Dry Spell Analysis in te Senegal River Basin

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2019-11-25

Introduction

In the fremework of Senegal project, climate variabilty analysis has also been conducted to the study of spatio-temporal dynamic patterns of dry spell periods during a particular seseaon of the year, eg. the growing season. Dry spells are periods of consecutive days longer than a threshold value, e.g. 3 days, in which precipitation is zero or lower then the threshold of 1 mm (Ratan and Venugopal (2013),Chaudhary, Dhanya, and Vinnarasi (2017),Masupha, Moeletsi, and Tsubo (2016),Froidurot and Diedhiou (2017)). Detection of all dry spells from 1981 to 2017 with sutiable R functions (Cordano (2015)) for an area covering the entire Senegal River basin and its surroundings. Dry spells dynamics are of great interest to detect the seeding periods at the beginning of the growing season, due to fact that crop growth is extramely sensitive to intermettence of dry and wet periods (Gornall et al. (2010)).

Dry Spell annual indices (Yearly aggregation)

In order to resume the behavoiour of dry spells during the latest deacades, aggregated indices have been defined for the growing season of each year. To calculate these indices, dry spells dynamics were extracted the dry spells for the entire period of the time series. The dry spells starting on a selected period of the year, generally corresponding to the growing season per each year, were selected and then each gruop of dry spells ocuuring in the same season has been aggregeted in order to obtain a single numeric values. In particular, the following indices has been extracted referring to each year.

- **drySpellCountLow** : number of dry spells of the rainy season equal or longer than 3 days and lower than 10 days (Figures 1,2,3);
- **drySpellCountIntermediate** : number of dry spells of the rainy season equal or longer than 10 days and lower than 21 days;
- **drySpellCountHigh** : number of dry spells of the rainy season equal or longer than 21 days;
- **drySpellCount**: number of all dry spells of the rainy season equal or longer than 3 days (Figures 4,5,6);
- **median** : median (50th precentile) of all dry spells of the rainy season equal or longer than 3 days;
- **max** : maximum of all dry spells of the rainy season equal or longer than 3 days ;
- **q25** : 25th precentile of all dry spells of the rainy season equal or longer than 3 days;
- **q75**: 75th precentile of all dry spells of the rainy season equal or longer than 3 days;
- **mean** : mean of all dry spells of the rainy season equal or longer than 3 days (Figures 7,8,9);
- **q90** : 90th percentile of all dry spells of the rainy season equal or longer than 3 days (Figures 10,11,12);
- **q90_7**: 90th percentile of all dry spells of the rainy season equal or longer than 7 days;
- **iqr** : difference between 75th and 25th percentiles (interquantile range - IQR) of all dry spells of the rainy season equal or longer than 3 days (Figures 13,14,15);
- **sum**: sum of the days of all dry spells of the rainy season equal or longer than 3 days;

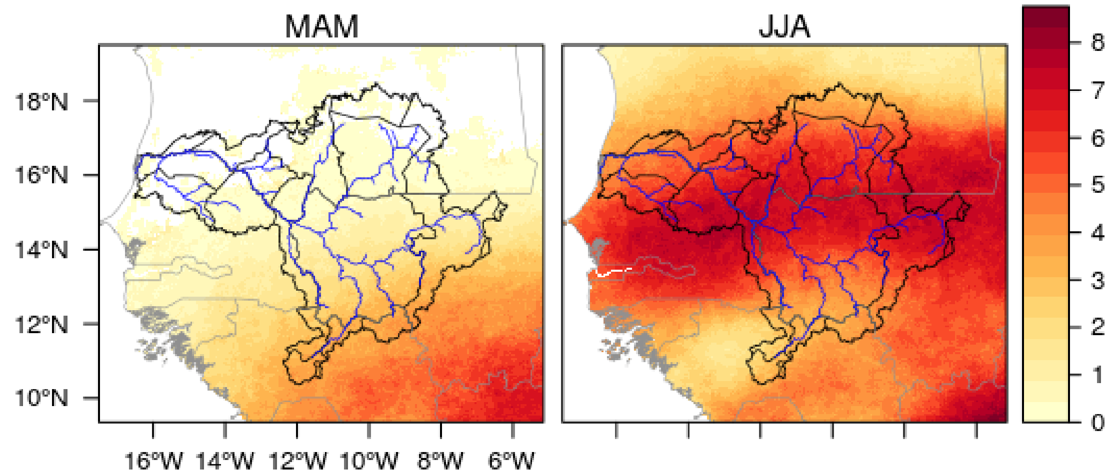

Figure 1: L-Mean (mean) of **drySpellCountLow**

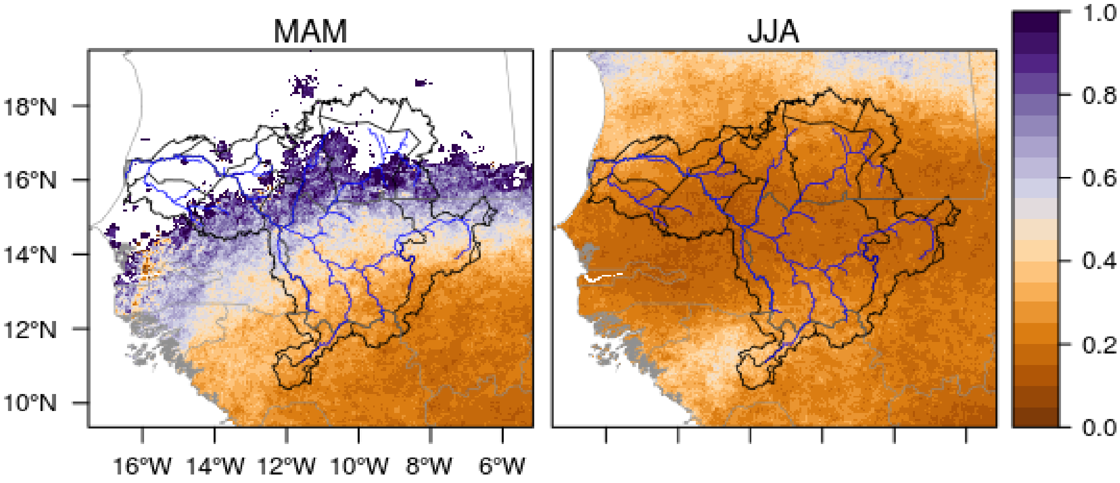

Figure 2: L-CV of **drySpellCountLow**

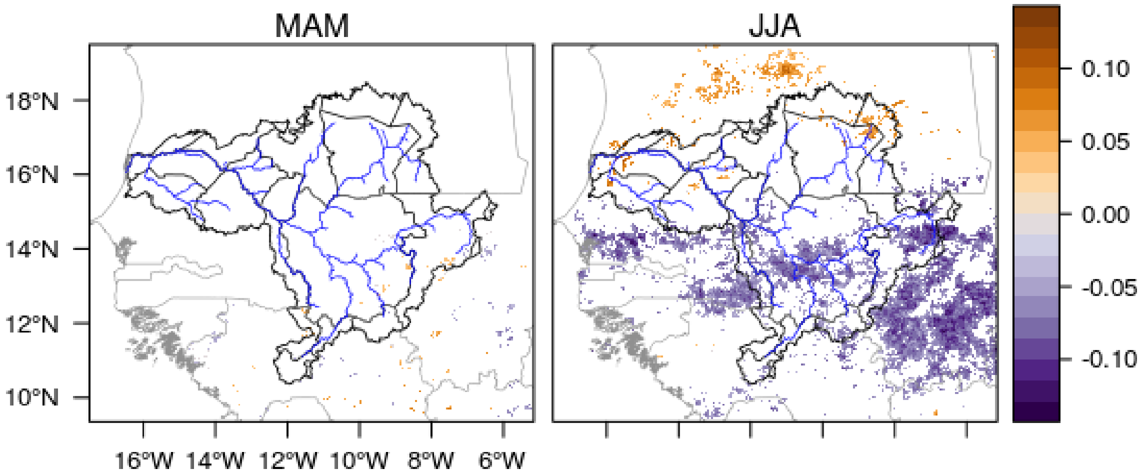

Figure 3: Mann-Kendall trend vs time of **drySpellCountLow** (quantity per year)

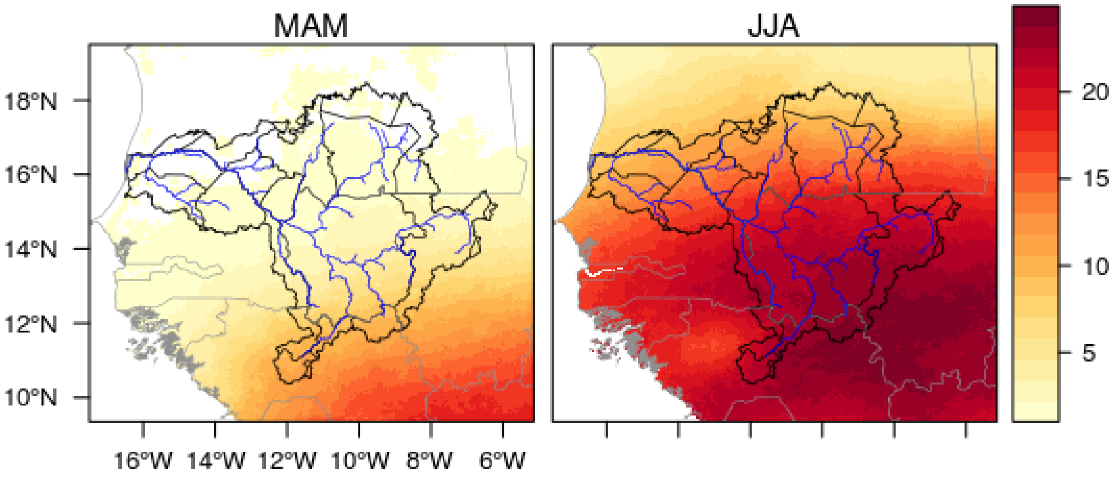

Figure 4: L-Mean (mean) of **drySpellCount**

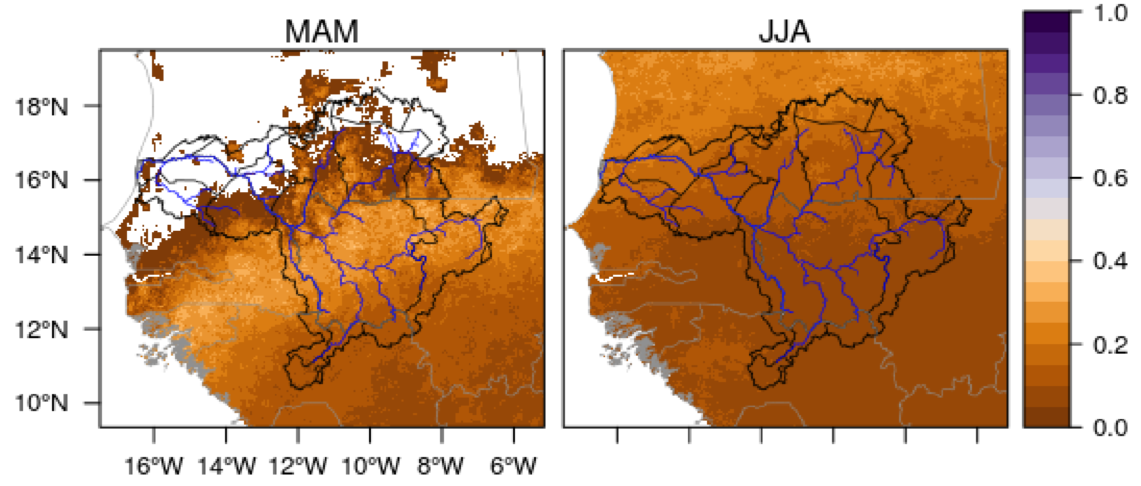

Figure 5: L-CV of **drySpellCount**

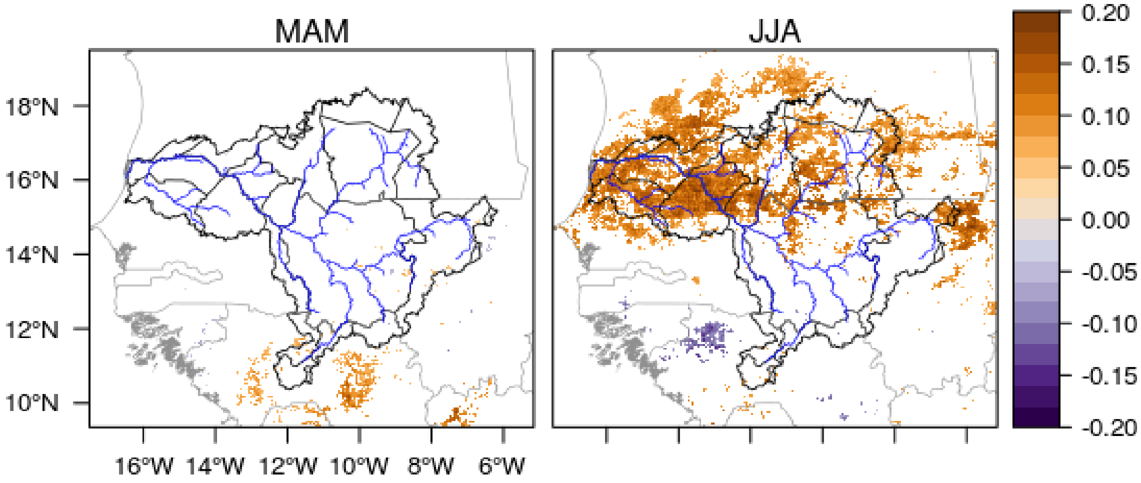

Figure 6: Mann-Kendall trend vs time of **drySpellCount** (quantity per year)

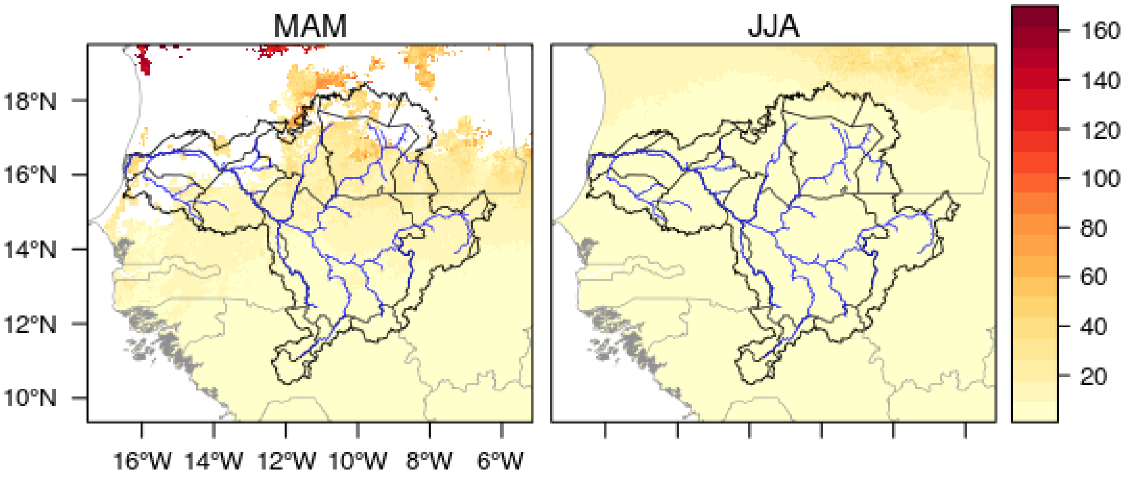

Figure 7: L-Mean (mean) of **mean**

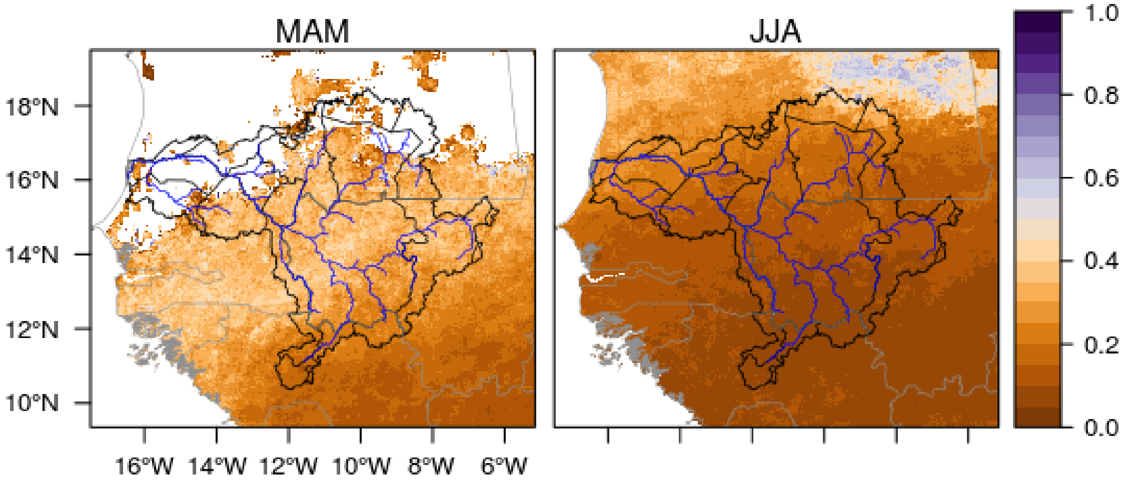

Figure 8: L-CV of **mean**

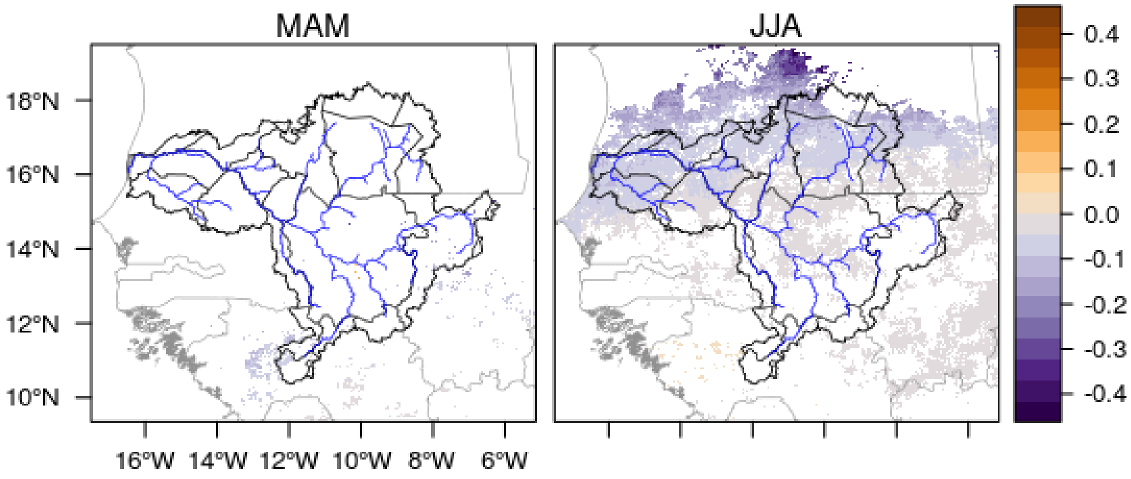

Figure 9: Mann-Kendall trend vs time of **mean** (quantity per year)

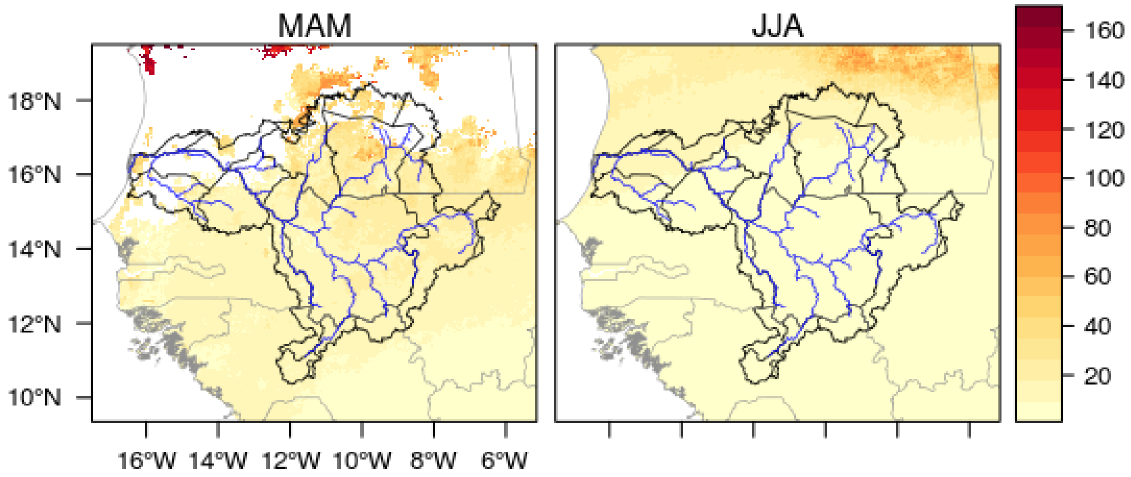

Figure 10: L-Mean (mean) of **q90**

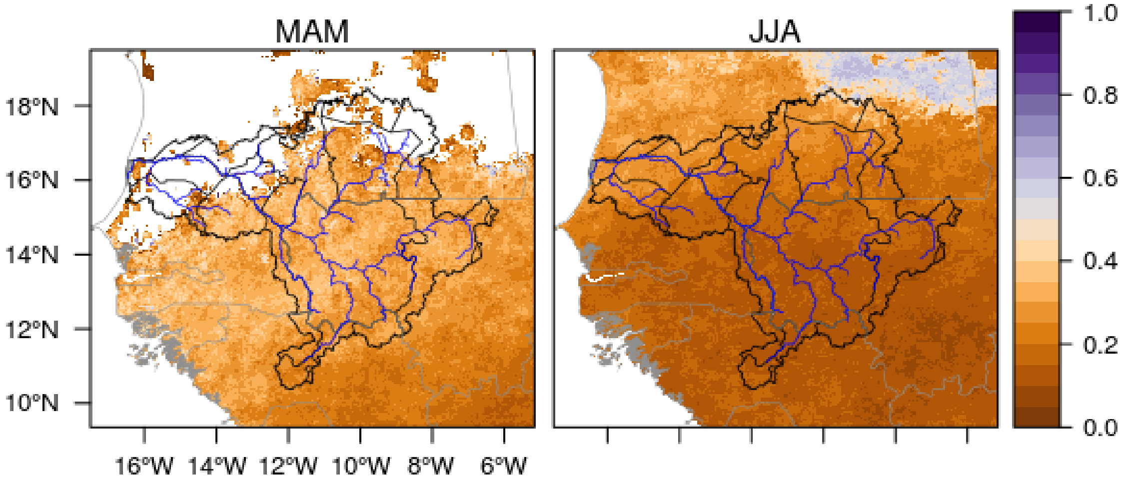

Figure 11: L-CV of **q90**

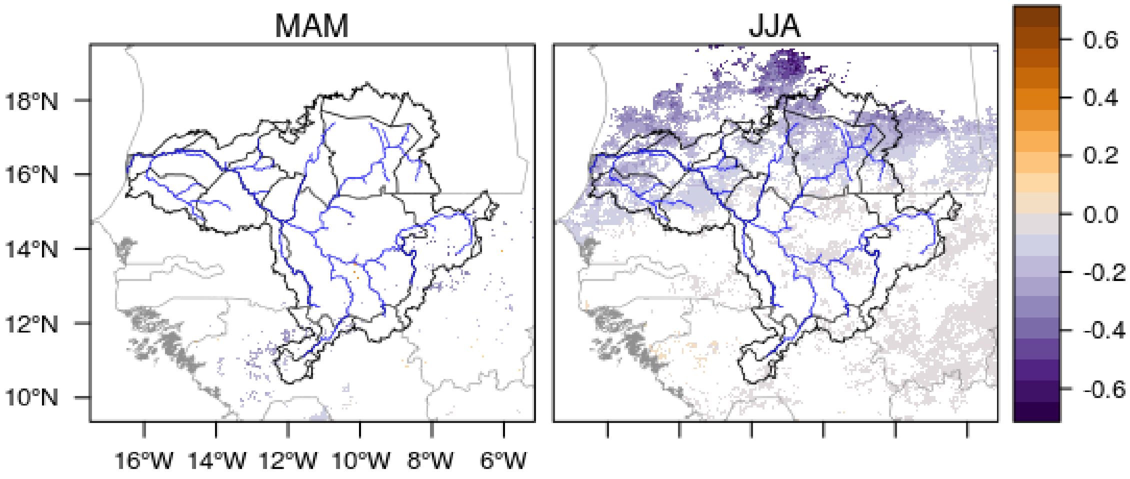

Figure 12: Mann-Kendall trend vs time of **q90** (quantity per year)

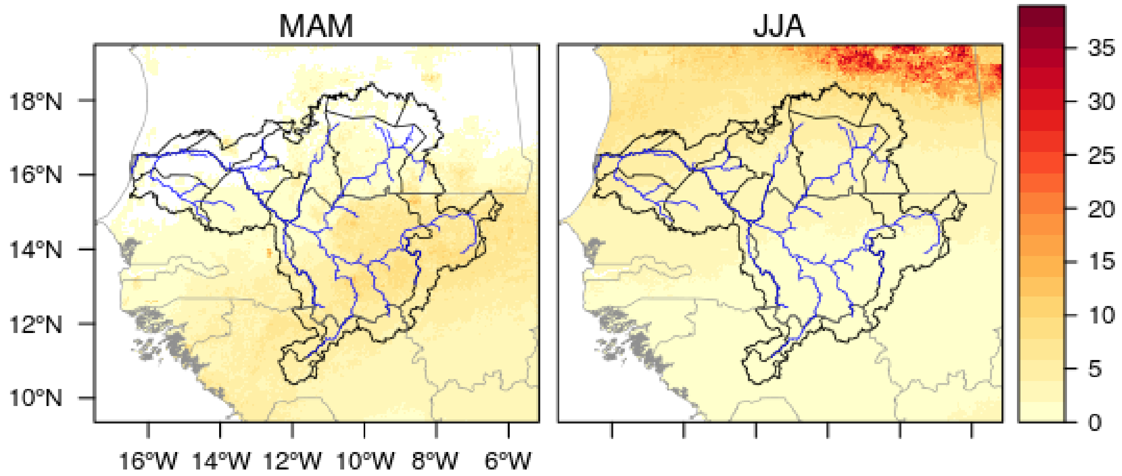

Figure 13: L-Mean (mean) of **iqr**

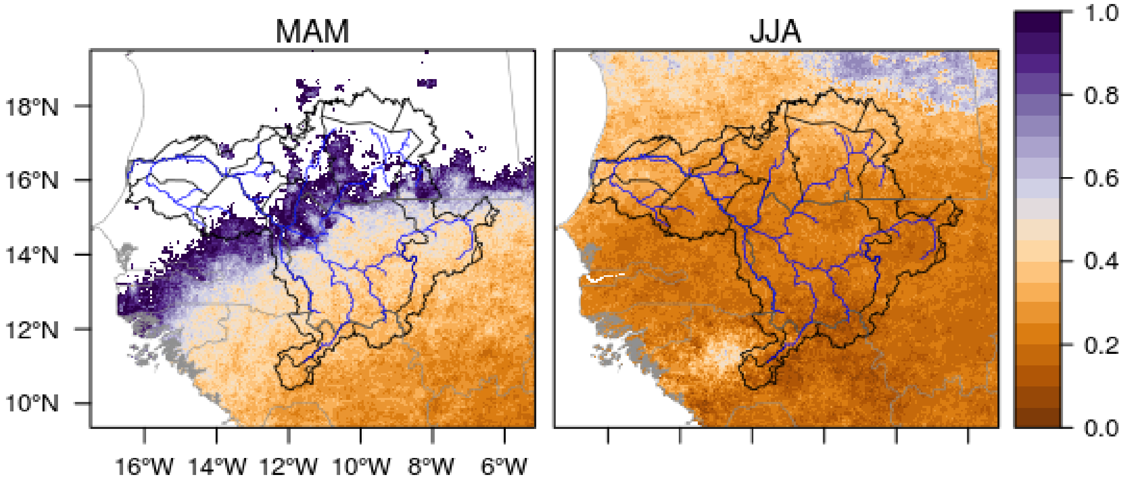

Figure 14: L-CV of **iqr**

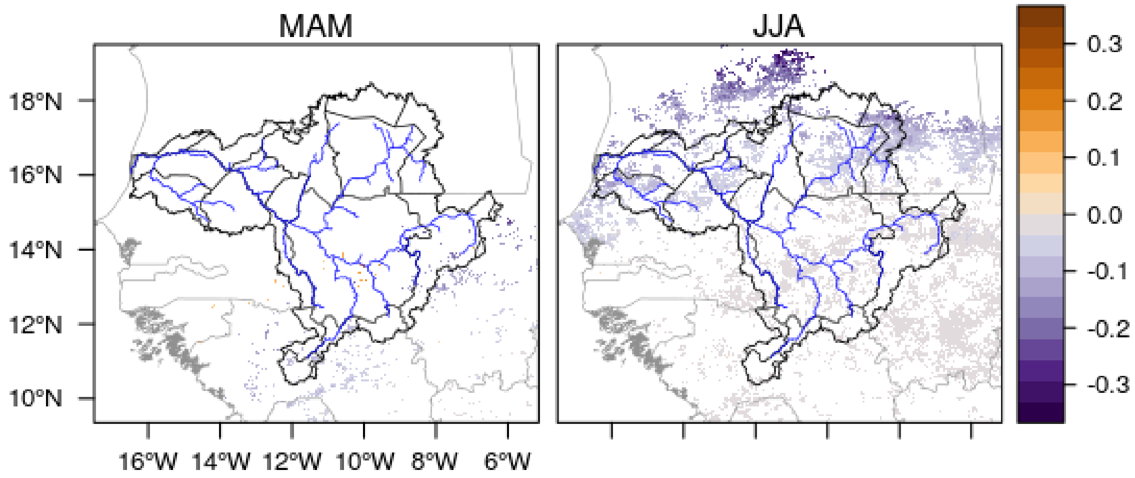

Figure 15: Mann-Kendall trend vs time of **iqr** (quantity per year)

Description

The analysis of dry spell patterns hes been preliminarly conducted for two different seasons: Northern Emishere Springs (MAM) and Summer (JJA). Precipitation values are taken from CHIPRPS Dataset (Funk et al. (2015)). The time series spans from 1981 to 2018. Both periods are selected to calculate the dry spell indices seperately. Figure 1 show the avarage, corresponding to the first L-Moment (Hosking (2019)), of the number of dry spells whose length is between 3 and 9 days that can occur in MAM and JJA periods respectively. The blank area in MAM map means that there is no numeric value: in these area no short dry spell occur on that period and there can be a period of no rain covering all the season. In fact the values in the adjacent area tend to be low. Figure 2 shows the variability , respesented by L-CV, of the mean short dry spell for the the entire sample. for both MAM and JJA. Figure 3 is an estimation of possible trend after Mall-Kendall statistical testing. It corresponds to the number of dry spells may avaragely increas or decreases per every year. In most cases the dependence of number of dry spell versus time is very poor. Figure 3 shows the espected trend, measured as number of short dry spells per year, where it is assumed to be significant (*p-value<=0.1*): during MAM no significant trend appears whereas during JJA small trends appears, specially in the Southern part, around between -0.05 and -0.015 in the Southern part of the basin (more rainy) and a slightly positive trend on the Southern part (more arid). Figures 4,5 show the mean,the L_CV for both MAM and JJA. The trend of the expected values of the number of all the dry spells longer than 3 days is illustrated in 6 : no significant trend occurs in the souththern part whereas in the northen part of the basin the number of dry spell tends to avaragely increase.

Figures 7 and 10 shows the MAM and JJA mean and the seasonal 90th percentile respectively, averaged on the whole 37-year long sample. Figures 8 and show the correspondings L-CVs on the whole 37-year long sample for MAM and JJA. Figures 9 and 12 illustate the trend of mean and 90th percentile duration against time deriving from Mann-Kendall statistical test. No significant trend of dry spell duration appears in MAM season whereas in JJA season area thera are zones with significant trend that is close to 0 in the Southern part and reach values up to -0.4 days/year (i.e. -12 days in 30 years)(Figure 12) in the Northern part of the Senegal Basin.

Finally , the variability of seasonal dry spell duration is given by the interquartile range function calculated aggregating the dry spell durations of each season. Figure 13 shows the avarage. Figure 14 shows the L-CV. L-CV is around values lower than 0.5 in most part of the areas for both MAM and JJA seasons. In MAM season (drier season) in areas with a dry climate (Northern part) and with a low number of dry spells L-CV of *iqr* tends to increase. L-CV of *iqr* presents patterns similar to the ones of L-CV of *drySpellCount* , Figure 2. Figure 15 shows the Man-Kendall trend whis is close to zero in the Southern part whereas is negative araound (-0.2 day/year) in the Northern part.

Discussion

The illustrated aggregation yearly indices resumes dry spells dynamics over two specific seasons: MAM and JJA. The temporal variation of dry spells over the year is relatively poor. In MAM, when precipitation is very low and and no significant temporal variability of dry spells can be retrieved by the analysis of the observation. In JJA, the temporal variation of dry spell duration is relatively higher but many area with no trends are present. Dry spell duration trend is quasi constant in the Souther Part of the basin whereas tends to increase in the Northern part. The number of dry spells in JJA tends to increase up to 0.20 number/year in Northern and Central part of the Basin, whereas there is no significant trend in the outhern part, except for short-duration dry spells whose number tends to decrease in the Southern part of asin.However, outcomes are in contrast with the ones obtained by Bichet and A (2018) according to which, in Sahel Region, the number of dry spells tends to increase but the duration tends to decrease.

Foreword

The outcomes of this preliminary analyis should have been comparad with crop data , e.g. definition and guidelined for the sowing and growing periods of the different types of crop, harvesting data from crop modelling data, for a better comprehension of the nexus between dry spell and agriculture. Even if dry spell variation, in this analysis, results to bevery poor to be retrieved from statistical analysis of spatially-gridded precipitation data, climate variability affects significantly rainfed agricultural activities of the Senegal River Basin Area. A further detailed analysis is required.

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