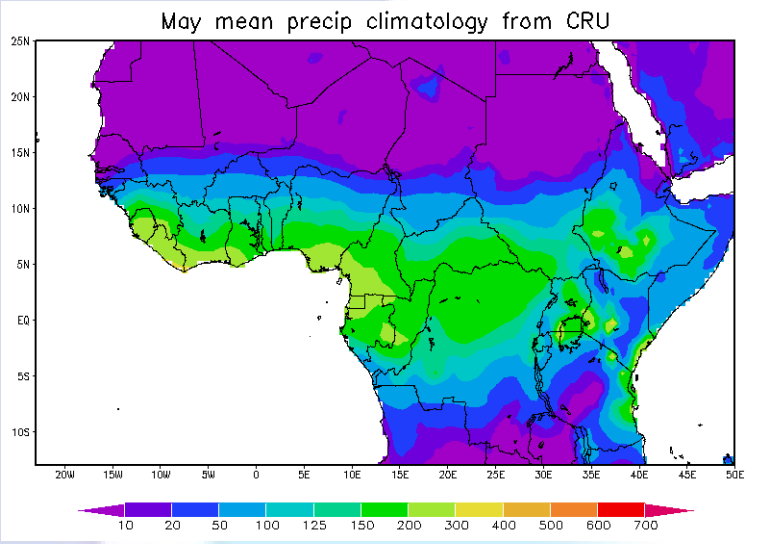
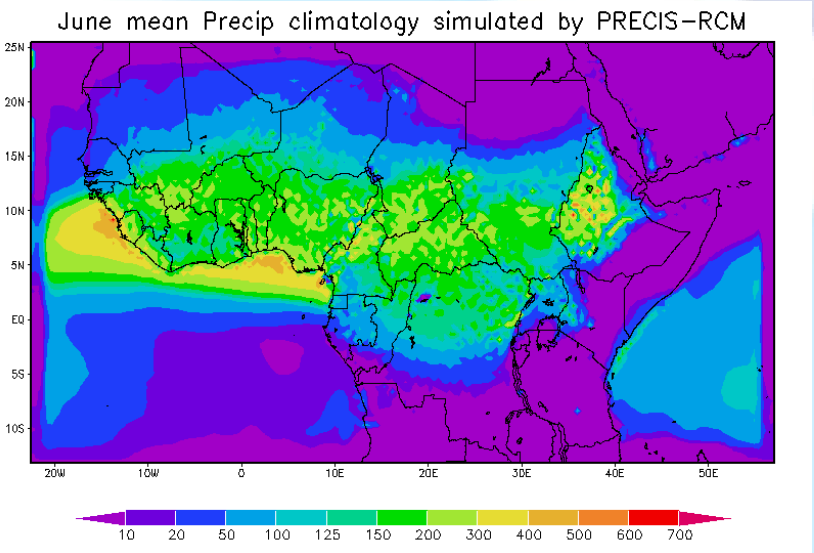


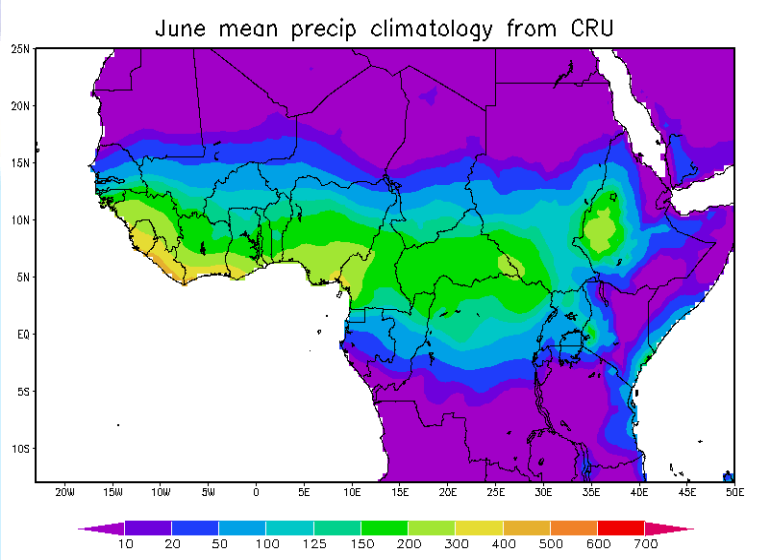
Figure 5. Annual cycle of observed and simulated 2 m air temperature (°C) over land areas. (a) West Africa, (b) Sahel, and (c) Guinea.

Precipitation climatology – May and June



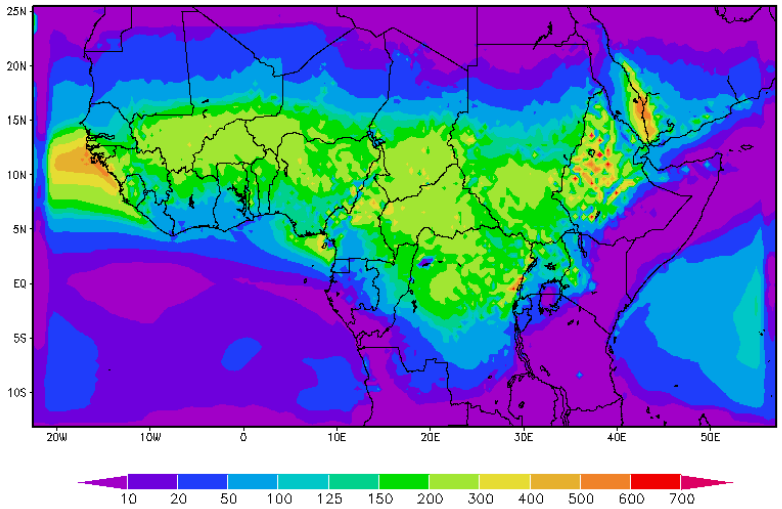




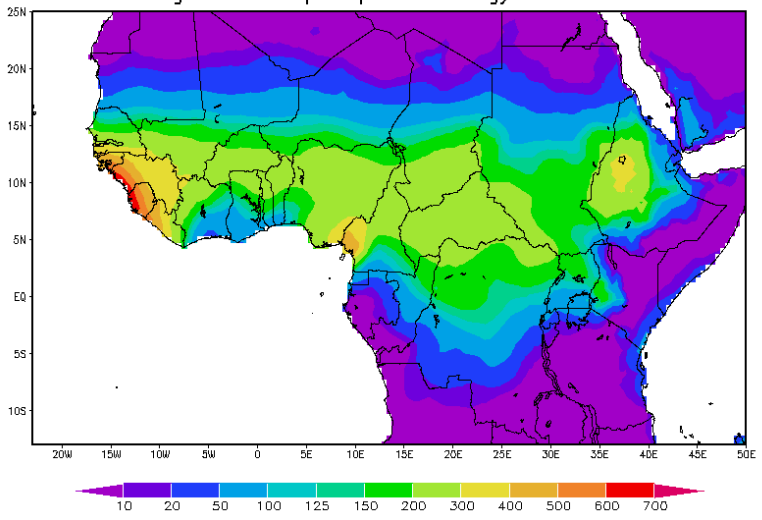


Same as above but for August and September

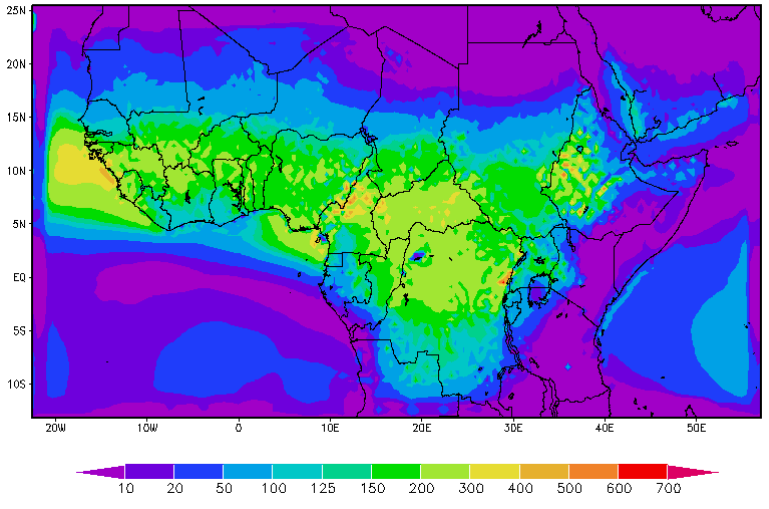
August mean Precip climatology simulated by PRECIS–RCM



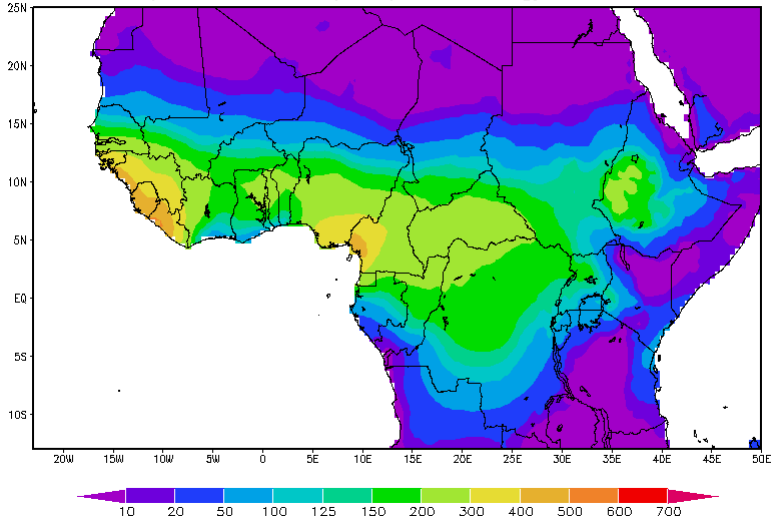
August mean precip climatology from CRU



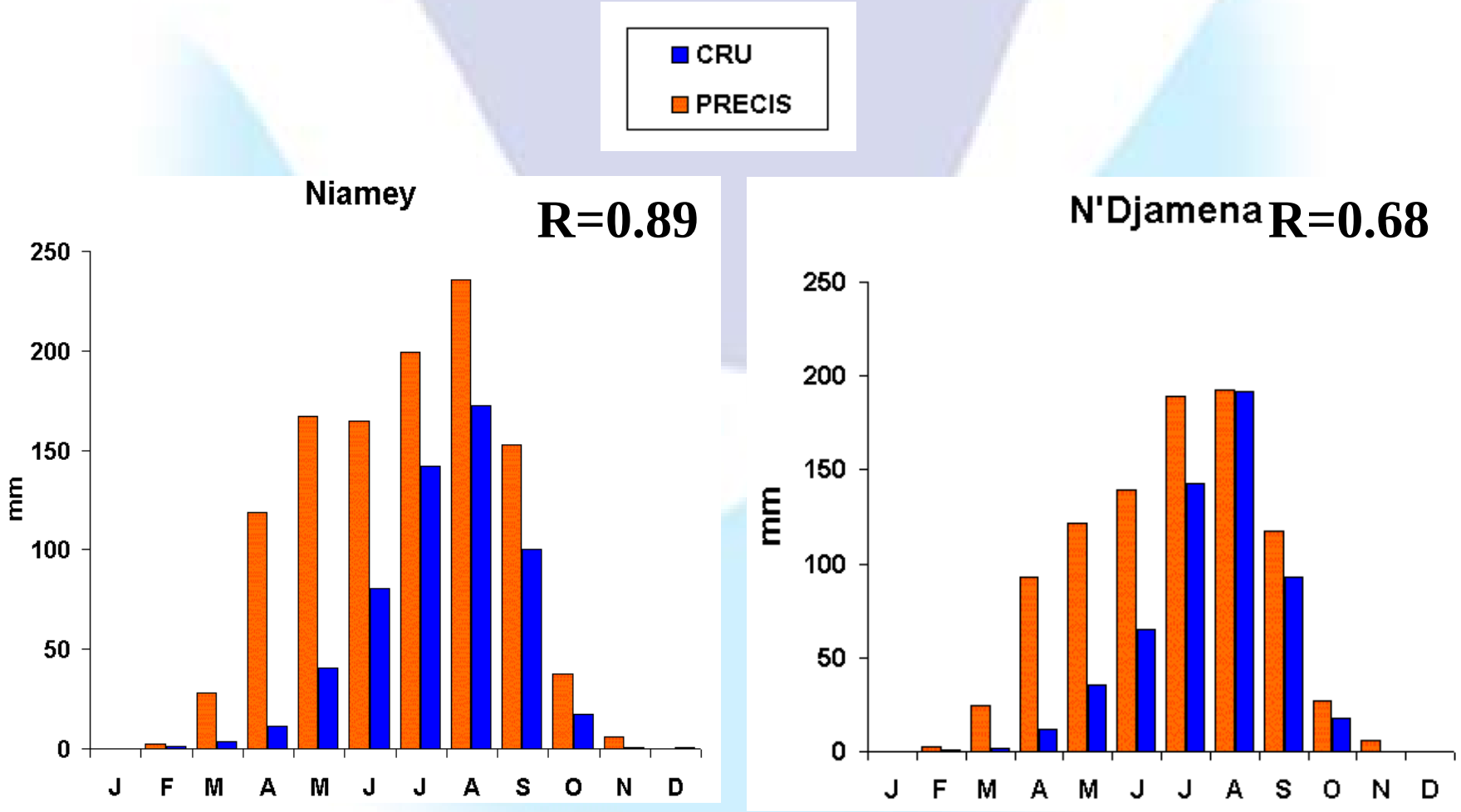
September mean Prec climatology simulated by PRECIS–RCM



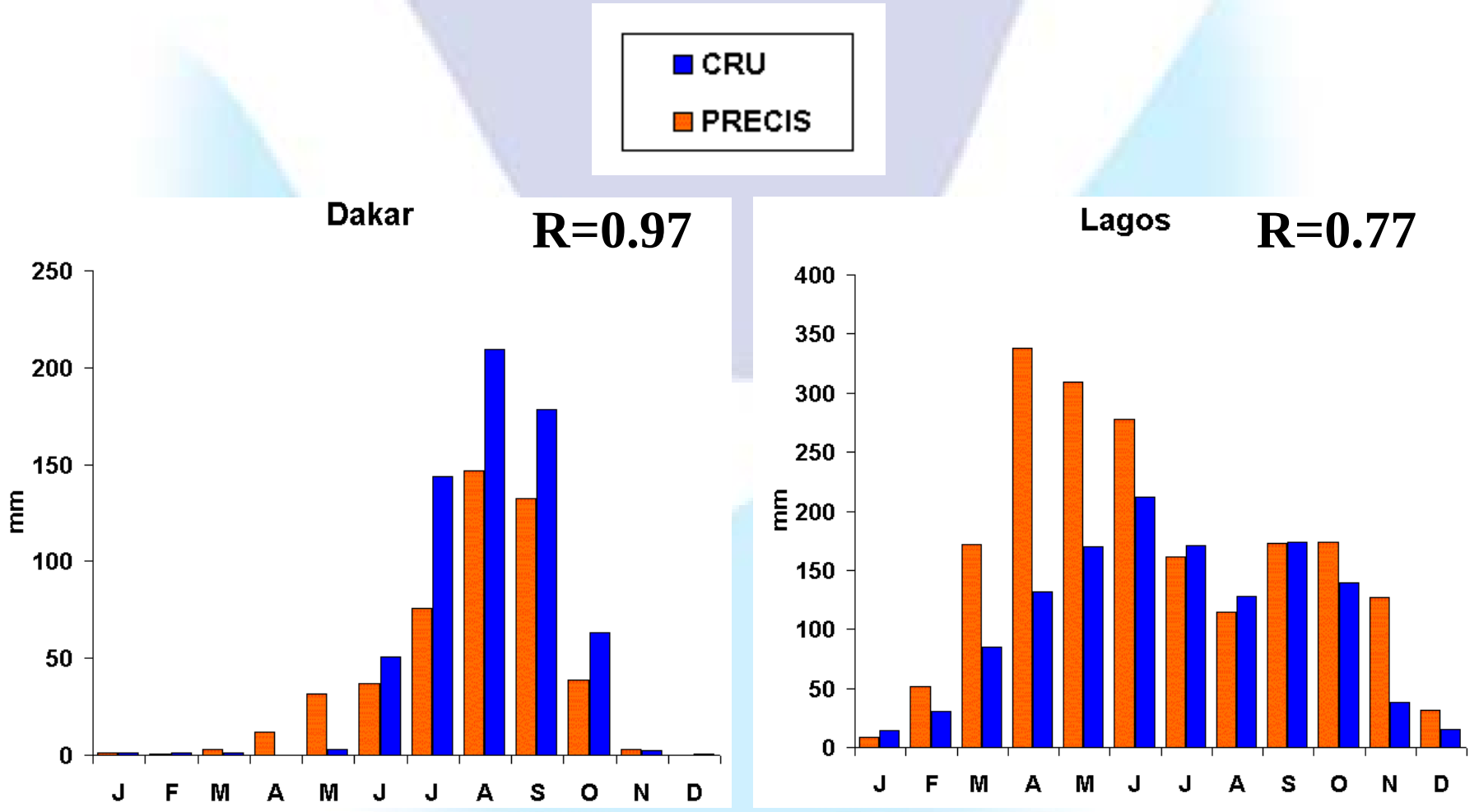
September mean precip climatology from CRU

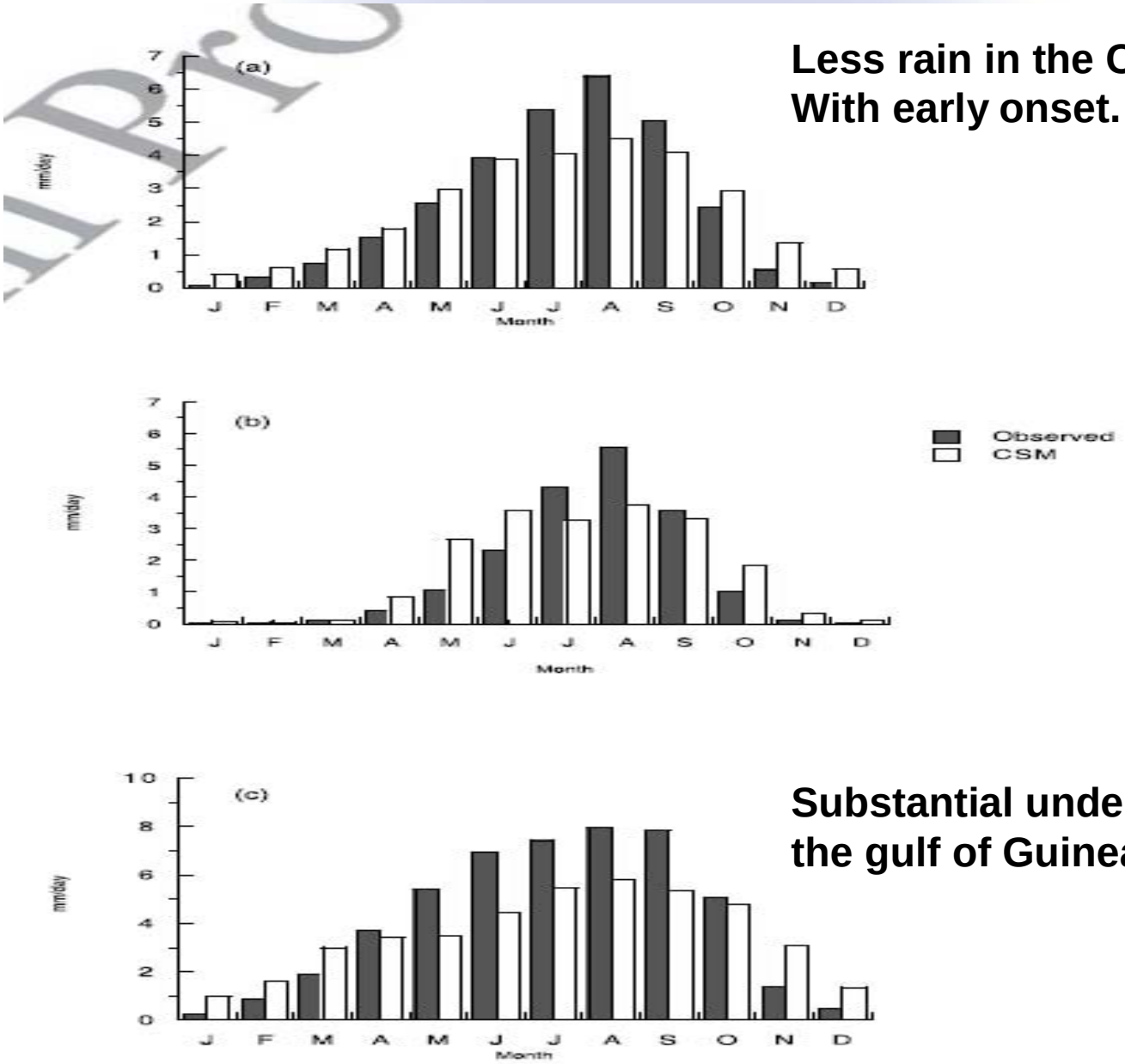


Annual cycle of precipitation. Early onset, peak and withdrawal on the moonson precipitation well captured



Annual cycle for Coastal cities



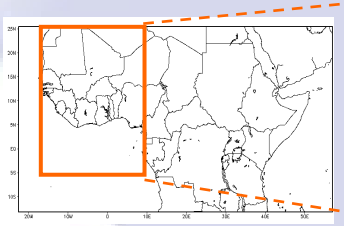


Less rain in the CSM over Sahel With early onset.

Substantial underforecasting over the gulf of Guinea.

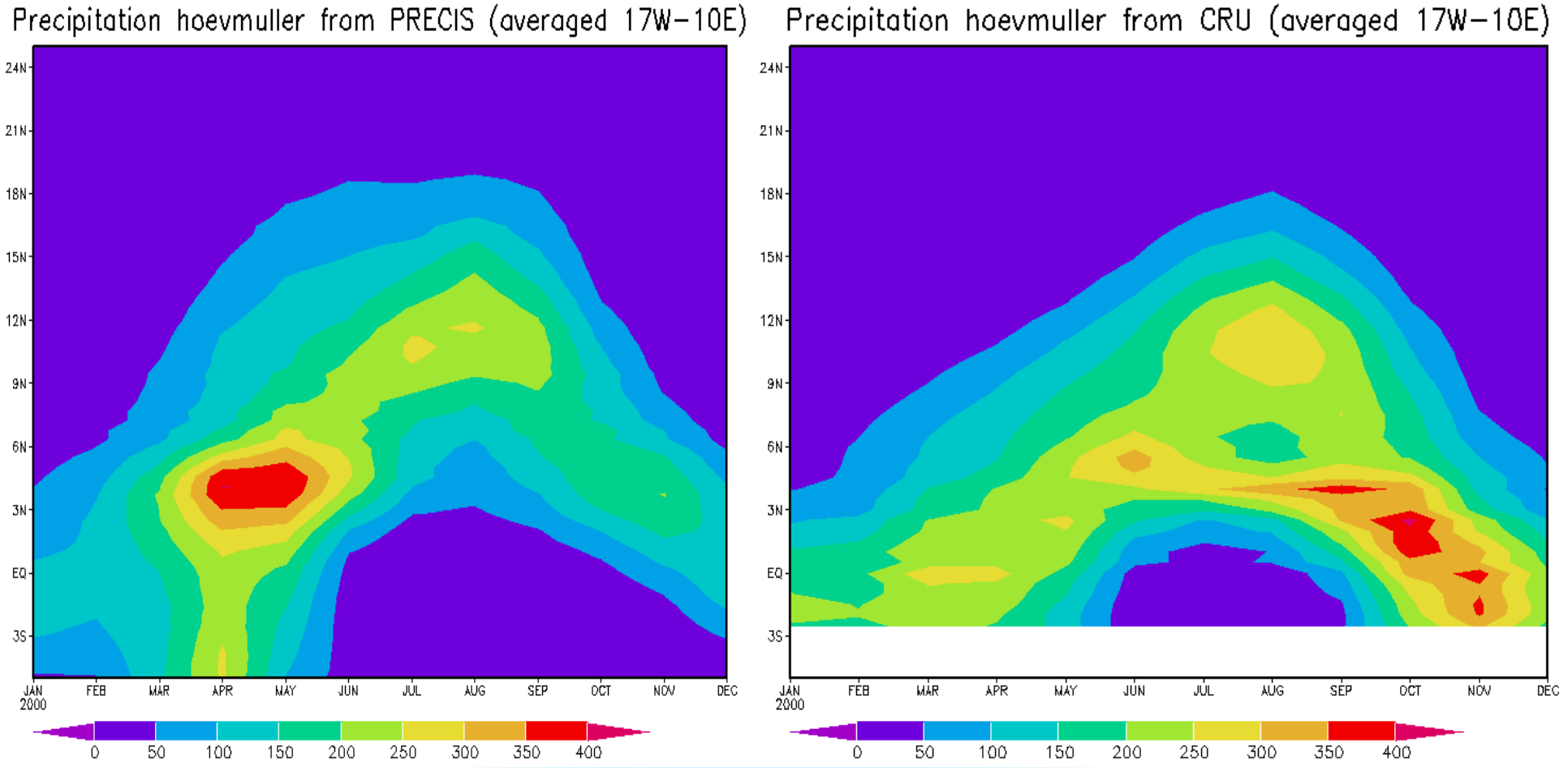
Figure 3. Annual cycle of observed and simulated precipitation rates (mm d^{-1}) over land areas. (a) West Africa, (b) Sahel, and (c) Guinea.

Annual cycle on a Hovmöller diagram



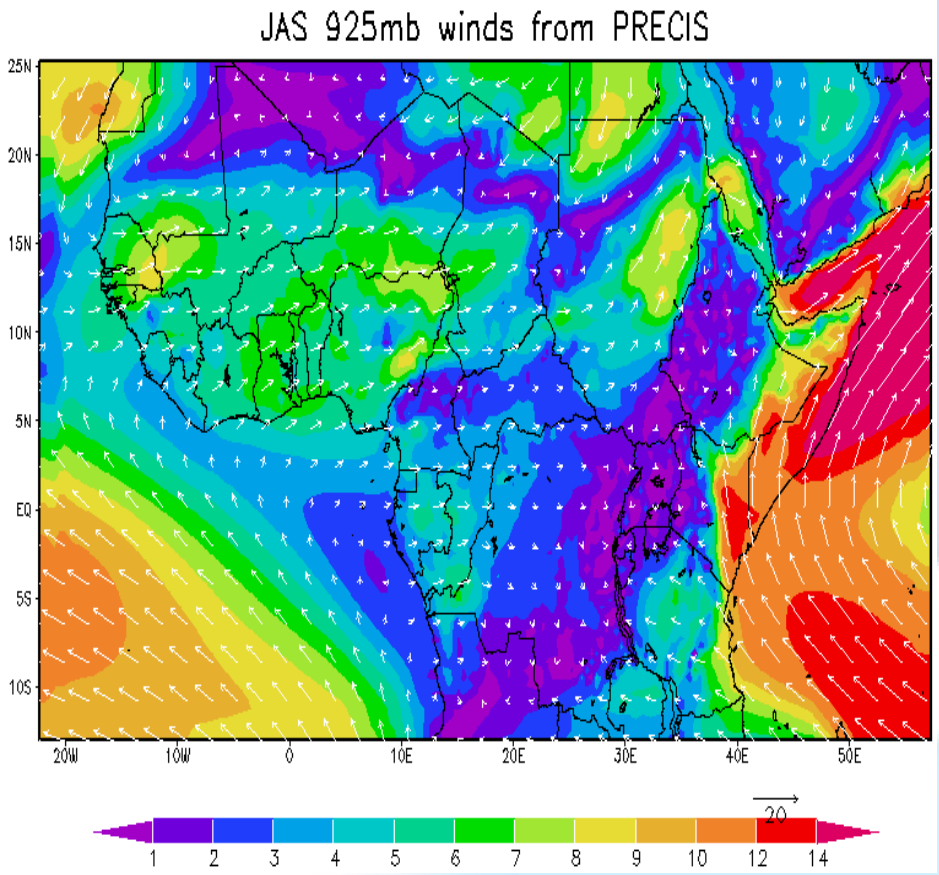
latitude

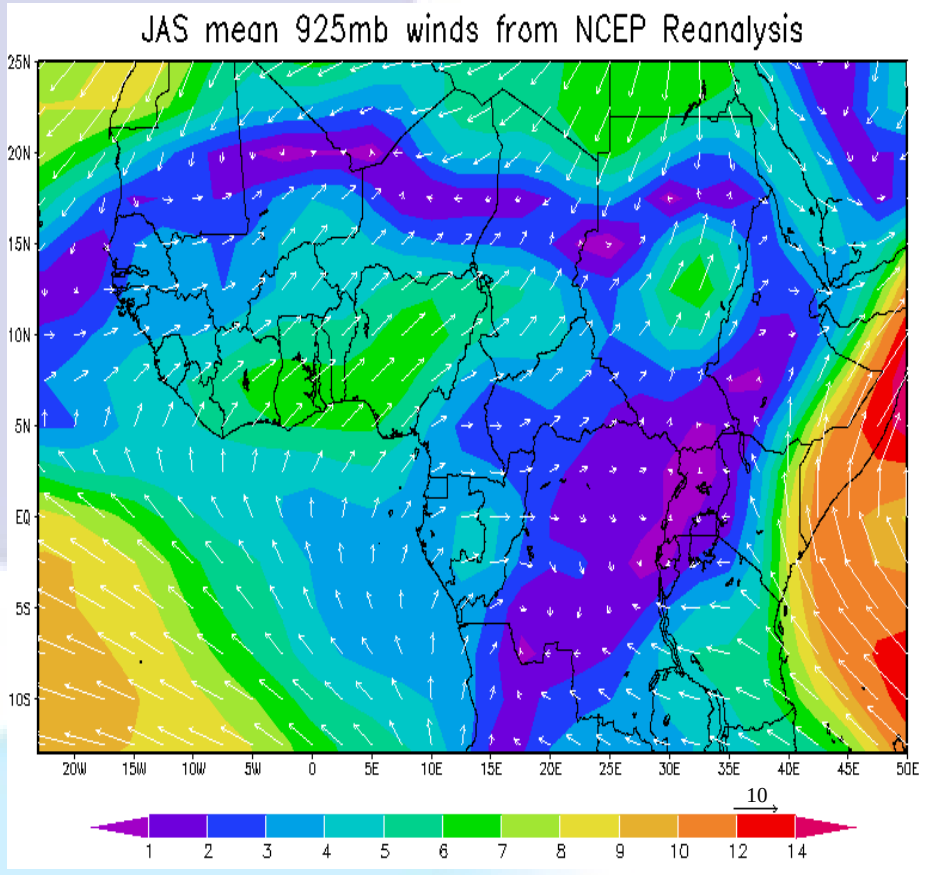
temps



Moonsson circulation

Stronger in the Model





Simulated AEJ below Its normal latitude Position .

« explain under prediction of rainfall over Sahel? »

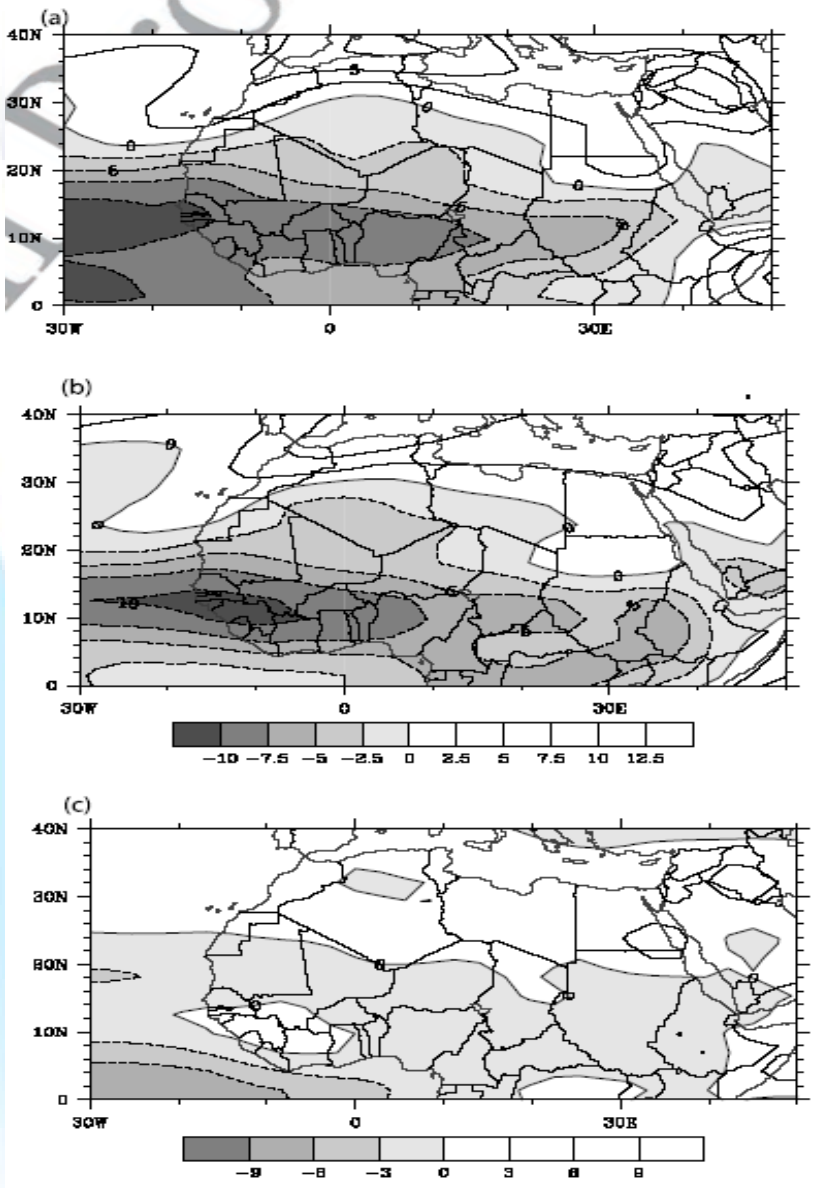


Figure 7. JJA 700 hPa zonal winds (m s^{-1}). (a) NCEP, (b) CSM, and (c) NCEP minus CSM. Negative values are easterly winds, and positive values are westerly in Figures 7a and 7b.

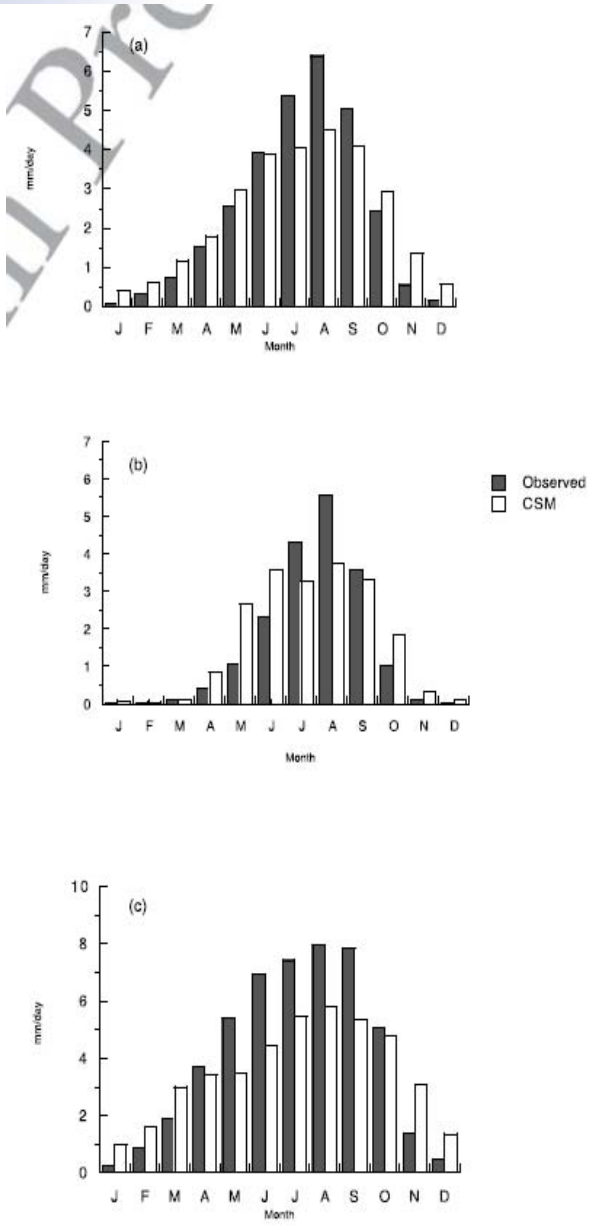


Figure 3. Annual cycle of observed and simulated precipitation rates (mm d^{-1}) over land areas. (a) West Africa, (b) Sahel, and (c) Guinea.

Simulated
TEJ core less intense

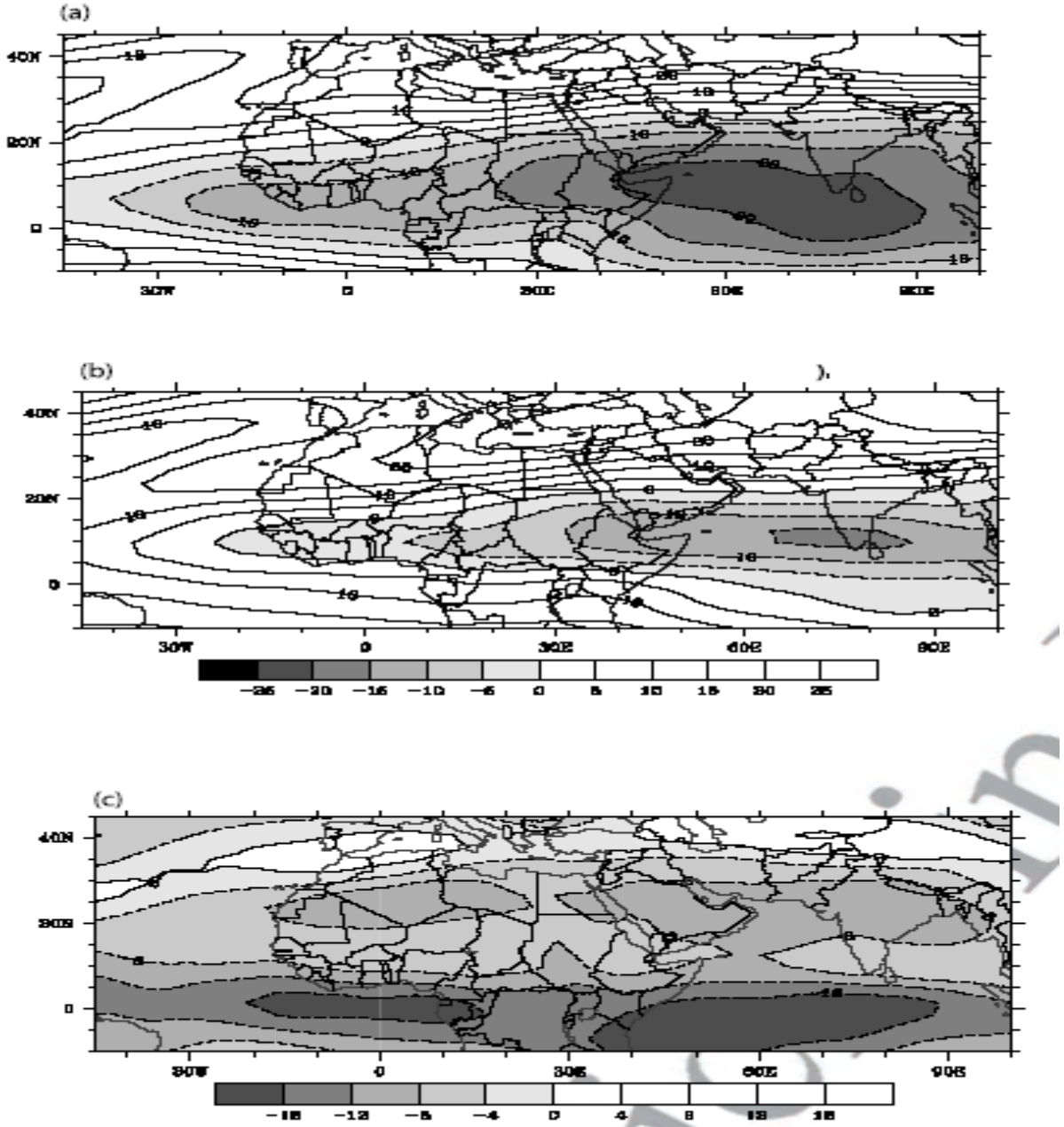


Figure 8. Same as Figure 7 except at 200 hPa.

Warming trend. Observations may be even warmer if the cool bias observed in past climate persists. With bias corrections CSM Temp projections over Africa become closer to other IPCC models. Normal-above normal precip trend more likely if the dry biasis corrected

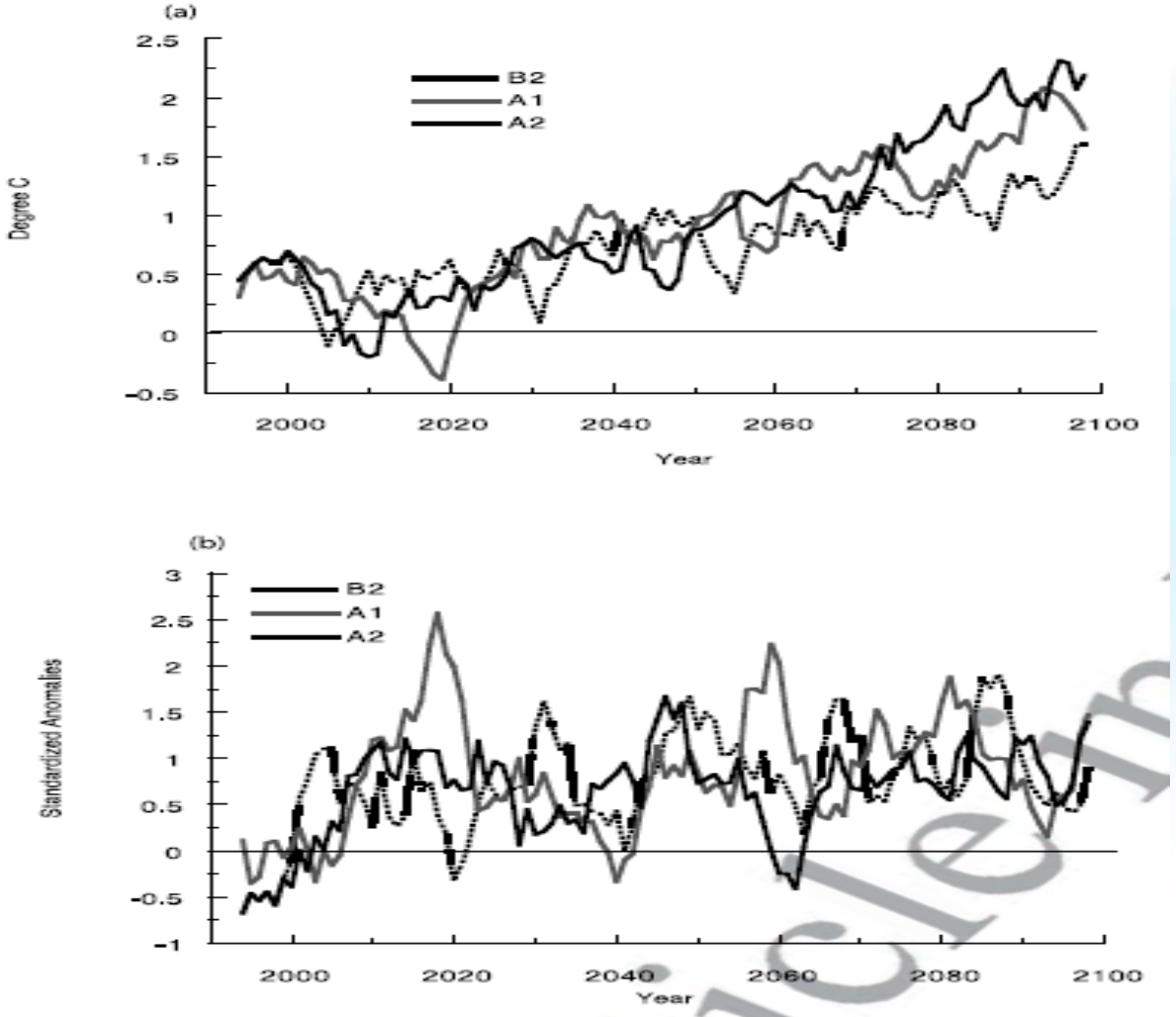


Figure 11. CSM B2, A1, and A2 21st century JJA Sahelian (a) temperature (°C) and (b) precipitation anomalies.

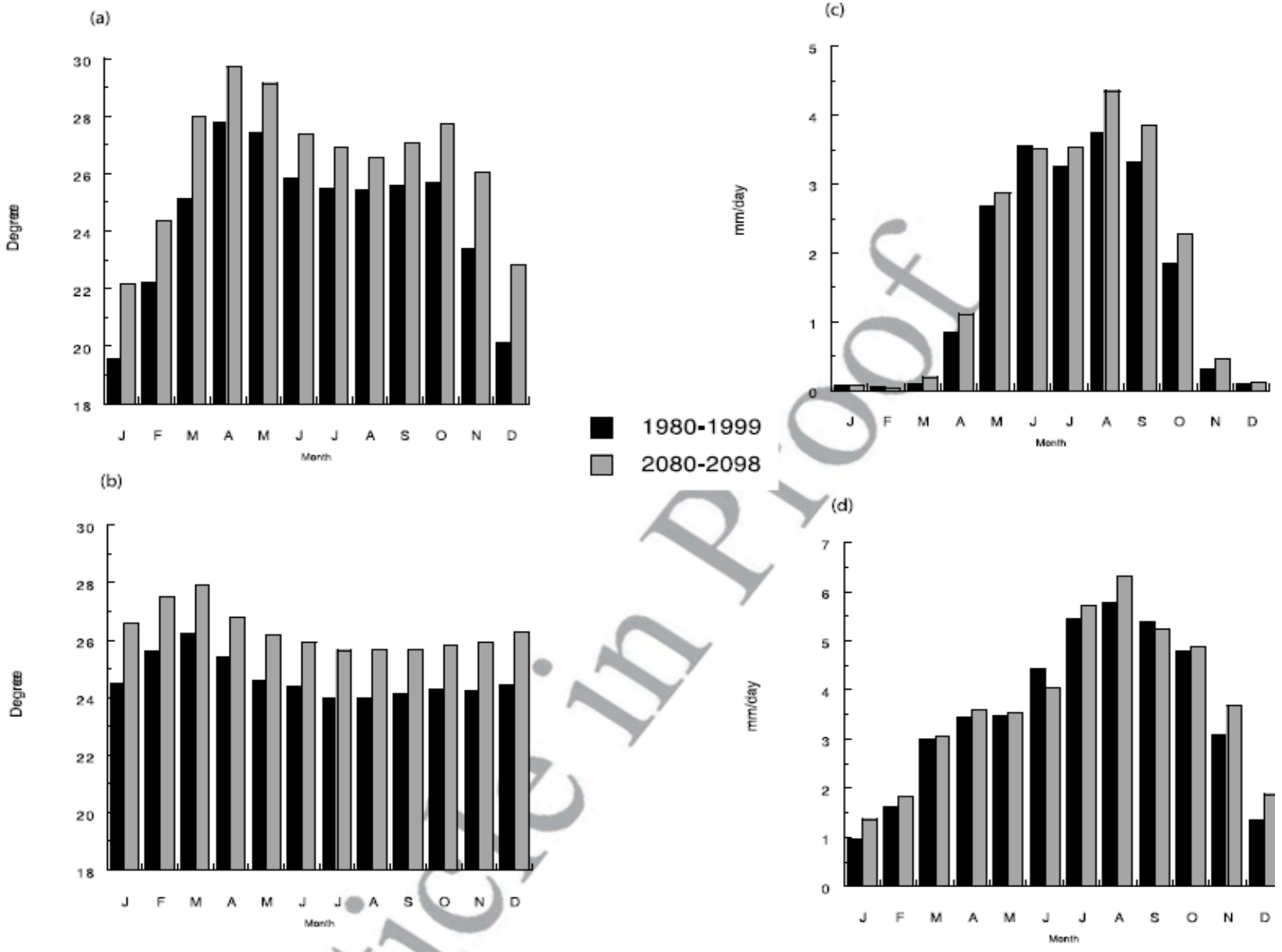
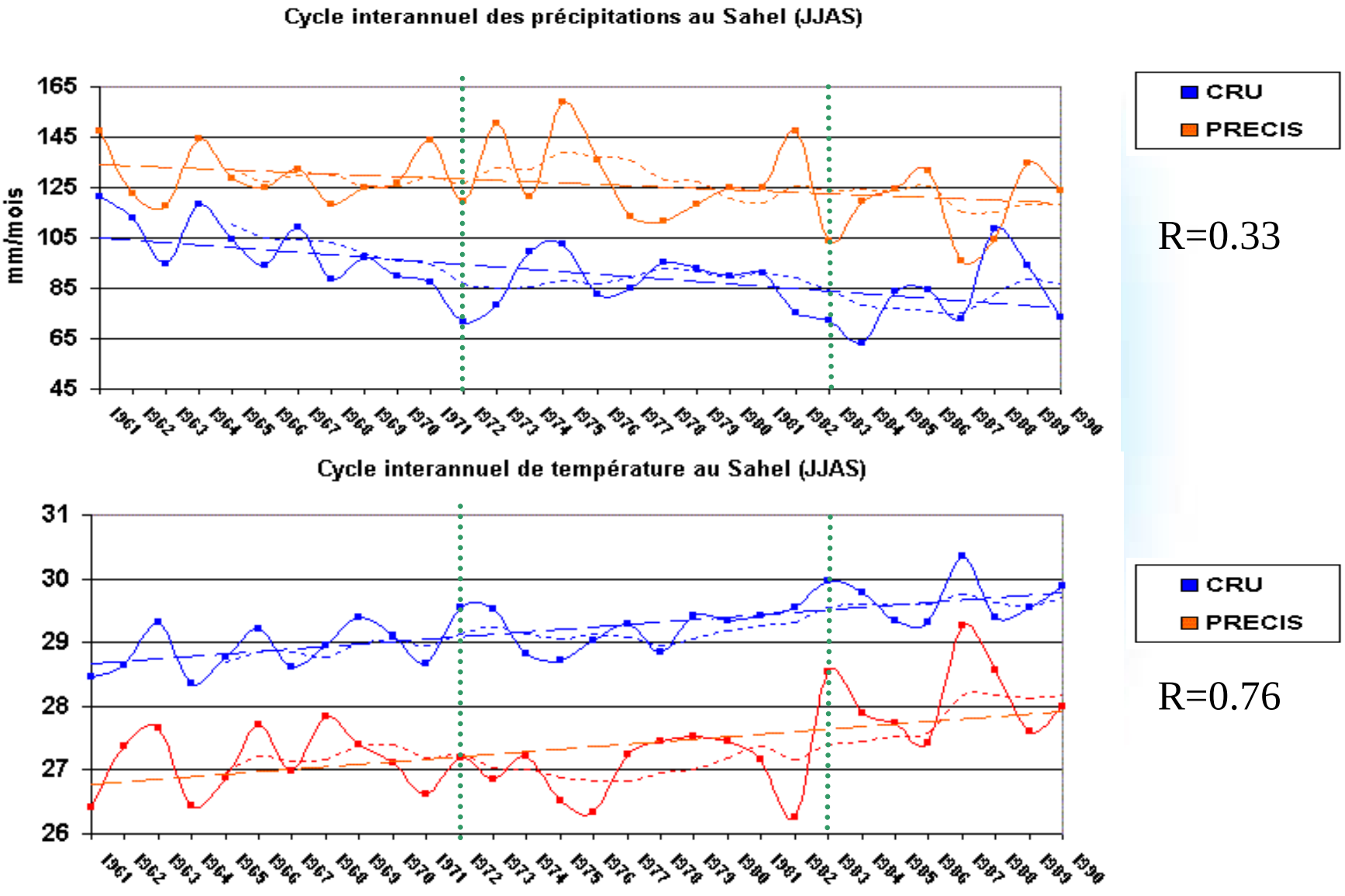


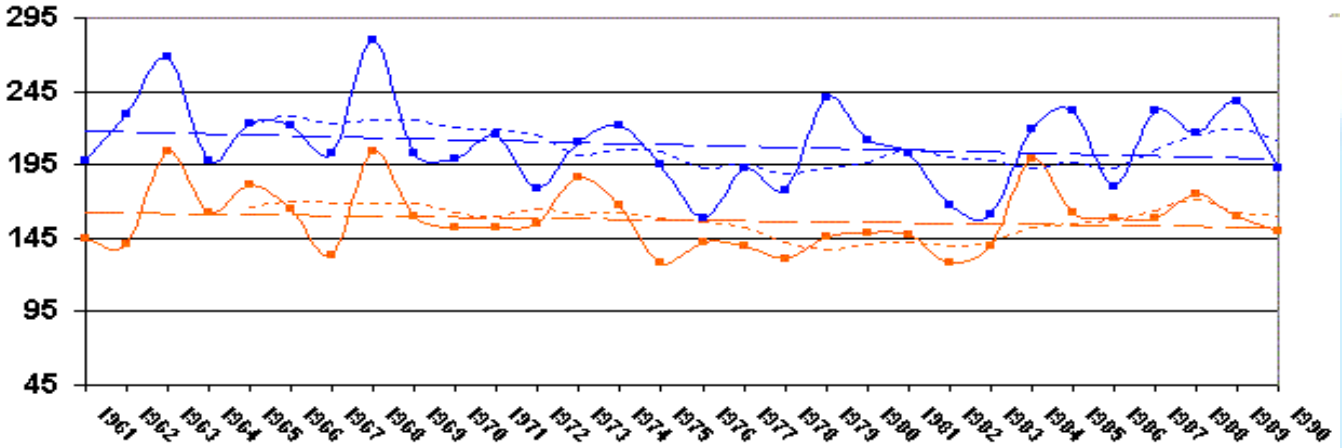
Figure 13. CSM 20th and 21st century annual cycle of simulated temperature (°C) and precipitation rates (mm d^{-1}) for land areas in the Sahel and Guinea regions. (a) Sahel temperatures, (b) Guinea temperatures, (c) Sahel precipitation rates, and (d) Guinea precipitation rates.

Interannual variability over Sahel



Gulf of Guinea

Cycle interannuel des précipitations sur la côte Guinéenne (JJAS)

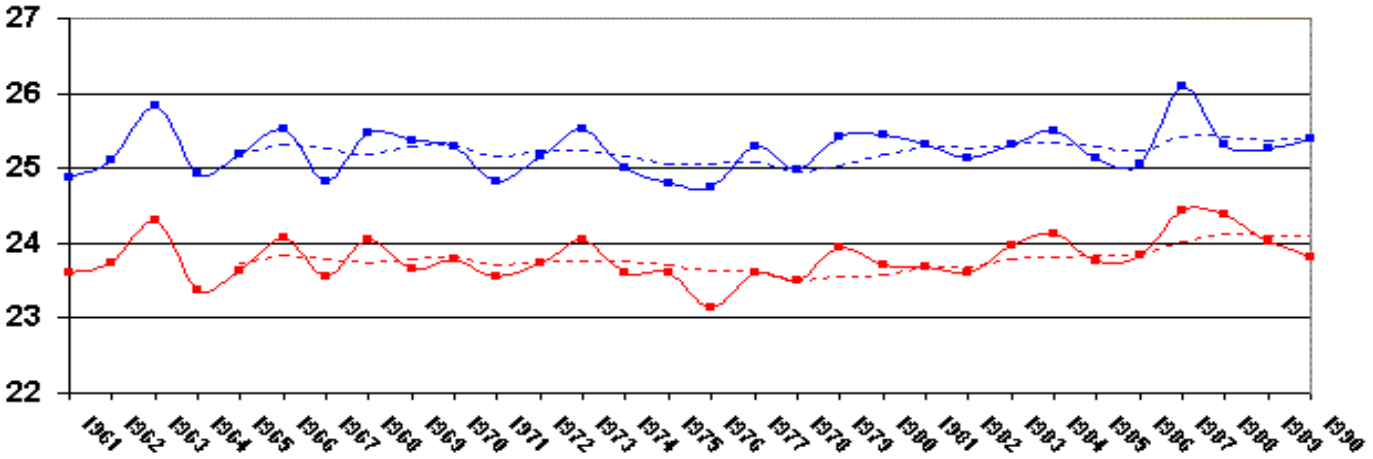


R=0.77

CRU

PRECIS

Cycle interannuel de température sur la côte Guinéenne (JJAS)



R=0.87

IPCC Models verification for better estimation of uncertainties in scenarios over Africa

- It is necessary to maintain (CMIP) and strengthen a comprehensive verification of IPCC models over all Africa.

- Such an experiment may help to better interpret models outputs and significantly improve estimation and communication of projections and related uncertainties for impacts and adaptation in Africa.

END