World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Assessment of climate change forecasts for the Agnéby watershed, south-eastern Ivory Coast

KONE Brahima [1,*], DIALLO Seydou [2], KAMAGATE Anzoumanan [3], OUATTARA Ismaïla [4] and KAMAGATE Bamory [2]

[1] *Laboratory of Energy, Climate and Environmental Studies, NANGUI ABROGOUA University, Abidjan Ivory Coast, 02 BP 801 ABIDJAN 02.*
[2] *Geosciences and Environment Laboratory, NANGUI ABROGOUA University, Abidjan Ivory Coast, 02 BP 801 ABIDJAN 02.*
[3] *Training and research unit for Marine Sciences, University of San-Pedro, city San-Pedro 01 BP 1800 San Pedro 01, Ivory Coast.*
[4] *Department of Mines and Reservoirs, Training and Research Unit in Geological and Mining sciences, University of Man Ivory Coast.*

World Journal of Advanced Research and Reviews, 2026, 30(02), 145-159

Publication history: Received on 20 March 2026; revised on 26 April 2026; accepted on 28 April 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.30.2.0665

Abstract

This study aims to characterize the impacts of climate change by the years 2050 and 2080 in the Agnéby watershed, located in southeastern Côte d'Ivoire. The methodology employed involves extracting key climate variables—specifically precipitation and temperature—from regional climate models. These data were then corrected to reduce biases using a linear regression method. This correction was applied to a historical reference period (1976–2005) as well as to two future climate projections corresponding to the time intervals 2025–2054 and 2055–2084. Data analysis reveals a decrease in average annual precipitation ranging from 0.27% to 0.72% under the RCP4.5 scenario. In contrast, the RCP8.5 scenario projects an increase of 0.2% followed by a decrease of 0.24% compared to the baseline period. Furthermore, temperatures are projected to rise by 1.18°C by 2050 and by 2.06°C by 2080, again according to the RCP4.5 scenario. Between now and the 2050s and 2080s, temperatures will rise by +1.74 °C and +2.47 °C, respectively. According to the RCP8.5 scenario, these increases could reach between +2.2 °C and +3.1 °C by 2080. During these same periods, projections indicate increases ranging from +2.35 °C to +3.78 °C. This climate change will lead to a gradual decline in surface water resources, exacerbated by the effects of climate change. This decline could jeopardize agricultural systems, a worrying situation since nearly two-thirds of the population depends on traditional agriculture for their livelihood.

Keywords: Forecasting; Climate Change; Agnéby Watershed; South-Eastern Ivory Coast

1. Introduction

Human-induced climate change is causing dangerous and widespread disruption to nature and affecting the lives of billions of people worldwide, despite efforts to reduce the risks (WMO, 2022). The populations and ecosystems least able to cope are the hardest hit, say scientists in the latest report from the Intergovernmental Panel on Climate Change [8]. Over the second half of the last century, water supply has declined in most of West Africa's major river basins. The reasons for this decline are a complex combination of climate change (such as rainfall), changes in land cover and use, and population growth [8]. Studies based solely on climate projections therefore suggest that river flows could decline by a further 20% to 40% by 2050, but the actual magnitude of future changes is uncertain and depends on multiple factors [19]. According to [4], climate change and land use change are already affecting the water cycle in West African

* Corresponding author: KONE Brahima

countries. In this respect, [2] show that climate change and land use change are considered major global environmental issues. Both factors can affect water resources in watersheds [18].

In Ivory Coast, several research studies have focused on the impacts of rainfall variability on water resources. Few studies have assessed the effects of climate change on water resources. [5] assessed the impacts of climate change on water resources in the Bandama watershed, a humid tropical zone. [3] highlighted the effects of rainfall variability on surface runoff in the Agnéby watershed. Very few studies have addressed the effects of human practices on climate change [11].

[17] highlighted the impacts of climate change and land use on surface water in the Davo watershed. In the specific case of the Agnéby watershed, agriculture remains a predominant sector of the economy, mobilizing 2/3 of the working population. Firstly, its vegetation cover has seen a deforestation rate of between 15 % and 20%, compared with a hydrometric deficit of 42 %, and finally between 1988 and 2020 the area has experienced the effects of human activities, falling from 64.35 % to 11.6 %, i.e. a regression of 52.8 % [12]. Between 1950 and 2013, this basin experienced an annual rainfall deficit varying between 15 % and 20%, against a hydrometric deficit of 42 % [1].

The Agnéby area will experience hydrometric declines of 32.62 % and 20.42 % between 2050 and 2080, according to [13], due to the effects of climate change. Over these two horizons, actual evapotranspiration is expected to exceed 2.8 % and 3.36 %, while the other three (03) balance terms will show rainfall deficits of 1.9 % and 1.23 %. Infiltration and runoff will show deficits of 9.77 %, 10.23 %, 2.5% and 1.5 % respectively. Given that water is an important component of development, it is important to act on adaptation to climate change with a view to protecting it in a context of sustainability. In this area, very few studies have characterized the effects of climate change in the near and distant future, and it is from this problem that the main objective of this study arises, which is to evaluate climate change forecasts in the Agnéby watershed. Specifically, the aim is to characterize climate change in the Agnéby watershed over the 2050 and 2080 timeframes.

2. Material and methods

2.1. Study Area

The Agnéby watershed lies between longitudes 5°33'0''W and 6°36'0''w on the one hand, and between latitudes 4°39' 0''N and 3°36'0''N on the other (Figure1). It covers an area of 8640 km2. The basin is sandwiched between the Bandama to the west and the Comoé and Mé to the east. The basin has a mild transitional equatorial climate, with cumulative rainfall of 1,784 mm.yr-1. Vegetation is mainly dense evergreen forest. The relief of the Agnéby is characterized by altitudes ranging from 100 m to 300 m. The basin's geology is based on Precambrian formations: arkosic schists north of Bongouanou and south of Agboville, mica-schists and granites in the central part [7]. The soil structure is divided into two types: ferralitic soils, both weakly and strongly denatured, found in the northern and central parts of the basin, and a complex of hydromorphic soils that have evolved little and are found in small areas.

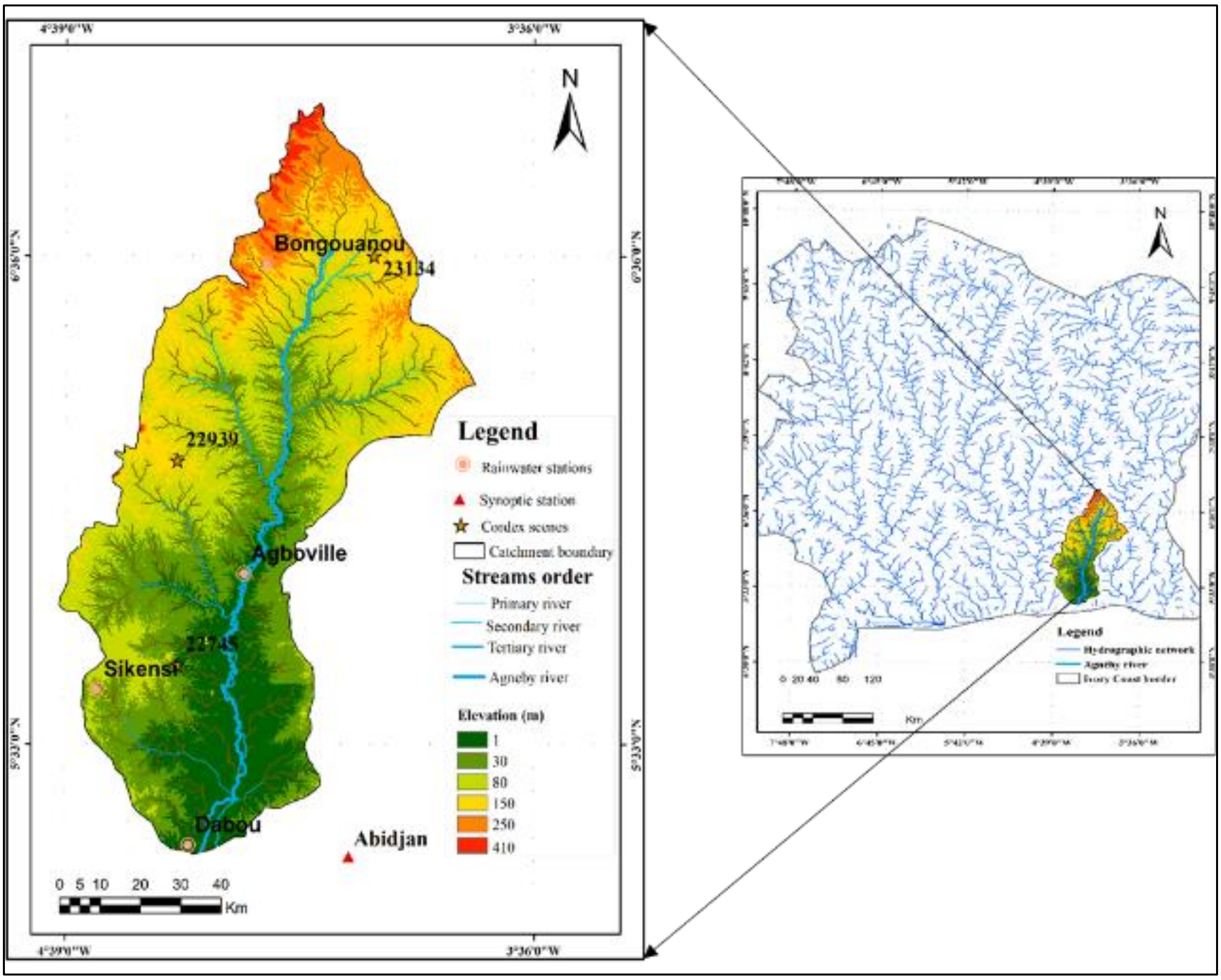


Figure 1 Location of the Agnéby watershed

2.2. Data

2.2.1. Data description

The climatic data collected in this study are daily rainfall and temperature from three (03) rainfall and synoptic stations. These data come from the airport operating and Development Company, Aeronautics and Meteorology Rainfall data has gaps ranging from one to three years. Satellite climate data were used to fill in the gaps. Temperature data from the satellite synoptic station at Abidjan were used for the period 1976 to 2005 (Table 1). CHIRPS data are gridded precipitation time series with a horizontal resolution of 0.05°.

Table 1 List of rainfall stations studied

Reference period of stations (1976-2005)			
Observation	Bongouanou	Agboville	Sikensi
	1976-2005	1976 -2005	1976-2005
	30 (Years)		
Gaps	3	2	1
without gaps	27	28	29
% full years	90	93	97

Daily data from climate models in NetCDF format are available for the period 1951-2100 (Table 2). These regional climate model data were obtained from the CORDEX-Africa programme (Coordinated Regional Climate Downscaling Experiment, http://www.cordex.org/) and comprise rainfall and temperature variables with a resolution of 50 km x 50 km. The regional climate models (RCMs) concerned are ALADIN63 (France), CCLM4-8-17 (Germany) and RACMO22E (Netherlands), whose data are derived respectively from the CNRM-CM5-LR, MPI-LR and EC-EARTH global climate models. For the assessment of the impact of climate change, the 1976-2005 period was considered as the reference period and the different representations of the historical regional climate models were performed by the ensemble on the two climate forcing scenarios (RCP4.5 and 8.5). The projections for the two scenarios RCP4.5 and 8.5 will be carried out over rolling thirty-year periods for the 2050 and 2080 horizons.

Table 2 Regional climate models derived from global climate models

Institutions	MCGs	MCRs	Country	Period
CNRM	CNRM-CM5-LR	ALADIN63	France	1951-2100
CLMcom	MPI-ESM-LR	CCLM4-8-17	Germany	1951-2100
KNMI	EC-EARTH	RACMO22E	Netherlands	1951-2100

2.3. Methods

2.3.1. Techniques for correcting biases in climate models

This method involves adding a correction or bias factor to the set of biases in the simulated time series (reference period and future period). The aim is to bring the simulated data for the historical period (1976-2005) closer to the observations for the reference period, so as to make the two series more consistent and comparable. The correction factor is first calculated from a comparison between the simulated reference period and the reference data for the same period. Like the delta method, this technique can be based on an average correction or on quantile. However, unlike the perturbation method, where the correction is applied over a given time horizon, the bias here can be removed from the complete time series [11]

2.3.2. Rainfall projections for 2050 and 2080

The quantile-quantile method has been used to correct biases in simulated daily rainfall. This method adjusts the quantile simulated by the regional climate models on the basis of rainfall observed during the reference period (1976-2005), thereby ensuring a better statistical match between the two series. This method is much more appropriate for correcting biases that are characterised by high spatial temporal variability. This correction is implemented at the scale of each month to respect the seasonal rainfall pattern. It is expressed by equation (Eq.1):

$$\overline{P_m^{obs}} = \overline{P_m^{Sim,ref}} \quad \text{(Eq.1)}$$

With: $P_m^{Sim,ref}$ the simulated month in question

Bias correction then consists of establishing an equality between N_m^{obs}, N_m^{sim} on the one hand and $P_{m,i}^{obs}$, $P_{,i}^{sim}$ on the other, the aim of which is to derive a correction factor for the reference period and the historical period of the regional climate models. It is expressed by the formula in equation 2:

$$N_m^{obs} = N_m^{sim} \,;\, P_{m,i}^{obs} = P_{m,i}^{sim} \quad \text{(Eq.2)}$$

With: N_m^{obs}, N_m^{sim} number of rainy days in the N years of the period, in month m of the observed and simulated data. $P_{m,i}^{obs}$, $P_{m,i}^{sim}$: rainfall of rank i in month m from observed and simulated data.

According to comparative studies, RCMs include a large number of low-intensity rainfalls and generate very high extreme rainfall. The amount of rain simulated by these RCMs is greater than the amount of rain observed [11].

For, $N_m^{sim} > N_m^{obs}$, the number of rains simulated by the RCMs is reduced by taking Nmin $= N_m^{sim} - N_m^{obs}$, and corrects the rainfall heights whose rank in the ranking is higher than Nmin (i > Nmin). Rainfall heights below Nmin are considered to be zero. Pm, min is the rainfall value corresponding to rank Nmin. Thus for the reference period (1976-2005) we have the following equations:

If $P_{m,i}^{sim} < P_{m,min}$, $P_{m,i}^{sim}$(corrected) = 0

If $P_{m,i}^{sim} > P_{m,min}$, $P_{m,i}^{sim}$(correted) $= P_{m,i}^{sim} + \Delta_m$, avec $\Delta_m = P_{m,i}^{obs} - P_{m,i}^{sim}$ (Eq.3)

For future periods, the minimum threshold is Pm, min, the previous formula is applied to all rainfall whose height is less than or equal to the height of the maximum rainfall of the RCM over the reference period ($P_{m,max}^{sim,ref}$)and is expressed by equation (Eq.4) :

For $P_{m,i}^{sim} > P_{m,max}^{sim,ref}$

$$P_{m,i}^{sim}(correted) = \frac{P_{m,i}^{sim}}{P_{m,max}^{sim,ref}} * P_{m,max}^{sim,ref}(corrected) \quad \text{(Eq.4)}$$

2.3.3. Temperature projections to 2050 and 2080

There are various scaling methods for bias correction, but the one chosen in this study is established by [11].). Its identification and performance have been demonstrated by [11]. It is expressed by equation (Eq.5):

With:

$$T_{m,i}^{cor} = T_{m,i}^{Sim} - \Delta Tm \quad \text{(Eq.5)}$$

$T_{m,i}^{Cor}$ *et* $T_{m,i}^{Sim}$: Corrected and simulated raw daily temperature values for day i month m.

ΔTm: Average monthly temperature variation rate, expressed by equation (Eq.6):

$$\Delta Tm = \overline{T_m^{Obs}} - \overline{T_m^{Sim}} \quad \text{(Éq.6)}$$

With:

$\overline{T_m^{Obs}}$ *et* $\overline{T_m^{Sim}}$: Observed and simulated monthly mean values for month m.

The parameter to be corrected is increased by the difference between the average monthly value observed and simulated by the RCMs during the reference period, month by month.

3. Results and discussion

3.1. Average monthly precipitation 2025-2054 and 2055-2084

3.1.1. 2050 horizon

In general, the regional climate models provide good seasonal simulations of short-term precipitation, compared with the 1976-2005 reference period (Figure 2). At the basin scale, the ALADIN63 model overestimates average precipitation during the short dry season of the reference period, while the CCLM4-8-17 and RACMO22E models underestimate it during the long dry and rainy seasons. Projections of monthly precipitation by all the models show deficits of 4.1% and 1.6% for RCP4.5, while RCP8.5 predicts excesses of 0.19% and 0.28% by 2050 during the two main seasons (Table 3). As for the short dry and rainy seasons, excesses of 0.90% and 2.31% will be observed under RCP4.5 and a deficit of 0.85% during the dry season as well as an excess of 0.27% under RCP8.5 compared with the reference period. This shows that climate change will have a variable impact on rainfall in the Agnéby basin, depending on the season, despite the fact that it belongs to a homogeneous climatic regime.

Table 3 Projected average monthly rainfall for 2050 in Agnéby

Seasons	**Reference period (1976 -2005)**	**MCRs package (2025-2054)**	
		RCP4.5 (Δ***P***%)	RCP8.5 (Δ***P***%)
Long dry season	48.24	-4.1	0.19
Great rainy season	154.69	-1.6	0.28
Short dry season	69.8	0.9	-0.85
Short rainy season	130	2.31	0.27

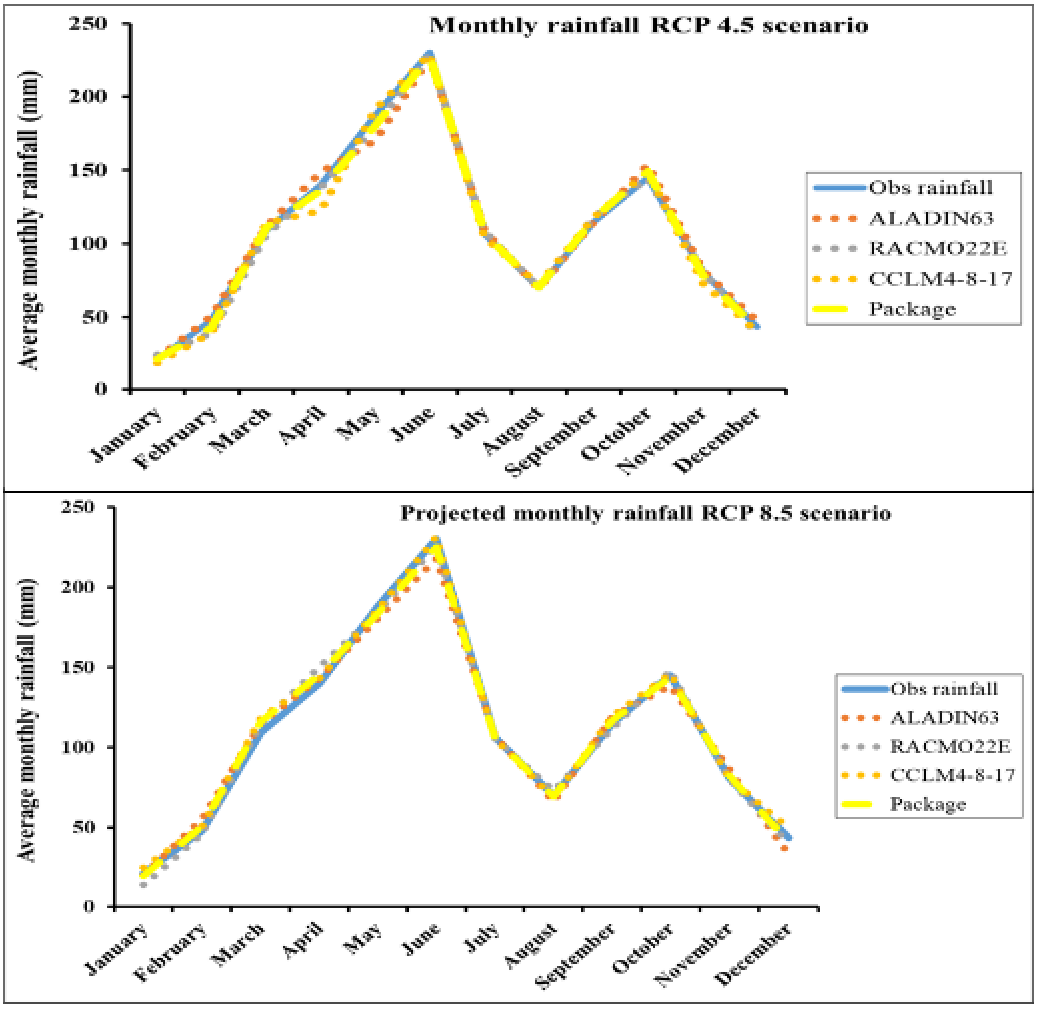


Figure 2 Projected average monthly rainfall in 2050 for the Agnéby catchment

3.1.2. 2080 horizon

The analysis in Figure 3 shows the ability of the ensemble of climate models to better represent monthly precipitation by 2080. The individual regional climate models simulate precipitation better under the RCP4.5 scenario and show both decreases and increases under RCP8.5. The seasonal trends compared with the reference periods predict decreases of 1.28 %, 0.46 %, 2.1 % and an excess of 1.28 % under the RCP4.5 scenario. For the RCP8.5 scenario, the precipitation excesses will be 5.39 %, 1.48 %, 0.05 % and a deficit of 3.17 % (Table 4). It also emerges that the impacts of change will be perceptible in the long term in the Agnéby catchment.

Table 4 Projected average monthly rainfall for 2080 in the Agnéby catchment area

Seasons	Reference period (1976 -2005) Mm	MCRs package (2055-2084)	
		RCP4.5 (ΔP%)	RCP8.5 (ΔP%)
Long dry season	48.24	-1.28	5.39
Great rainy season	154.69	-0.46	1.48
Short dry season	69.8	-2.1	-3.17
Short rainy season	130	1.28	0.05

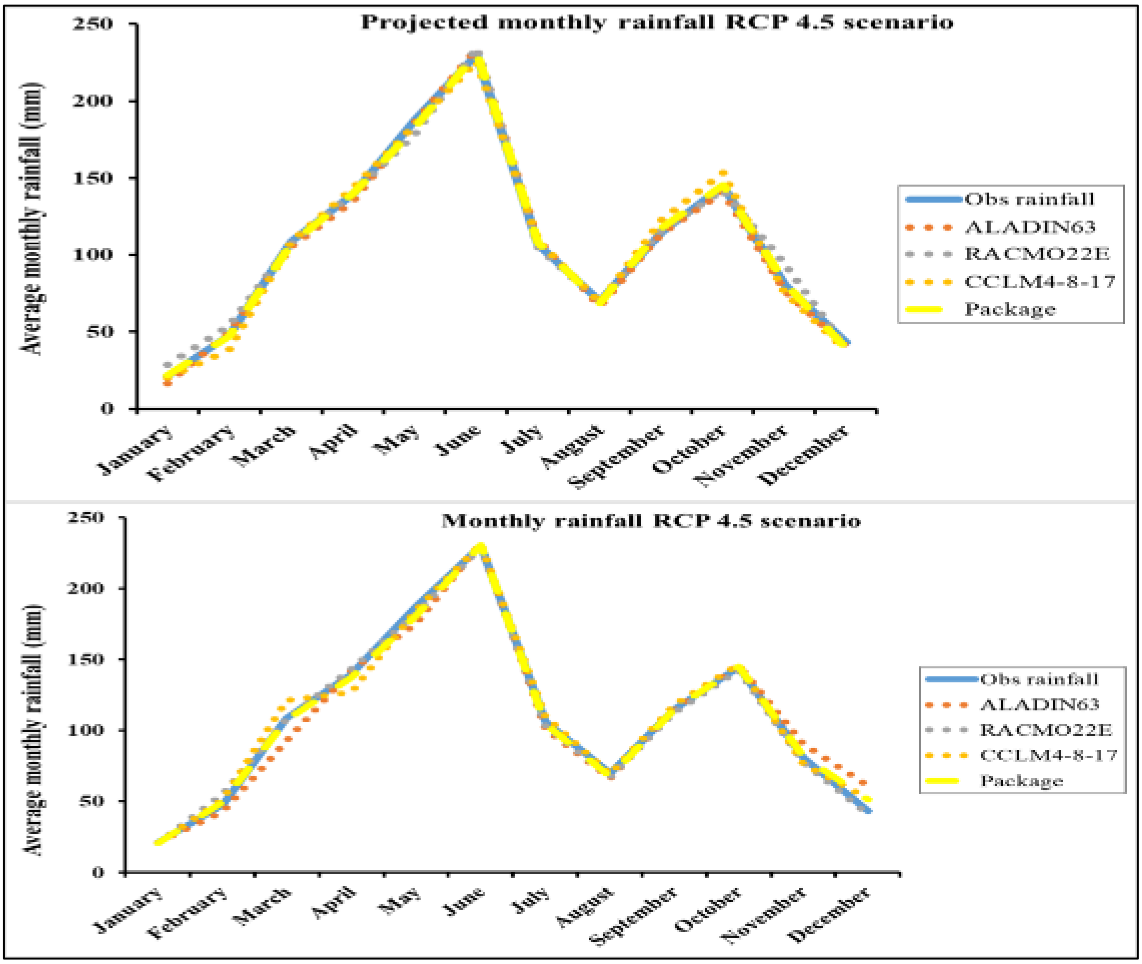


Figure 3 Projected average monthly rainfall in 2080 for the Agnéby catchment

3.1.3. Projected average annual precipitation at catchment scale

Figure 4 shows the changes in mean annual rainfall projected for the basin at 2050 and 2080 for the two scenarios. The analysis shows that all the regional climate models reproduce the simulated rainfall better. The variation in rainfall by 2050 compared with the reference period predicts a deficit of 0.27 % under RCP4.5. For the decadal periods, the 2030 decade forecasts an excess of 7.45 %, while the 2040 and 2050 decades forecast deficits of 5.29 % and 3 % respectively. The year 2050 will record average annual rainfall of 104.48 mm with a deficit of 3.27 %. (Table 5).

Under the RCP8.5 scenario, all the RCMs show a good representation of projected precipitation compared with that of the reference period. By 2050 Precipitation forecasts predict an excess rainfall of 0.2 %. The 2030 and 2050 decades will see respective excesses of 12.19 % and 0.13 %, while the 2040 decade will see a deficit of 11.71 %. The year 2050 will see an excess of 4.9 %.

By 2080, all the regional climate models (RCMs) show an increase in precipitation during the 2055-2059 sub-period, while the 2060-2064 sub-period shows decreases, with alternating periods of greater deficit over the rest of the period according to the RCP4.5 scenario. Annual variations compared with the reference period will show basin-wide deficits of 0.72 % and 0.24 %. The 2070 and 2080 decades will have deficits of 7.3 % and 6.55 %, while the 2060 decade will have an excess of 11.6 % under the RCP4.5 scenario. For the RCP8.5 scenario, only the 2070s will have a surplus of 5.9 %, to the detriment of the 2060s and 2080s, which will have deficits of 0.3 % and 6.31 % respectively. We can therefore deduce that climate change will affect average annual rainfall in the short and long term in the Agnéby catchment.

Table 5 Projected annual variations in precipitation under the two scenarios

<table>
<tr><td colspan="7">Horizon 2025 - 2054 (ΔP %)</td></tr>
<tr><td rowspan="2">Agnéby catchment</td><td colspan="3">RCP4.5</td><td colspan="3">RCP8.5</td></tr>
<tr><td colspan="3">-0.27</td><td colspan="3">0.2</td></tr>
<tr><td colspan="7">Decadal variations in rainfall compared with the reference period</td></tr>
<tr><td>Reference period</td><td colspan="3">RCP4.5 (ΔP %)</td><td colspan="3">RCP8.5 (ΔP %)</td></tr>
<tr><td rowspan="2">108.02 (mm)</td><td>2030</td><td>2040</td><td>2050</td><td>2030</td><td>2040</td><td>2050</td></tr>
<tr><td>7.45</td><td>-5.29</td><td>-3</td><td>12.19</td><td>-11.1</td><td>0.13</td></tr>
<tr><td colspan="7">Horizon 2055 -2084 (ΔP %)</td></tr>
<tr><td rowspan="2">Agnéby catchment</td><td colspan="3">RCP4.5</td><td colspan="3">RCP8.5</td></tr>
<tr><td colspan="3">-0.72</td><td colspan="3">-0.24</td></tr>
<tr><td>Reference period</td><td colspan="3">RCP4.5</td><td colspan="3">RCP8.5</td></tr>
<tr><td rowspan="2">108.02 (mm)</td><td>2060</td><td>2070</td><td>2080</td><td>2060</td><td>2070</td><td>2080</td></tr>
<tr><td>11.6</td><td>-7.3</td><td>-6.55</td><td>-0.3</td><td>5.9</td><td>-6.31</td></tr>
</table>

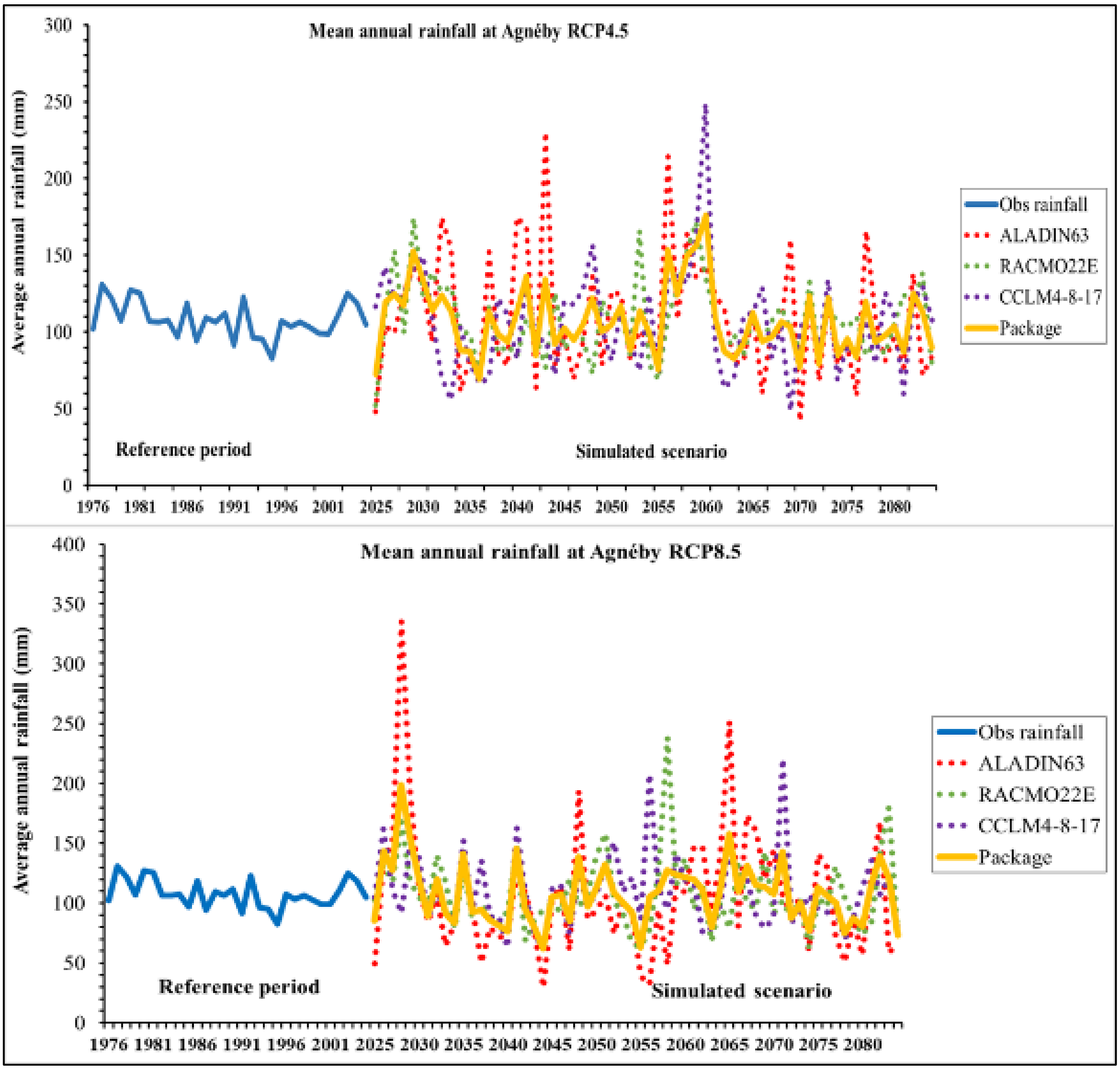
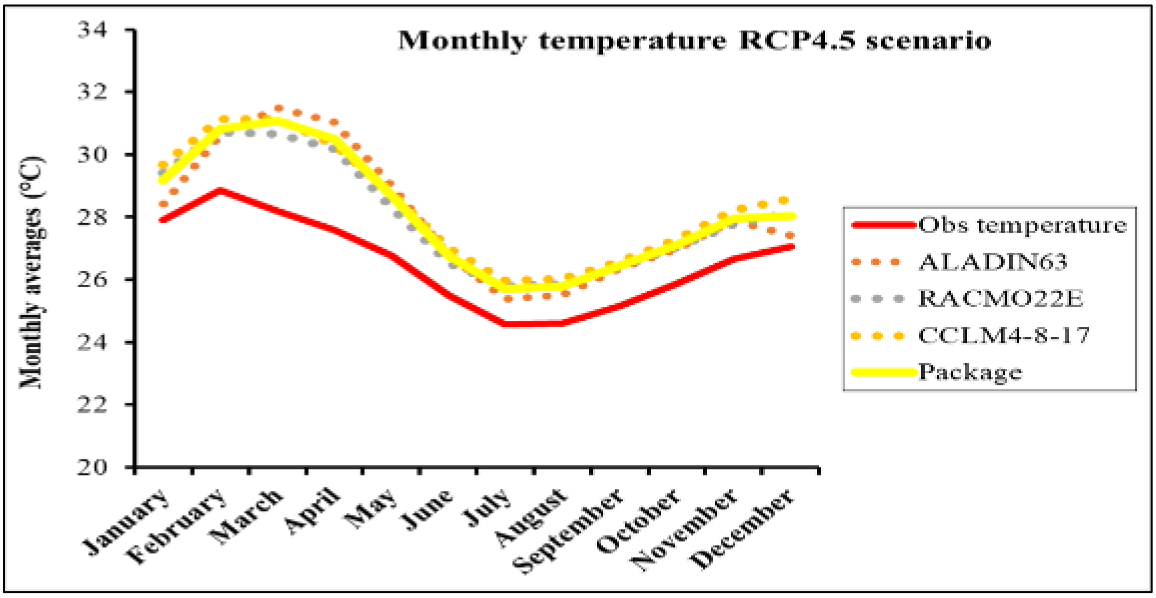


Figure 4 Projected mean annual precipitation at the Agnéby scale

3.2. Temperature projections for the Agnéby for 2050 and 2080

3.2.1. Average monthly temperatures 2025- 20254

Analysis of Figure 5 by the MCRS ensemble predicts seasonal increases of +1.68°C, 1.82°C, 1.2°C and 1.26°C for the RCP4.5 scenario and +2.27°C, +2.42°C, +1.68°C and +1.81°C for RCP8.5 respectively during the long dry season, the long rainy season, and the short dry season and short rainy season by 2050. The temperature increases for the 2050 horizon for the two scenarios predict temperature increases during the rainy seasons rather than the dry seasons.



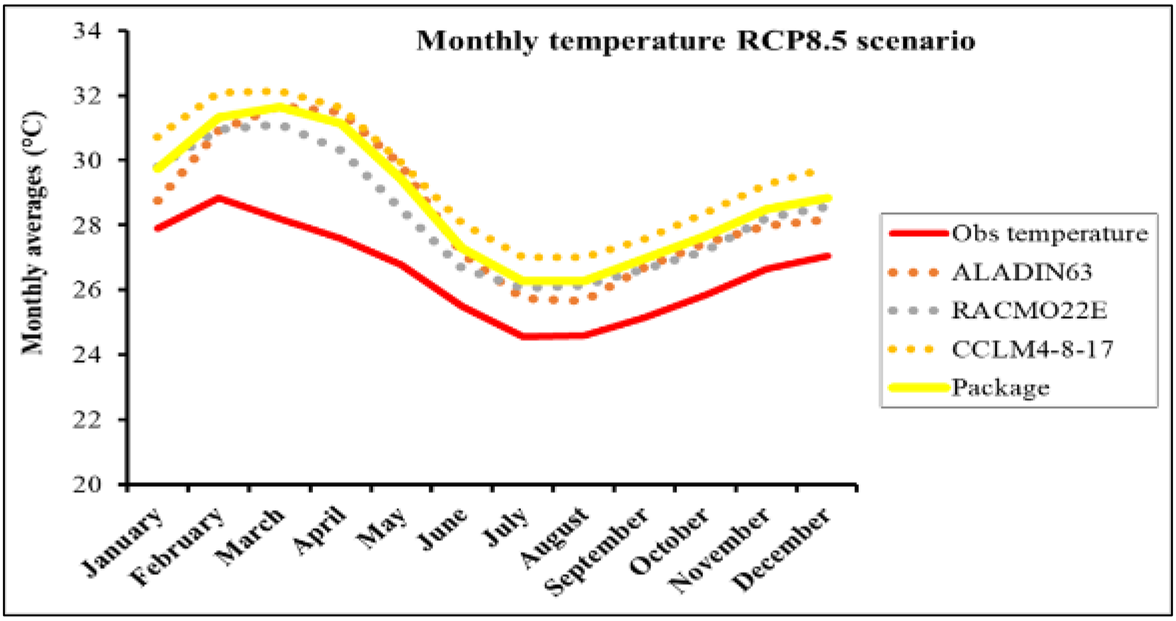


Figure 5 Projected average monthly temperatures on the Agnéby in 2025-20254

3.2.2. Average monthly temperatures 2055-2084

Projections of temperatures over a long time horizon show that all the climate models are predicting increases, irrespective of the scenario (Figure 6). The individual models ALADIN63 and CCLM4-8-17 further overestimate monthly temperatures during the long dry season. The seasonal trends show increases of +2.17°C, +2.28°C, +1.57°C and +1.63°C for the RCP4.5 scenario and +3.26°C, +3.33°C, +2.40°C and +2.57°C under the RCP8.5 scenario compared with temperatures in the reference periods. A fundamental observation is that temperatures during the rainy seasons show greater increases than those during the dry seasons, which could cause a shift in the rainy months in the zone.

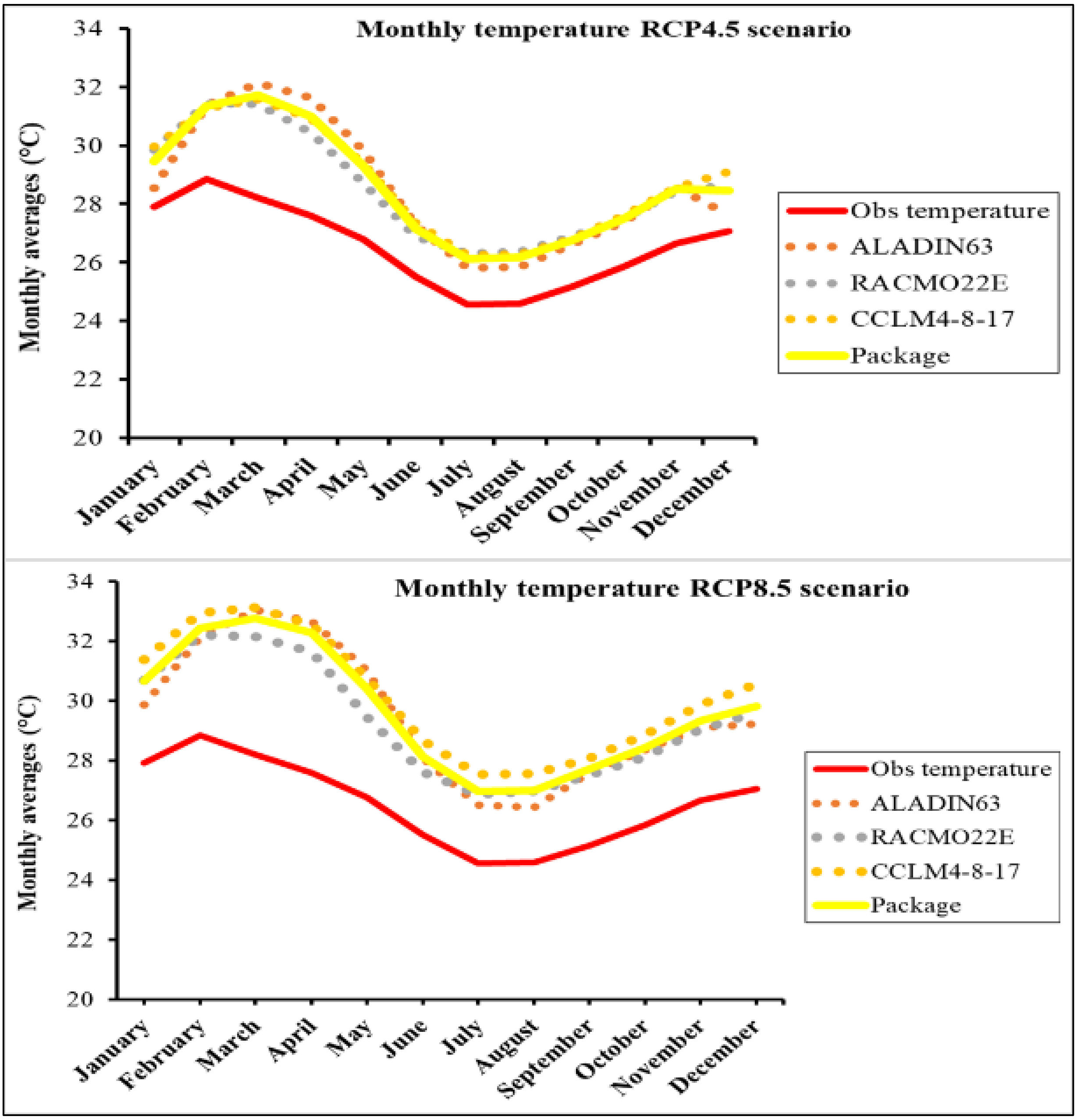


Figure 6 Projected average monthly temperatures on the Agnéby in 2080

3.2.3. Projected mean annual temperatures in the Agnéby catchment area

Projections of mean annual temperatures on the Agnéby by all the regional climate models (RCMs) show increases over the two simulated scenarios (Figure 7). The annual temperatures projected to 2050 and 2080 indicate the following conclusions:

-For the RCP4.5 scenario, temperatures will rise by +1.18°C and 2.06°C respectively by 2050 and 2080 compared with the reference period (Table 2). The 2030s, 2040s and 2050s will record increases of +1.42°C, +1.67°C and +1.77°C, while the 2060s, 2070s and 2080s will record increases of +1.92°C, +2°C and +2.28°C respectively. The 2050s and 2080s will see respective increases of +1.74°C and +2.47°C compared with the reference period.

For the RCP8.5 scenario, average temperatures will rise by +2.2°C and 3.1°C respectively by 2050 and 2080. The 2030s, 2040s and 2080s will see increases of +1.83°C, +2.31°C and +2.43°C, while the 2060s, 2070s and 2080s will see increases of +2.71°C, +3.06°C and +3.5°C respectively. In 2050 and 2080, annual temperatures will reach 28.9°C and 30.33°C respectively, with increases of +2.35°C and +3.78°C compared with the reference period.

Table 6 Average annual temperatures in the Agnéby catchment area.

Average annual temperatures in the Agnéby catchment area				
Reference period	Package MCRs			
	RCP4.5		RCP8.5	
26.55	2050 ($\Delta t°C$)	2080 ($\Delta t°C$)	2050 ($\Delta t°C$)	2080 ($\Delta t°C$)
	+1.18	+2.06	+2.2	+3.1

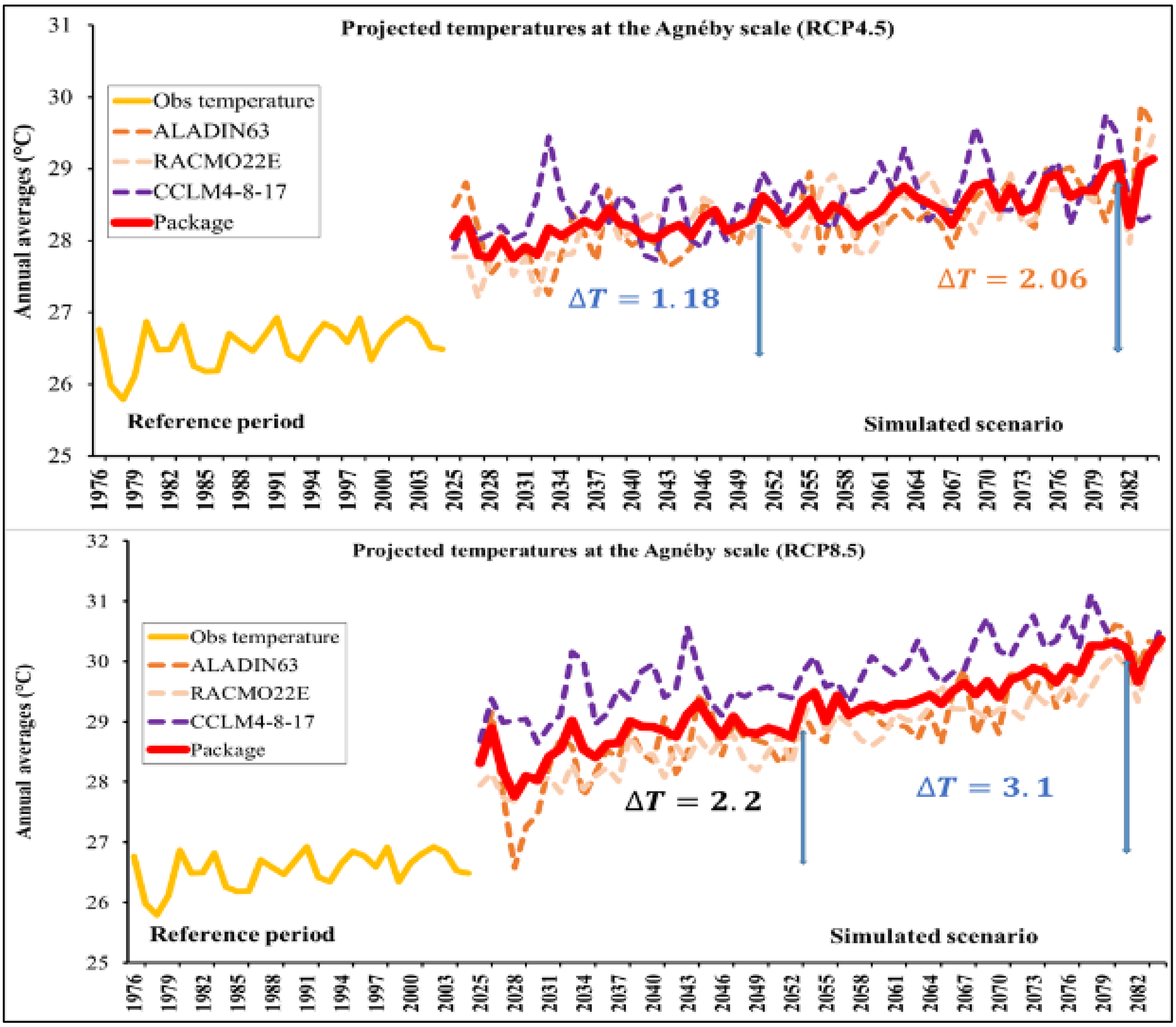


Figure 7 Projected mean annual temperatures at the Agnéby scale in 2080

4. Discussion

4.1. Precipitation projections for 2050 and 2080

The projections of climatic variables carried out in the context of this study concern average monthly, seasonal and annual trends, with a reference period of 1976-2005 and simulations for the 2050 and 2080 horizons. Analysis of the results for all three regional climate models reveals that seasonal rainfall variations will record deficits of between 4.1 % and 1.6 % for RCP4.5, while RCP8.5 predicts excesses of 0.19 % and 0.28 % by 2050 during the two main seasons. As for the short dry and rainy seasons, excesses of 0.9 % and 2.31 % will be observed under RCP4.5 and a deficit of 0.85 %

during the dry season, as well as an excess of 0.27 % under the RCP8.5 scenario in the rainy season compared with the reference period. For the 2080 horizon, seasonal trends compared with the reference periods predict decreases of 1.28 %, 0.46 %, 2.1 % and an excess of 1.28 % in the RCP4.5 scenario. In the RCP8.5 scenario, the excess precipitation will be 5.39 %, 1.48 %, 0.05 % and a deficit of 3.17 %. The change in mean annual precipitation by 2050 compared with the baseline period predicts a deficit of 0.27 % in the RCP4.5 scenario. The year 2050 will record a deficit of 3.27 %. In the RCP8.5 scenario, rainfall is forecast to be 0.2 % higher. In 2050, there will be an excess of 4.9 % across the catchment area. By 2080, according to the RCP4.5 scenario. The average annual variations will be 0.72 % lower in the RCP4.5 scenario and 0.24 % lower in the RCP8.5 scenario. The year 2080 will record deficits of 0.04 % and 0.25 % respectively for the two scenarios RCP4.5 and RCP8.5. From this we can deduce that climate change will affect the short- and long-term mean annual rainfall in the Agnéby catchment compared with the reference period. . Our results are superior to those of [16], who predict a 19.2 % decrease in rainfall in western Côte d'Ivoire over the N'zo Sassandra by 2071-2100. Our analyses show and confirm the impact of climate change on the Agnéby area through decreases and increases according to all the models. Our results corroborate those of [8] who shows in his work that hydrological responses will be deficient by 36.62 % and 20.42 % respectively over the 2050 and 2080 horizons. Our results corroborate those of [6], who predicts increases in spring rainfall of 5 % to 20 % and 5 % to 30 % in Morocco by 2050. Our results are of the same order as those of [21], who reached the same conclusion, showing a drop in rainfall (-10.8 %) in the Lobo catchment by 2085-2100. These results are also consistent with those of [20], which predicts that rainwater availability could fall by 20 % in parts of southern Ivory Coast by 2080. The deficits observed in this work are lower than those observed by [14], who estimated the decrease in rainfall in the west Sahel at around 12.60 % by 2091-2010. In the Ivorian context, [15] highlighted a drop in rainfall (-9.12 %) in the Gulf of Guinea by 2091-2100. The situation of decreasing monthly rainfall in the south-east of Ivory Coast, and particularly in the Agnéby area, can be explained by excessive desertification of the vegetation cover and could have harmful consequences for certain human activities that depend heavily on summer rainfall, such as rain-fed agriculture. To our knowledge, no study of future projections for Ivory Coast has previously targeted seasonal trends in change, which makes it difficult to compare our work with others and may call into question its robustness, given the interannual variability.

4.2. Temperature projections for 2050 and 2080

Furthermore, temperature projections for the basin as a whole will increase by +1.18°C and +2.2°C respectively in the RCP4.5 and RCP8.5 scenarios. By 2050, temperatures will have risen by +1.74°C and +2.35°C compared with the reference period. These results confirm that the Agnéby area will experience the effects of climate change with different temperature increases by 2050. Our results are in line with the results of the sixth report of the Intergovernmental Panel on Climate Change [8], which predicts a temperature rise of 1.3°C to 1.9°C over the period 2021-2040 and 1.9°C to 3°C over the period 2041-2060. By 2080, temperatures will have risen by +2.2°C in the RCP4.5 scenario and +3.1°C in the RCP 8.5 scenario. The year 2080 will record increases of +2.47°C and +3.78°C respectively for the two RCP4.5 and 8.5 scenarios. The results of this work confirm that the Agnéby area will experience the impact of climate change in terms of temperature increases, whatever the scenario for the 2050 and 2080 horizons. Our results are in line with the work carried out by [14], which predicts a temperature increase (+3.9°C) in the N'zo-Sassandra watershed in Côte d'Ivoire, as well as with that of [9; 20], which notes that the projections will be more alarming by 2100, with an expected increase in average temperatures of +2 to +4.5°C and an increase of +3.1°C in 2080 in Ivory Coast. It is therefore important to establish crops adapted to an alarming rise in temperature to avoid famine in the distant future in this region sustained by agriculture. As far as temperature is concerned, the results of past studies concur on the rise in temperature (3-4.5°C) in the Gulf of Guinea by 2091-2100 [11] and an increase in this parameter (2.28-4.1°C) in the Bandama watershed by 2075 according to [5]. The results of the work of the [10] are the benchmark in the international context, i.e. a temperature rise of around 4°C by 2100.

5. Conclusion

At the end of this work, the precipitation and temperature forecasts (2050 and 2080 horizons) carried out in this study are based on two different scenarios RCPs (Represntative Concentration Pathways) 4.5 and 8.5. The 1976-2005 period is the reference period and the 2025 to 2054 and 2055 to 2084 periods are the projected scenarios. On the scale of the basin, average rainfall will record a deficit of 0.27 % for the RCP4.5 scenario and an excess of 0.2 % for the RCP8.5 scenario by 2050. The year 2050 will record a deficit of 0.17 % for the RCP4.5 scenario and an excess of 0.05 % for the RCP8.5 scenario compared with the reference year. By 2080, precipitation will be 0.72 % and 0.24 % lower in the two scenarios. The year 2080 will see decreases of around 0.04% and 0.25% respectively in the RCP4.5 and RCP8.5 scenarios. Average temperatures will then rise by +1.18°C and +2.2°C respectively in the RCP4.5 and 8.5 scenarios by 2050. The 2030s, 2040s and 2050s will see increases of +1.42°C, +1.67°C and +1.77°C under the RCP4.5 scenario, while under RCP8.5 they are expected to rise by +1.83°C, +2.31°C and +2.43°C. For the year 2050, temperatures will rise by +1.74°C and +2.35°C respectively under the RCP4.5 and RCP8.5 scenarios, compared with the reference period. . By

2080, temperatures will have risen by around +2.06°C and 3.1°C in the RCP4.5 and RCP8.5 scenarios across the basin. The decadal periods 2060, 2070 and 2080 will increase by +1.92°C, +2°C, +2.28°C and +2.71°C, +3.06°C and +3.5°C respectively. The year 2080 will record increases of +2.47°C and 3.78°C compared with the reference period. We can therefore deduce that the Agnéby catchment will experience the impacts of climate change, which could have more severe consequences for the agricultural sector and livelihoods. Furthermore, future climatic conditions may no longer represent optimal growing conditions for current crops. Farming practices and crop types will therefore have to be adapted to higher temperature. To address these adverse effects of climate change on future trends, these findings need to be considered in adaptation strategies and development plans for the relevant vulnerable sectors, as well as in land-use planning for climate change in the forested south-east of the country.

Compliance with ethical standards

Acknowledgements

We would like to extend our sincere thanks to the Société d'Exploitation et de Développement Aéroportuaire, Aéronautique et Météorologique (AAMODC), as well as the CORDEX-Africa project (http://www.cordex.org/), for providing the data essential to the completion of this study. Our thanks also go to the trainers whose contributions have enriched this article on climate change trends.

Disclosure of Conflict of interest

No conflict of interest to be disclosed.

References

[1] Akissi B. P. K., Attoungbré J-P., Zomi C. L., Agnidé E. L., Bamory K., and Boko A., (2022). Spatialization of rainfall in the Agneby catchment in Agboville, Ivory Coast. Rev. Ivoir. Sci. Technol., 39 (2022) 34 - 54 34.ISSN 1813-3290, http://www.revist.ci

[2] Boyd E., Corbera E., Estrada M. (2008). UNFCCC negotiations (pre-Kyoto to COP-9): what the process says about the politics of CDM-sinks. International environmental agreements politics. Law and Economics, 8(2): 1–18.

[3] Brahima K., Amidou D., Vamoryba F., Dabissi N., Bamory K., (2019). Effect of Rainfall Variability the Runoff in the Agnéby Watershed in South-East Ivory Coast. European Scientific Journal September 2019 edition Vol.15, No.27 ISSN: 1857 – 7881 (Print) e - ISSN 18577431.Doi:10.19044/esj.2019.v15n27p383URL:http://dx.doi.org/10.19044/esj.2019.v15n27p383.

[4] Cornelissen T., Diekkrüge B., Giertz S. (2013). A comparison of hydrological models for assessing the impact of land use and climate change on discharge in a tropical catchment. Journal of Hydrology, 498: 221–236.Congalton, R. G. (1991). A revieuw of assessing the accuracy of classifications of remotely sensed data', Remote Sensing of Environment, 37(1), pp. 34–46.

[5] Goula B. T. A., Kouassi V. J., Savané I. (2006). Impacts du changement climatique sur les ressources en eau en zone tropical humide : Cas du bassin versant du Bandama en Côte d'Ivoire. Agronomie Africaine 18 (1): 1 - 11 (2006).

[6] Fatima D. (2010). Distribution des précipitations hivernales sur le Maroc dans le cadre d'un changement climatique : descente d'échelle et incertitudes. THÈSE DOCTORAT DE L'UNIVERSITÉ DE TOULOUSE. Institut National Polytechnique de Toulouse (INP Toulouse). mercredi 6 octobre 2010. Pp 163.

[7] Girard, G. (1963). Study of the catchment area of the river Agneby.

[8] IPCC, (2022). IPCC Sixth Assessment Report (AR6), 2021-22. Impacts, adaptation options and investment areas for a West Africa resilient to climate change.

[9] IPCC (2013) CHANGE CLIMATE. (2013). Edited by Thomas F. Stocker Dahe Qin, Gian-Kasper Plattner Melinda M.B. Tignor Simon K. Allen Judith Boschung, Alexander Nauels Yu Xia Vincent Bex Pauline M. Midgley and Working Group I Technical Support Unit, Working Group I Contribution to the Fifth Assessment Report of the IPCC, Summary for Policymakers. Kendall MG (1975) Rank Correlation Methods, Oxford Univ. Press, New York.

[10] IPCC, (2007) CHANGE CLIMATE. (2007). The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Cambridge University Press, 2007.

[11] Kone B., (2024). Impacts of climate change and agricultural intensification on the sustainability of surface waters: the case of the Agnéby catchment in south-eastern Ivory Coast. DOCTORATE THESIS NANGUI ABROGOUA University in Environmental Sciences and Management 15 April 2024, pp 352.

[12] Koné, B. Ouattara, I., Coulibaly L., DAO, A., Fadika, V., Noufe, D. D., Kamagaté, B., (2022). Impact of Land use Dynamics on Runoff in the Agnéby Watershed, South-Eastern Ivory Coast. Volume 7, Issue 6, June – 2022. International Journal of Innovative Science and Research Technology. ISSN No: -2456-2165.

[13] Koné B., Ismaila O., Dao A., and Kamagaté B., (2024). Climate change and water resources: application of the swat model to the south-east Agnéby watershed of Ivory Coast. International Journal of Innovation and Applied Studies ISSN 2028-9324 Vol. 41 No. 4 Feb. 2024, pp. 1257-1272 © 2024 Innovative Space of Scientific Research Journals http://www.ijias.issr-journals.org/.

[14] Kouakou K.E., Kouassi A.M., Kouadio Z.A., Goula-Bi T.A., Savané I. (2016). Hydrological modification of the Comoé watershed in a context of climate change. International Journal of Innovation and Applied Studies, vol.15, n°4, 799–811.

[15] Kouakou K. E., Kouadio Z. A., Kouassi F.W., Goula B T.A., and SAVANE I (2014): Temperature and rainfall modelling in a context of climate change: the case of West Africa. Africa Sciences. 10(1) (2014) 145 – 160.

[16] Kouassi A. M., Gnangouin A. Y. J., Kouame K. A., Yao C. A., N'guessan N'Guessan E. (2023). Prospective analysis of low flow rates in a context of climate change in West Africa: case of the N'zo-Sassandra catchment, (Western Ivory Coast).

[17] Morton (2017). Impacts of climate change and land use on surface waters in the Davo catchment

[18] Praskievicz S, Chang H. (2011). Impacts of climate change and urban development on water resources in the Tualatin River Basin, Oregon. Annals of the association of American geographers; 101:249–71.

[19] USAID, M.A. (2014). Mapping the Exposure of Socioeconomic and Natural Systems of West Africa to Coastal Climate.

[20] World Food Programme, (2019). WFP Ivory Coast Country Brief August 2019, Rome, Italy.

[21] Yao A.B., Kouassi K.L., Kouakou K.E., Goula B.T.A., Gayé A.T. (2019). Assessment of the potential impacts of climate change on the flows of the Lobo River, Central-West of Côte d'Ivoire. Africa Science, vol. 15, no. 4, 330–342