Mapping Spatial and Temporal Variability of Rainfall in Côte D'Ivoire using TRMM Data

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Abstract

In Côte d'Ivoire précipitations are very variable. Under standing the spatial and temporal variabilité of précipitation is crucial for agrometeorological applications. However, there are a few number of climate synoptic stations with poor quality of climate data. Satellite-based data such as TRMM data could be an alternative. This study first compared TRMM data to in situ climate data, and later mapped the spatial and temporal variability of rainfall in Côte d'Ivoire. Correlations between TRMM data and in-situ data showed that TRMM data correctly reproduce seasonal patterns. Also, the results of analysis revealed an alternation of rainy years and dry years with high rainfall deficits.

Keywords— TRMM, rainfall, variability, in situ data.

I. INTRODUCTION

Precipitation is one of the most important factors in the climate studies. They highly contribute to hydrological cycle and have obvious impacts on living beings. From a climate perspective, the intensity and distribution of precipitation is likely to be affected in the context of global climate change. Precipitation measures are essential to improve our understanding of the mechanisms of climate change. In Côte d'Ivoire, the measuring instruments (in-situ) for rainfall data collection remain insufficient for a thorough assessment of rainfall fields. In fact, only fourteen rainfall stations are spread over the entire national territory. Thus, at the national scale, the spatial density of these rainfall data is still low. In addition, these synoptic stations have certain shortcomings, namely the spatial distribution and the poor quality of the archive data. It is important to address this issue by using other data sources. The present study aims to contribute in improving knowledge of the spatial and temporal distribution of precipitation in Côte d'Ivoire using TRMM satellite data.

II. MATERIALS

A. In-Situ Rainfall Data

The rainfall data used in this study are monthly data from 1998 to 2010 of four synoptic stations: Abidjan, Bondoukou, Korhogo and Yamoussoukro, collected from the National Meterological Services (SODEXAM). These stations cover the main climatic zones of Côte d'Ivoire.

B. TRMM Data

TRMM satellite data are monthly rainfall data for the same (1998 to 2010). These data were provided by the algorithm 3B43 combining TRMM image syntheses, other satellite data and ground data [1]. The data are available at a spatial resolution of 0.25 degree and acquired on Giovanni website (https://giovanni.gsfc.nasa.gov/giovanni/)

III. METHODS

A. Validation by Graphic Comparison

This method graphically compared the two datasets. The purpose of this analysis is to observe the possible correspondences in precipitation between TRMM and *in-situ* data. The use of the Nicholson method allowed identifying the excess and deficit periods within this time series. This will bring out the appearance of the two curves.

B. Validation by Correlation Coefficient

To ensure the reliability or good quality of the estimation data provided by the TRMM satellite, the correlation coefficient (R) method was computed. This method is the ratio between the covariance (γ) of the observations, the estimates and the product of their standard deviations. It gives an indication of the intensity and direction of the linear relationship between the two variables. The correlation coefficient then varies between -1 and +1, with a correlation considered strong if it is between -1 and -0.5 or between +0.5 and +1. The correlation is considered to be low when the correlation coefficient is between -0.5 and 0 or between 0 and 0.5 (http://grasland.script.univ-paris-

diderot.fr/STAT98/stat98_6/stat98_6.htm).

C. Mapping Annual Average Rainfall Using TRMM

This method involves importing the precipitation product 3B43 (NetCDF format) into ArcGis for rasterization. TRMM data were converted into a point for interpolation to finally map the rainfall patterns. The interpolation was done with the Grid method, which is an easy access tool and used for

manipulation and visualization of Earth observation data [1].

IV. RESULTS AND DISCUSSION

- A. Graphic Comparision of TRMM and In-Situ Data
 - 1) Abidjan

In the analysis of Fig. 1, we observe a concordance between

the ground data and the estimation data. We also noticed that the estimation data tended to underestimate rainfall patterns during the dry season and a tendency for a slight overestimation of rainfall during the rainy season.



Fig 1: Comparison of TRMM and in-situ data at Abidjan station

2) Bondoukou

At Bondoukou station (Fig. 2), there was also a concordance between*in-situ* data and TRMM data. In terms

of trends we observe that TRMM data have a slight tendency to underestimate rainfall during the dry season and have a slight tendency to overestimate it during the rainy season



Fig 2: Comparison of TRMM and in-situ Data in Bondoukou

3) Korhogo

In the analysis of Fig. 3, we observe a concordance between ground data and estimation data.

This graph allows us to observe an upward trend in TRMM data during the dry season and a downward trend during the rainy season.



Fig 3: Comparison of TRMM and in-situ Data in Kohrogo

4) Yamoussoukro

There was also a concordance between the ground data and the estimation data. We also observed

that the TRMM data overestimated rainfall patterns during the dry season and to underestimated rainfall during the rainy season (Fig. 4).



Fig 4: Comparison of TRMM and in-situ Data in Yamoussoukro

B. Statistical Analysis

Statistical analysis showed a very high correlation between TRMM and *in-situ* data. Abidjan is an exception with a moderately low correlation compared to the others; and Korhogo had the strongest correlation coefficient with 0.90. This analysis showed a strong correlation between the satellite estimates rainfall data and that of synoptic stations (Table 1).

| Table I: Correlation Coefficients (R) from 1998-2010 For |
|--|
| 4 Synoptic Stations |

| Synoptic Stations | Correlation Coefficients (R) |
|-------------------|---------------------------------|
| Abidjan | 0,66 |
| Bondoukou | 0,76 |
| Korhogo | 0,90 |
| Yamoussoukro | 0,74 |

C. Mapping Annual Average Rainfall Using TRMM Data

The following results are focused on the yaers 2001 and 2002 where there were high spatial rainfall variability

1) Rainfall Pattern in2001

In 2001, the most watered areas (Fig. 5) were in the southern and southeastern areas with 405 to 449 mm and the average watered area is west and northwest. The low precipitation regime was recorded in the north, center and northeast. Also, we notice that, the rainiest months were May, June, August. The average wet months were April, July, September, October, and the driest months were January, February, March and December.

Analysis of Fig. 6 showed that Abidjan and Yamoussoukro stations had a similar trend. Whereas there was difference in trends between Bondoukou and Korhogo (both in the northern part of the country). Indeed, in Korhogo the rainiest months were May, June, July, August and September and the driest January, February and December. While at Bondoukou station the highest rainfall amounts were found in April, June and September, the lowest in January, February and December.



Fig 5: The Average Monthly Rainfall Regimes Using TRMM Data in 2001



2) Rainfall Pattern in 2002

In 2002 (Fig. 7), we observe a decrease in rainfall in the south and in the south-east of the country from 181 mm 202mm.The northwest and southwest zones are the most watered and the sparsely watered areas are northern and central. Also, there were high rainfall amounts in June and August. Whereas the lowest rainy periods were January, February, March, May, November and December.

In Fig. 8, we observe that Abidjan and Yamoussoukro stations had a similar trendwith the same rainy periods and high precipitation rates lasting 3 months, namely June, July and October with the highest rate in June (230 mm). Also, the same dry seasons with low precipitation rates during the months of January, February, November and December. The driest month is January with only 22 mm. In contrast to these two stations, the Bondoukou and Korhogo stations had different trends in rainfall patterns.



Fig 7: Annual Average Rainfall using TRMM data



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D. Discussions

Methods used in this work showed a very strong correlation between *in-situ* data and TRMM data. This is confirmed by studies by Dubreuil*etal*.[2], Tra Bi *et al.* [3], and Bigot [4]. These authors showed that TRMM data correctly reproduce seasonal patterns. They also noted an underestimation and an overestimation of rainfall by the TRMM estimation data.

Mapping of rainfall regimes revealed spatial and temporal variabilities. Indeed, the rainfall is characterizedby an alternative rainy and dry years with important rainfall [1] deficits. It should be noted the gradual decrease in rainfall and the accentuation of the rainy irregularity. This variability was very important in Korhogo and Bondoukou, in contrast in Abidjan and Yamoussoukro where it slightly [2] varied. The results obtained are in agreement with the study by Brou[5], who showed in a abrupt decrease in rainfall in the Northh, Center, East and the South of the Cote d'Ivoire. [3] The author also noted that some areas in the country had a high record of rainfall amounts, namely Tabou station, which is the rainiest part of the country throughout the year.

V. CONCLUSION

The TRMM data provide a good measure of rainfall events as compared to ground data. They show a fairly good correlation with ground station data. But they tend to overestimate rainfall during the dry season and underestimate it during the rainy season. As for the analysis of the spatial and temporal variability resulting from the TRMM images, the mapping method allowed us to highlight the variability in rainfall pattern. We therefore note a

predominance of dry years. As a result, we found that the Abidjan station and the Yamoussoukro station had a similar trend in rainfall patterns, while those of Korhogo and Bondoukou were asynchronous, with the exception of the year 2007. In order to have more accurate estimates, we plan to correlate the TRMM satellite data with TAMSAT to see which of these is better suited to our area and which has less deviation from overestimation and underestimation.

REFERENCES

- G. J.Huffman, B.Adler,U. Rudolf,P.R. Schneiderandand Keehn, Global precipitation estimates based on a technique for combining satellite-based estimates, rain gauge analysis and NWP model precipitation information,J. Climate, vol. 8, No. 5, p1284-1295, 1995.
- [2] V. Dubreuil., A. Jallet, J. Ronchail and G. Maitelli,Estimation des précipitations par télédétection au Mato Grosso (Brésil), Annales de l'Association Internationale de Climatologie, Vol. 1, pp.133-156, 2004.
 -] Z. A.Tra Bi, Étude de l'impact des activités anthropiques et de la variabilité climatique sur la végétation et les usages des sols, par utilisation de la télédétection et des statistiques agricoles, sur le bassin versant du Bouregreg (Maroc), Thèse de doctorat de l'Université d'Artois,2013.
- [4] S. Bigot, Variabilité climatique, interactions et modifications environnementales (L'exemple de la Cote d'Ivoire), 398p, 2004.
- [5] Y. T. Brou, Climat, mutations socio-économiques et paysages en Côte d'Ivoire, Mémoire de synthèse des activités scientifiques présenté en vue de l'obtention del'Habilitation à diriger des recherches. Université des sciences et technologies de Lille, 212 p, 2005.
 - B. Pauthier, Etude des précipitations intenses sur la région Sud de l'Océan Indien, pp.25, 2012.