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Contribution Of Remote Sensing To The Study Of Spatiotemporal Evolution Of Rainfall In Senegal : Exploitation Of TRMM 3B43 Low Spatial Resolution

Mamadou Lamine Ndiaye[1*]
[1] Geoinformation Laboratory, Geography Dept., Cheikh Anta Diop University of Dakar, Senegal
mlndiaye02@gmail.com

Vieux Boukhaly Traore[2]
[2] Hydraulics and Fluid Mechanics Laboratory, Dept. of Physics, Cheikh Anta Diop University of Dakar, Senegal
vieuxboukhalytraore@yahoo.fr

Mame Aissatou Toure[3]
[3] Climatology and Environmental Laboratory, Cheikh Anta Diop University of Dakar, Senegal
aishatoure.toure@gmail.com

Giovani Malomar[4]
[4] Physics of Solid and Sciences of Materials Laboratory, Cheikh Anta Diop University of Dakar, Senegal
giovanieliemalomar@yahoo.fr

Amadou Tahirou Diaw[1]
[1] Geoinformation Laboratory, Geography Dept., Cheikh Anta Diop University of Dakar, Senegal
guede1914@gmail.com

Aboubaker Chedikh Beye[2,4]
[4] Physics of Solid and Sciences of Materials Laboratory, Cheikh Anta Diop University of Dakar, Senegal
acbeye@refer.s

Abstract*— Many studies on the climate through rainfall in development paths in the country often face constraints related firstly to the acquisition of data daily measurements, reliable and with few deficiencies and other units at insufficient observation networks. This limits the knowledge of the precipitated water volume and its spatial and temporal distribution. The use of satellite rainfall data is seen as an alternative that has generated much expectation among experts in the field. Satellite data TRMM (Tropical Rainfall Measuring Mission) are a perfect illustration around the world. This article proposes to study and analyze the spatial and temporal evolution of rainfall in Senegal using satellite data TRMM 3B43-in monthly time. We have selected for this purpose, the period from 2000 to 2012. The use of these data (image rotation, georeferencing, extraction of the study area, the IDW interpolation method and the realization of graphics) allowed us an exploratory analysis and cartographic scale at the annual, monthly and interannual. All the results obtained, reported variability in time and space of rainfall. Indeed, 55% of the years of the study period are seen as surplus. Moreover, 2003 was the wettest year (with an average of 883 mm) and 2002, the least wet year (with an average of 411 mm). The cartographic analysis also confirmed these observations. The overview of the different cards revealed an uneven distribution of rainfall in the country: the heavy rainfall recorded in the South (1400 mm) and low north (400 mm). These results constitute a real asset and indicator for meteorologists and climatologists in the use of TRMM rainfall data for a better characterization of rainfall. Therefore, traditional methods of data collection can now be strengthened to ensure the reliability of the results for the hydro data.

Keywords—Remote sensing, TRMM data, Rainfall spatiotemporal change, Senegal.

I. INTRODUCTION

Rainfall is the most important factor of the climate both for people and for ecosystems [1]. It remains to this effect the most used parameter in studies and analyzes of the climate [2,3]. For some time now, its interests are placed at the center of scientific and policy makers concerns in the world in general and Africa in particular [4,5]. In many developing countries such as those of tropical Africa that are often difficult to access related to multiple natural, political and socio-economic constraints, the mastery of climate variability through the rainfall is very limited [6, 7,8]. In West Africa, particularly in Senegal, experts in the field have real

difficulties in this regard. This could be justified by the difficulty in acquiring data of daily measurements, reliable and with few gaps (given the traditional observation methods) but also to the accurate assessment of the precipitated water volume, distribution spatiotemporal, inadequate observation network and qualified personnel on the territory [9]. The measurement techniques previously used, are based on estimates based in turn on empirical tools do not always yield the expected results [10]. The most important issue, both for the West Africa than in other regions of the world, is looking for tools or robust techniques to acquire data reliable and complete rain live in the tropics [11]. This then proves to be the indispensable condition to accurately characterize the rainfall events in order to propose solutions to development projects [3]. According to [12], satellite data TRMM (Tropical Rainfall Measuring Mission) would represent an effective alternative for the study of the spatial and temporal variability in rainfall because of their reliability. The launch of this satellite in 1997 was a milestone for the study of tropical rains because for the first time, rainfall radar was installed on a satellite [13]. This instrument provided the opportunity to collect information on phenomena previously inaccessible and especially to collect consistent information on the tropics. This radar is associated with a passive microwave sensor whose measured data allowed a significant advance for the estimation of precipitation rates [14]. The satellite also carries a thermal infrared sensor whose data have so far been much less used. Among the various existing estimates, data from the TRMM spectroradiometer, are particularly interesting since they have been specifically designed to provide information in tropical regions fall almost two thirds of global rainfall [15,16] .These satellites can address the problem of rainfall in real time and its use in weather forecasting [8]. Indeed, thanks to their wide spatial coverage, they can easily access even the remotest areas, with significant temporal frequency. Several studies have shown the relevance of TRMM data for a study on rainfall [16,17,18,19,20]. This study therefore aims to analyze the spatial and temporal distribution of rainfall in Senegal using TRMM 3B43 data-no monthly time over the period from 2000 to 2012. It should be noted that Senegal has 14 regions spread mainly in five rainfall zones (East, West, North, South and Central) and three climate areas (Sahelian, Sudanese and Guinean). Thus in this study we try to analyze the rains through mapping and graphing. Studies based on such data were previously conducted on Senegal: most climate studies were limited to the analysis of annual and monthly rainfall data from empirical measurements techniques.

II. MAERIALS AND METHODS

A. Study area

The Senegal covers an area of approximately 196,712 km². It is bounded to the north by Mauritania, on the east by Mali, to the south by Guinea Conakry, southwest by Guinea Bissau and west by the Atlantic Ocean (with a coastline 700 km) (Figure 1). It has 13 million inhabitants spread over 14 regions. [21] The Senegal relief is generally fairly flat (lower altitude 50m on nearly 75% of the territory). The highest altitudes (581m) are found in the extreme southeast in the foothills of Fouta [22]. Its vegetation is dependent on rainfall distribution, following north-south gradient. Three major phytogeographic areas stand out: the Sahelian, Sudanian and Guinean domains. The climate of Senegal is characterized by high rainfall variability from one year to another, more formidable variability than the annual average is lower; plus annual total is shrinking, more rains are uncertain and irregular and more deficits is serious. Thus in the south, the average of 1250 mm (Ziguinchor raingauge), results from rainfall ranging from 900 mm to 1 400 mm ,in the north, the average of 414 mm (Linguere raingauge), covers rainfall ranging from 850 mm in exceptionally rainy year to 200 mm in dry years [23,24]. In short, the climate insecurity hanging over the northern half of the country is not only due to low rainfall and the brevity of the rainy season; it would be mainly the result of the inter-annual irregularity of the rains. The drought that periodically hit the country since 1968, emphasized the gravity of this situation by its dramatic consequences on the ecological balance and all human activities in areas north. The abundance of exceptional rainfall of 1999 compared to those of recent decades gives hope to the rural world, which aspires to sustainable return of good rainfall.

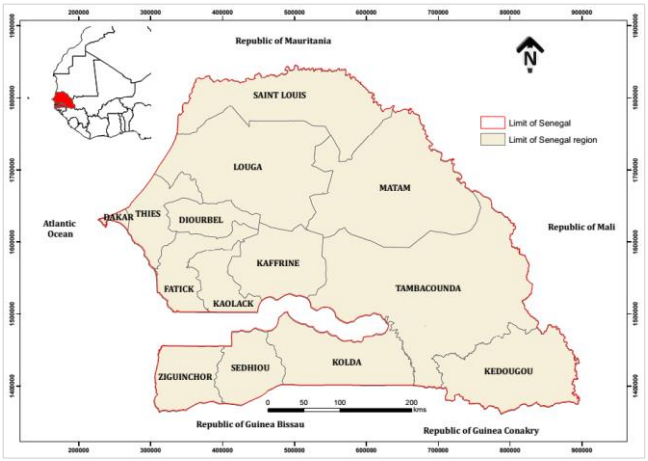

Fig. 1. Localization of the study area

B. TRMM 3B43 date and exploitation

The TRMM (Tropical Rainfall Measuring Mission), is a joint program between NASA and JAXA, dedicated to the study of rainfall in tropical areas which represent 2/3 of terrestrial precipitation. The satellite was launched on 27 November 1997. Its orbit is low (400 km) and inclined at 35 ° to the equator. In this way the satellite is capable of sampling all phases of diurnal cycle but covers only a region between 38N and 38S [14]. The rainfall radar, which is the main instrument of this satellite, a ground resolution of 5 km and a 250 km swath. The main limitation of this tool is its lack of precision for the lower rainfall than 1 mm / h [14]. In this study, among all

TRMM databases pre-calibrated and / or pre-analyzed data used are tri-hourly products TRMM 3B43 with a spatial resolution of 0.25 ° x 0.25 ° or 5 km. They are used to analyze the relationship between rainfall and flooding episodes in Dakar. Given their existence since 1997, we have chosen a 12-year study period, from 2000 to 2012. A total of 12 images per month were downloaded separately on a series of 12, making a total of 144 pictures treat. The TRMM data requires pretreatment steps for proper interpretation. The first step is a georeferencing of images and then rotated 90 ° to position them on the axis of the equator. Rainfalls being recorded in mm / hour are converted to mm / month. Then we performed an extraction of rainfall in the study area and its conversion into ASCI format exportable to Excel for making graphics and under ArcGIS, where they are converted to shp file. Finally account we conducted an interpolation of data for the production of precipitation map.

III. RESULTS AND DISCUSSION

A. Annual rainfall

Figure 2 shows the evolution of annual rainfall of Senegal for the period from 2000 to 2012. The analysis of figure brings up irregularities. Of the 13 years of the study period, 7 recorded a higher average rainfall interannual (700 mm), or about 54%. The year 2003 was the wettest (883 mm) and 2002 that the lowest rainfall (472 mm), with a gap of 411 mm. Figures 3 and 4 confirm 2003 as the rainiest and 2002, less rainy. It may be noted that the heavy rainfall recorded in the south and gradually the lowest in the north (Figure 5) .These results are perfect match those found in the literature.

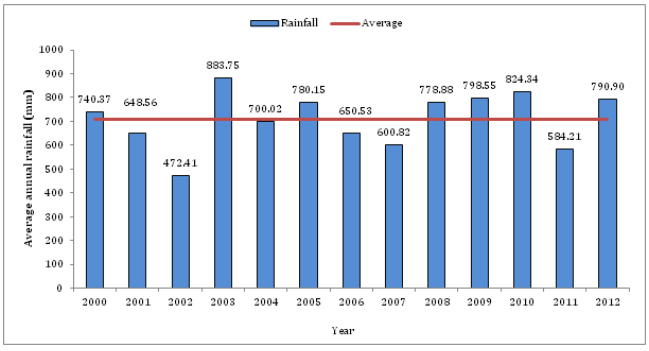

Fig. 2. Evolution of the annual rainfall from 2000 to 2012

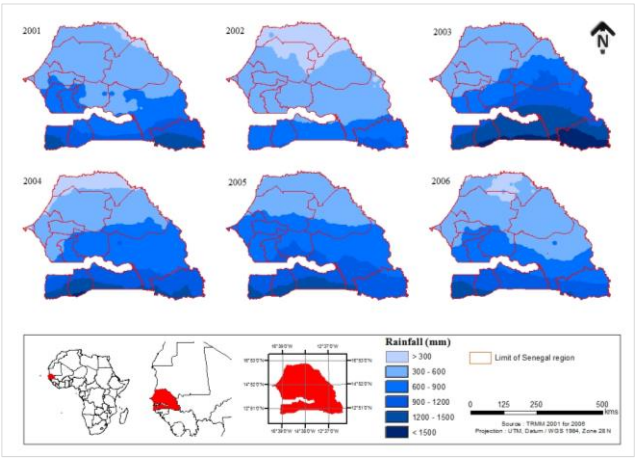

Fig. 3. Spatial distribution of rainfall between 2000 and 2006

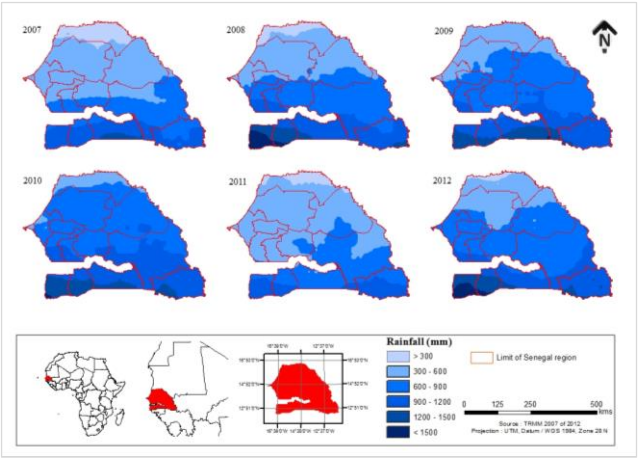

Fig. 4. Spatial distribution of rainfall between 2007 and 2012

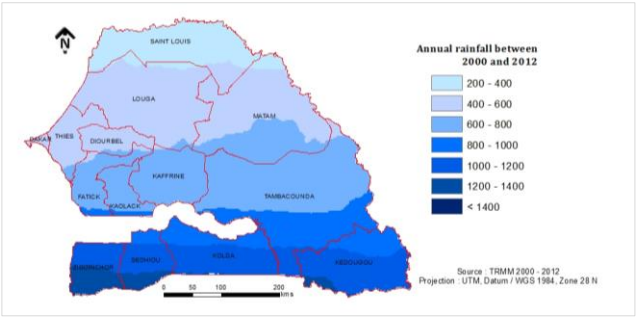

Fig. 5. Summary of the spatial distribution of rainfall in Senegal between 2000 and 2012

B. Units

Figure 6 shows the monthly distribution of rainfall in a given year and over the entire study period. Analysis of the results generally puts in evidence a wet period from June to October and a dry season from November to May 7 is mapping summary of the inter monthly variation of rainfall. It confirms the existence of two seasons mentioned in Figure 6.

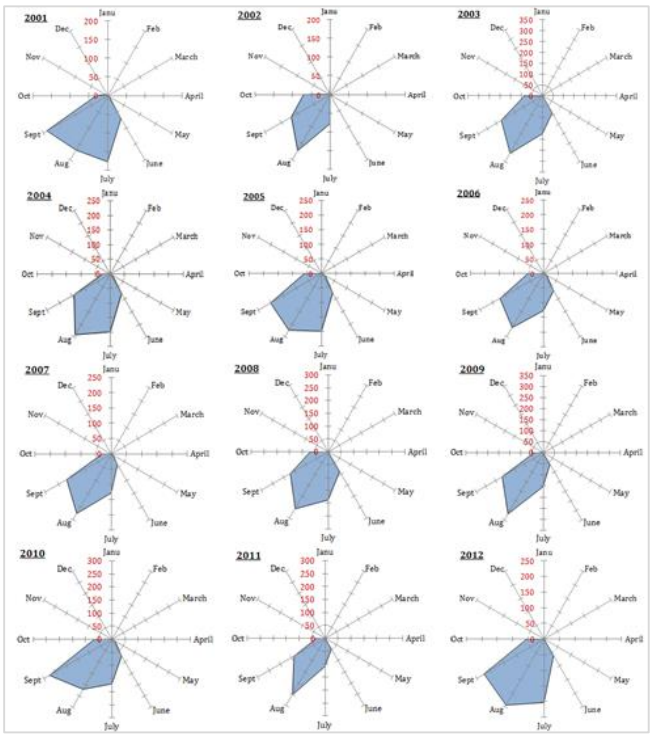

Fig. 6. Evolution of the monthly rainfall between 2001 and 2012

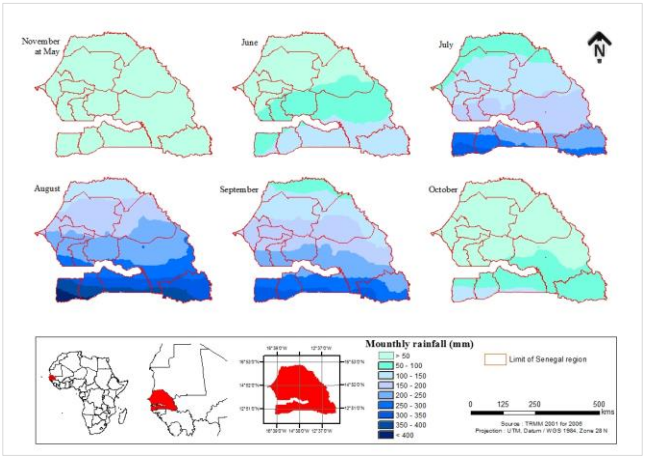

Fig. 7. Evolution intermonthly rainfall of Senegal between 2000-2012

C. Rainfall of rainy month

We present in Figure 8 the evolution of monthly rainfall over the study period. We limited ourselves here in the rainy months of the year. The analysis shows that with the exception of 2001 and 2010, August is the wettest month throughout the study period and October the less rainy. We mapped thereto rainfall of August through 9 and 10 to best view this observation. Furthermore, the accumulated rainfall class 2003 months as the wettest year and 2002 as the less humid. Which is fully consistent with the observations made above.

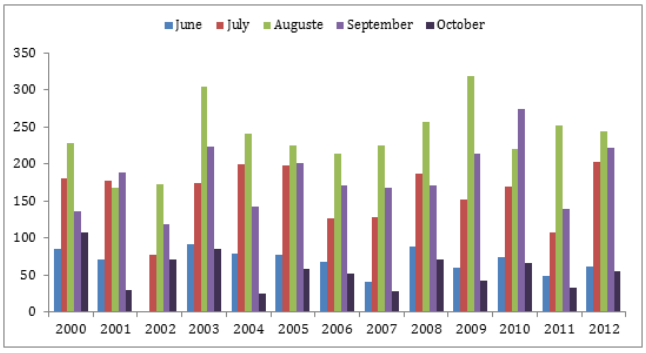

Fig. 8. Evolution of the monthly rainfall between 2000 and 2012

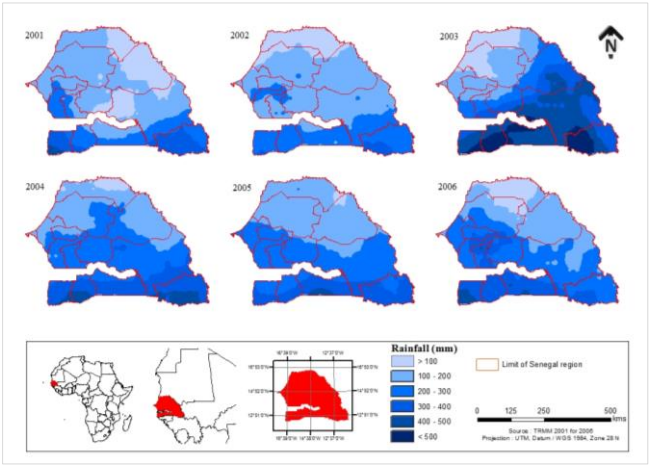

Fig. 9. Spatial distribution of interannual rainfall in August 2001 to 2006

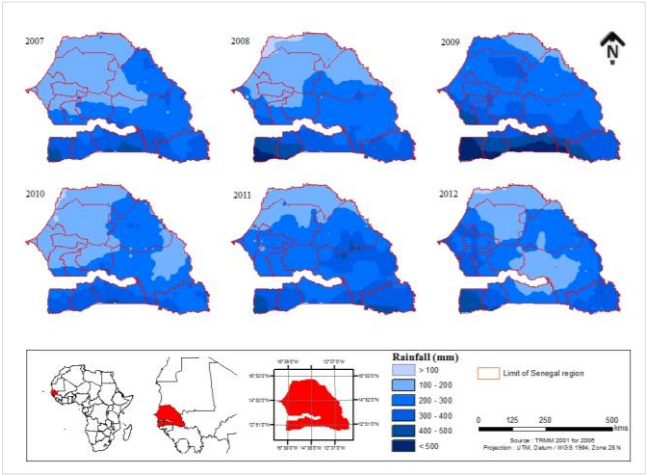

Fig. 10. Spatial distribution of interannual rainfall in August between 2007 and 2012

IV. CONCLUSION

A. It was in this article to highlight the potential of TRMM satellite data to study the spatial and temporal variability of rainfall in Senegal. This study is motivated by the many constraints of data from empirical collection methods concerning among others, gaps in the series, data quality and lack of observation stations network which may challenge the results of research related to rainfall. The TRMM data offer against by the opportunity to have daily data quality, reliable tropical areas in Senegal image. The operation of TRMM 3B43 data-in this study allowed characterizing the evolution of both spatial and temporal rainfall throughout the national territory. These data were pretreatment object and judicious treatment to lead to the preparation of charts and maps for more detailed analysis. Overall, the results suggest appear surplus and deficit years. About 55% of years have a higher rainfall than average in the series (700 mm). The year 2003 was the wettest with 883 mm and the least rainy year 2002, with 411 mm. These exploratory results are confirmed by those mapping. Furthermore, analysis of maps showed that rainfall shows a very significant change, coupled with an increasing gradient from north to south. The rains are more important south commonly called Casamance (regions of Ziguinchor, Sédhiou, Kolda, Kédougou and Tambacounda), with an average of 1400 mm and less important in the north, particularly in the regions (Saint Louis, Louga and Matam), with an average of 400 mm. With this in mind, we can highlight the TRMM data are a great way to study the spatial and temporal variation in rainfall. The TRMM data can be used on large scales, like the whole of Africa. In addition, this study will help to highlight the impact of rainfall variability on ecosystems in Senegal.

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