Climatological analysis of temperature and pluviometry in Guinea 1960-2016

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Abstract

The purpose of this study is to improve the understandings on climate variability in Guinea. The methodology used is based on climatological analysis. The pluviometry and temperature data recorded at 12 meteorological stations were used. The annual variability of temperature shows the semi-annual cycle, and the interannual evolution of monthly mean temperature is characterized by an increasing trend over the years. The pluviometry values seems to indicate a decrease since 1960s, and is characterized by an annual cycle. The northward distributions of the temperature and rainfall show an increase and decrease respectively for the country.

Keywords***:*** Temperature, Pluviometry, Climate variability in Guinea; Climate normal; Semi-annual cycle and annual cycle.

Introduction

Long-term climate variability can help for estimating its impact on human activities. Climate change can cause prolonged risks leaving people threatened by food shortages and diseases. During the last decade, and particularly since the mid-2000s, the development community has begun to engage seriously with the issue of climate change and its implications for the world's poor, this has led to a growing interaction with the climate research community (Conway, 2011).

Precipitation is a key variable in West Africa in general and more specifically over the Sahel (eco-climatic and biogeographic zone of transition in Africa between the Sahara to the north and the Sudanian Savanna to the south) region where economies, livelihoods and food security are highly dependent on rainfed agriculture Gbobaniyi et al., (2014).

Scientific understanding of the African climate system as a whole is low. For certain regions in Africa, the level of understanding is reasonable, for other parts, such as the Guinea region, very little is known. That's why, in a context of climate change, it is essential to identify the areas or periods which bear the brunt of change and, to analyse the possible variabilities of the climatic parameter such as the temperature.

The specific objective of this study is to provide a climatological analysis of the variability of the temperature as well as the pluviometry in Guinea during 57 years (1960-2016).

Then, after the explanation of methods and instrumentation used, the results are presented and discussed in 4 sections before concluding.

Data and method of analysis

We first analyzed our data set through statistical approaches. The daily temperature (maximum and minimum) and daily rainfall recorded from 12 stations covering Guinea (Fig. 1) during 57 years (1960-2016) were used. The monthly mean temperatures used in this study were calculated from the daily minimums and maximums measured at these stations.

The monthly rainfall values were obtained by using the sum of daily rainfall for each month. And the annual mean pluviometry were calculated by averaging the monthly rainfalls for each year. Precipitation and temperature

climatologies, and their interannual variability, were calculated for each station. These climatological means were calculated according to the World Meteorological Organization (WMO) Guidelines on the Calculation of Climate Normals, WMO (2017) by using the reporting period that's from 01 January 1961 to 31 December 1990.

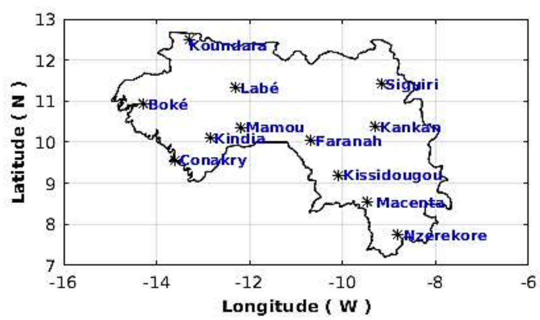

Figure 1: Geo-location of meteorological stations in Guinea.

Results and discussions

Inter annual climatology of temperature and rainfall

Figure 2(a) shows the interannual evolution of monthly mean temperatures measured for the period from 1960 to 2016 for each meteorological stations. A significant observation is that temperatures seems to be higher during March and November. In general, the interannual evolution seems to indicate an increasing temperature trend over the study period. One more thing to point out is the sharp increase of temperatures during 2008 which in consistent with a study by Wang and Wong (2000). In their study, Wang and Wong (2000) reported that the year 1998 temperature averaged for the globe was the highest on record at that time, and the annual mean temperature of China in 1998 was +1.38°C above the normal average.

An exceptional increase in temperature in 1998 is observed in Guinea. This exceptional increase temperatures could be associated to the global warming. Simmons et al., (2008) highlighted in their global temperature analysis that it was probably only in 1998 that the 1°C above the pre-industrial level was first reached, and this was in the latter stages of a somewhat strong El Niño event. A study by Cleave et al., (2017) confirmed that the 1998 step change was associated with a decrease in winter ice duration of 39 days (a 34% decline), an increase of ∼2–3°C in mean surface water temperature (July–September averages), and a 91% increase in July–August evaporation rates, reflecting an earlier start to the summer evaporation season in the Lake Superior.

The figure 2(b) shows the interannual evolution of monthly rainfall from 1960 to 2016 for each station. The annual maximum of the pluviometry is observed in July-August-September. The interannual evolution of the pluviometry shows the inter-seasonality which distinguish between wet years and dry years, and depicts different structure for different station. This variability was also reported by other studies such asHope et al., (2010) who explained the alternation between dry and wet years in the southwest and southeast of Australia.

In general, the rainfall shows a decreasing trend since 1960's over Guinea. The results reported in this study are consistent with results reported by Villar et al., (2009), where they highlighted that the mean rainfall in the Amazon basin decreases during the 1975–2003 period. Contrary to our result, Descroix et al., (2015) underlined that the pluviometry began to increase in the middle or at the end of decade 1991-2000 for two West-African sub-spaces.

The southern part of Guinea has longest length (8-9 month) of wet season. This observation was also reported in a study by Loua et al., (2017) where they used data from the southern Guinea meteorological station at N'zerekore site.

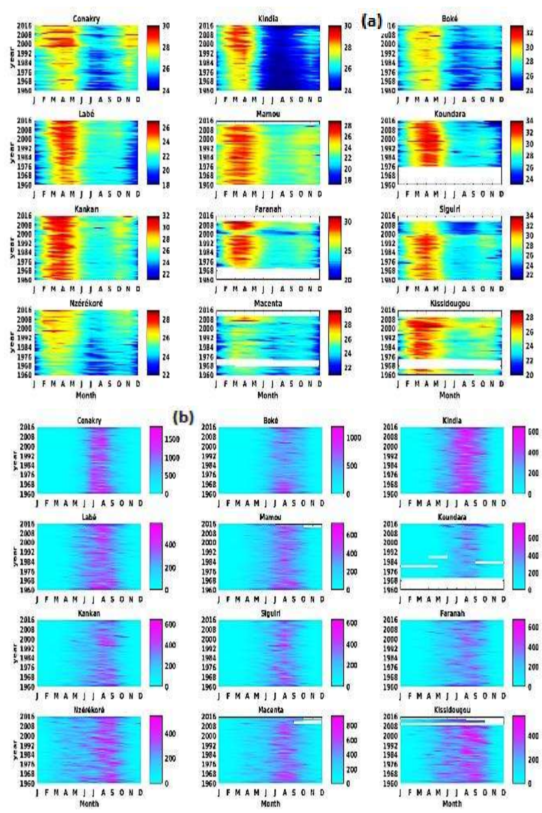

Figure 2: Interannual evolution of temperature (a) and rainfall (b) at 12 stations from 1960 to 2016.

Annual climatology of temperature and rainfall

The yearly variation of the temperature shows an almost identical variability for all the stations, with a bimodal curves (Fig. 3(a)) which correspond to a semi-annual cycle.

It is noteworthy that the temperature is found to be very high in northern part and lowest in the southern and coastal part of the country. Koundara is the hottest region where monthly mean of approximately 32°C is recorded in April. Labe is the coldest region with a yearly mean of approximately 22°C and the minimum value of about 15°C where recorded.

Compared to temperature, pluviometry distribution seem to be opposite, with the coastal and southern regions having high pluviometry relatively compared to the middle and northern parts (Fig. 3(b)). Conakry site seems to be an area most abundantly rainfall with a yearly average of 3753 mm, followed by Macenta with an annual rainfall averaged of 2559 mm. On the other hand, Koundara is observed to be the driest regions with yearly rainfall averaged of 943.4 mm.

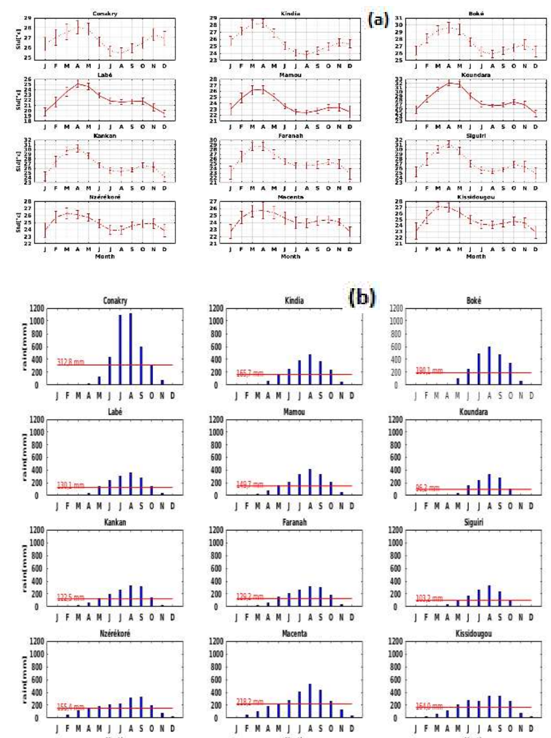

Figure 3: Annual climatology of temperature (a) and rainfall (b) of 12 stations in Guinea.

Global variability of temperature and rainfall

On a national scale, the variability of the temperature and the rainfall is marked by a semi-annual cycle and an annual cycle, respectively. During the year, the minimum temperature may reach 21.6 °C in April and 20.2°C in September, the lowest values are observed in January (15.7°C) and August (20.4°C) (Fig. 4(a)). The maximum temperature rises until about 35.1°C in March and 31.6°C in December and may decrease at the lowest values of 28.3°C in August and 30.6 °C in December. When considering climatological averages, the monthly mean temperature may reach the maximum values of 28.3°C (±2.2) in April and 25.2°C (±1.6) in October with minimum values of 24.0°C (±1.4) in August and 23.8°C (±1.9) in December.

Figure. 4(b) shows the monthly climatology of rainfall during the 57 years. In our results, it is observed that in Guinea the rainfall depth can reach 450 mm on average in August and the lowest rainfall quantity in January.

Indeed, this variation is in relationship with the seasonal oscillation of the Inter-Tropical Convergence Zone (ITCZ). A study by Nicholson (1981) reported that the northward displacement of ITCZ may be the first factor responsible for abnormally wet years for the sub-Saharan region. Thus, the rainy season in Guinea as in West Africa is modulated by the West African Monsoon (WAM). Monsoon rainfall over West Africa occurs during the June through September period CLIVR (2017). A study by Cook (2015) also reported that rainfall in the vicinity of the Guinean coast lingers through May and June, while the marine Atlantic ITCZ moves to the north.

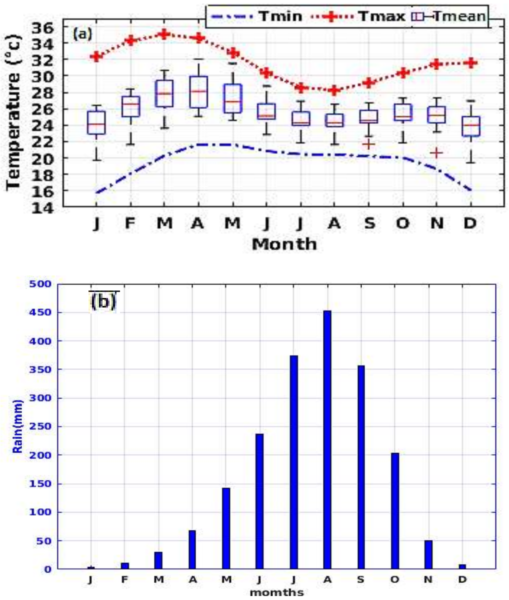

Figure 4: Overall distribution of temperature (a) and rainfall (b).

Latitudinal variation of temperature and rainfall

Figures 5(a) and 5(b) show the temperature and rainfall variation according to the increasing latitudinal positions of each station. It is evident that an increase in temperature with latitude is significant except for the Labe site and Macenta site. It is also notice that there is a significant decrease in temperature for the station of Labe in spite of its position which is further north compared to Boke site. We also noticed such decrease in temperature at the station of Macenta which is further north compared with that of N'zerekore. The observed decrease in temperature at both stations Labe (the highest meteorological station above the sea level in Guinea) and Macenta (a very rainy and great forest area in Guinea), may result from the influence of the massif of Fouta Djallon (which arises up to 1025 m above the sea level) for Labe site and the forest of Ziama (112.300 hectares of woodland) for Macenta site.

The variation of the pluviometry is characterized by a northward decreasing. It is also observed that there is an exception at the station of Conakry and Macenta. The rise of the pluviometry at Conakry is understandable by the coastal effect. The presence of the forest of Ziama explains the rise of the pluviometry compared to the neighbouring stations.

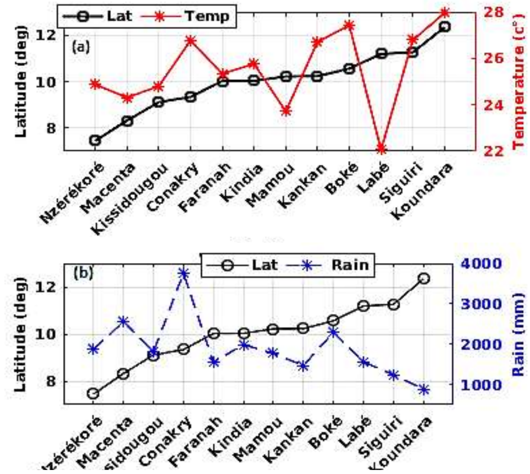

Figure 5: Latitudinal variation of temperature (a) and rainfall (b).

Summary

This climatological analysis allowed us to improve our understanding of the variability of temperature and pluviometry during 57 year in Guinea. An upward trend of the temperature is observed in all Guinea meteorological sites used in this study. A decrease in pluviometry since the end of 1960s characterized by a disturbance in rainfall patterns modifies gradually the climate.

The extension of this analysis over the whole western Africa by using Era-Interim data coupled with satellite data would allow to describe more on the climate variability and to improve the knowledge in this zone which is besides the political conflicts, the victim of the consequences of climate risks.

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References

Cleave, K.V., Lenters, J.D., Wang, J., Verhamme, E.M., 2017. A regime shift in Lake Superior ice cover, evaporation, and water temperature following the warm El Niñ winter of 1997–1998. Limnology and Oceanography 59, 1889–1898. https://doi.org/10.4319/lo.2014.59.6.1889

CLIVAR, 2017. African Monsoon | www.clivar.org [WWW Document]. URL /african-monsoon (accessed 12.27.17).

Conway, D., 2011. Adapting climate research for development in Africa. WIREs Clim Change 2, 428–450. https://doi.org/10.1002/wcc.115

Cook, K.H., 2015. Role of inertial instability in the West African monsoon jump. J. Geophys. Res. Atmos. 120, 2014JD022579. https://doi.org/10.1002/2014JD022579

Descroix, L., Diongue Niang, A., Panthou, G., Bodian, A., Sane, Y., Dacosta, H., Malam Abdou, M., Vandervaere, J.-P., Quantin, G., 2015. Évolution récente de la pluviométrie en Afrique de l'ouest à travers deux régions : la Sénégambie et le Bassin du Niger Moyen. Recent trend on rainfall in West Africa through two regions: Senegambia and the Middle Niger River Basin 25–43. https://doi.org/10.4267/climatologie.1105

Espinoza Villar, J.C., Ronchail, J., Guyot, J.L., Cochonneau, G., Naziano, F., Lavado, W., De Oliveira, E., Pombosa, R., Vauchel, P., 2009. Spatio-temporal rainfall variability in the Amazon basin countries (Brazil, Peru, Bolivia, Colombia, and Ecuador). Int. J. Climatol. 29, 1574–1594. https://doi.org/10.1002/joc.1791

Gbobaniyi, E., Sarr, A., Sylla, M.B., Diallo, I., Lennard, C., Dosio, A., Dhiédiou, A., Kamga, A., Klutse, N.A.B., Hewitson, B., Nikulin, G., Lamptey, B., 2014. Climatology, annual cycle and interannual variability of precipitation and temperature in CORDEX simulations over West Africa. Int. J. Climatol. 34, 2241–2257. https://doi.org/10.1002/joc.3834

Hope, P., Timbal, B., Fawcett, R., 2010. Associations between rainfall variability in the southwest and southeast of Australia and their evolution through time. Int. J. Climatol. 30, 1360–1371. https://doi.org/10.1002/joc.1964

Loua, R.T., Beavogui, M., Bencherif, H., Barry, A.B., BAMBA, Z., Amory-Mazaudier, C., 2017. Climatology of Guinea: Study of Climate Variability in N'zerekore. Journal of Agricultural Science and Technology (JAST) 7. https://doi.org/10.17265/2161-6256/2017.04.001

Nicholson, S.E., 1981. Rainfall and Atmospheric Circulation during Drought Periods and Wetter Years in West Africa. Mon. Wea. Rev. 109, 2191–2208. https://doi.org/10.1175/1520-0493(1981)109<2191:RAACDD>2.0.CO;2

Simmons, A.J., Berrisford, P., Dee, D.P., Hersbach, H., Hirahara, S., Thépaut, J.-N., 2008. A reassessment of temperature variations and trends from global reanalyses and monthly surface climatological datasets. Quarterly Journal of the Royal Meteorological Society 143, 101–119. https://doi.org/10.1002/qj.2949

Wang, S., Gong, D., 2000. Enhancement of the warming trend in China. Geophysical Research Lettres 27, 2581–2584.

WMO, 2017. Directives de l'OMM pour le calcul des normales climatiques, Édition 2017. ed, OMM. OMM, Genève.