PRECIPITATION INDICES TRENDS AND CORRELATIONS AT A RAINGAUGE STATION IN PORTUGAL

Maria João Guerreiro
Assistant Professor
CIAGEB, Faculty of Science and Technology
University Fernando Pessoa, Porto, Portugal
mariajoao@ufp.edu.pt

Teresa Lajinha
Assistant Professor
CIAGEB, Faculty of Science and Technology
University Fernando Pessoa, Porto, Portugal
tlajinha@ufp.edu.pt

Isabel Abreu
Assistant Professor
CIAGEB, Faculty of Science and Technology
University Fernando Pessoa, Porto, Portugal
iabreu@ufp.edu.pt

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ABSTRACT
The objective of this study is to provide insight on precipitation indices trends, based on daily precipitation records, and the SPI (Standardized Precipitation Index), based on monthly precipitation records, evaluate correlations and establish relationships between them in the 1911-1999 period. A negative trend was observed in the month of March for several indices, as well as a tendency for the dry semester to start sooner.

KEYWORDS
Climate change, precipitation indices, CLIVAR, SPI

RESUMO
O objectivo deste estudo é avaliar tendências temporais em índices de precipitação mensais, calculados com base na precipitação diária, e no índice de precipitação SPI (Standardized Precipitation Index), calculado com base na precipitação mensal, na estação udométrica do Chouto, avaliar correlações e estabelecer relações entre os vários índices, no período de 1911-1999. Observa-se uma tendência de decréscimo para o mês de Março em diversos índices e uma tendência para uma antecipação no início do semestre seco.

PALAVRAS-CHAVE
Alterações climáticas, índices de precipitação, CLIVAR, SPI

1. INTRODUCTION

Observational records and climate projections indicate that water resources might be influenced by climate change, which will also affect ecosystems and human societies (Bates et al.15).

The Intergovernmental Panel on Climate Change (IPCC 7-22), refers that precipitation trends in the Mediterranean region, Sahel, southern Africa and parts of southern Asia have declined from 1900 to 2005. Durão et al. (241-42) state that, based on time series records for Mediterranean climate areas, most of the actual studies and projections of rainfall patterns indicate a decrease in the rainfall amounts but an increase in the frequency of heavy/intense rainfall events, mostly in the winter season, which may have repercussions on soil erosion.

In spite of this precipitation decreases, an increase in heavy precipitation events has also been verified in Europe by Tank and Können (3665-80) with stronger increases in the cool season (Bates et al.28).

Climate change can be studied based not only in terms of tendencies in temperature but also by analyzing changes in precipitation, characterized by changes in the mean, variability and extremes (WMO 1-12).

Extreme weather events, like heavy rainfall and drought, are economical and human costly and damaging, so, knowledge of their future trends are mandatory for planning adaptation strategies (Van der Linden and Mitchell 15-21). Tank and Lenderink (4-31) sustain that economic development and living conditions sustainability depends on our ability to manage the risks linked to extreme events.

River flows, lake and wetland levels, and evaporation will be affected by changes in mean and extreme values of precipitation. Crops damage, soil erosion and surface and groundwater contamination, with an increasing risk of diseases and a possible loss of property could be consequences of more intense precipitation events. In contrast, a rising in drought events may conduct to lower yields and possible failure in agriculture and livestock development, which will lead to shortage in food and water, increase of wildfires, and also loss of property. Based on this kind of interrelations, climate variability information integrated into water resources management would help to adapt to longer term climate change impacts (Bates et al.75).

Three indices of extreme rainfall: extreme intensity - average intensity of rain falling above the long-term 95th percentile; extreme frequency - number of precipitation events above the long-term 95th percentile; and extreme percent - proportion of total rainfall falling above the long-term 95th percentile, had be examined by Nicholls, Trewin and Haylock (1-22), who had suggested that the extreme intensity incorporates changes in all events above the upper percentiles, and if the number of wet days changes equally over all intensities, the extreme intensity will not change. In a study developed by the authors the results did not provide strong evidence of climate becoming more extreme or variable, although they point out that significant changes could possibly occur at a regional level (Nicholls, Trewin, and Haylock 1-22).

The CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (CLIVAR) published a series of indices for characterization of climate variability and change, of which 40% are related to precipitation.

McKee, Doesken, and Kleist (17-22), developed an index based on monthly precipitation totals that had been used as a drought index, the SPI (standardized precipitation index), but some authors had also suggested that this index can be used as an indicator of the progress of soil saturation conditions conducting to floods (Seiler, Hayes and Bressan 1365-75).

The SPI was defined as the number of standard deviations that the experiential cumulative precipitation at a given time scale (normally a month, 3 or 6 months and 1 or 2 years) would deviate from the long-term mean. After fitting a Gamma distribution function to the cumulative precipitation data this is approximately transformed to a normal standardized distribution (Ntale and Gan 1335-57), so a SPI equal to zero implies that the corresponding amount represents 50% of the cumulative gamma fitted distribution (McKee, Doesken and Kleist 17-22). SPIs ranging from −1 to +1 express a normal pluviometric regime and values out of this range represent relevant deviations from the normal rainfall amount. SPIs ranging from +1 to +2 are associated with moderately wet and very wet episodes and SPI values exceeding +2 are representative of extremely wet monthly episodes. Moderately dry, very dry and extremely dry spells are characterized by the same SPI ranges with a negative sign (Lana, Serra and Burguen 1669-91).

To identify significant linear trends at monthly, seasonal and annual time scales, several precipitation indices were evaluated by Norrant and Douguédroit (89-106) for 63 stations in the Mediterranean, and a few significant monthly trends were identified, diminishing primarily during the winter months and especially in March in the Atlantic region. At the same time, it was observed a significant decrease in winter rainfall on the Iberian Peninsula during the second half of the 20th century (Bustins, Vide and Lorenzo 171-76).

Upon a study carried by Lima, Marques and Lima (11-18) the annual precipitation series for nine stations in Portugal show no trend, yet a monthly level analysis showed that there is a decreasing tendency in the rainfall of March and November, which is compensated by an increase in December and January, although not significant.

Considering the six general drought categories defined by Wilhite and Glauntz (in McKee, Doesken, and Kleist 17-22): meteorological, climatic, atmospheric, agricultural, hydrologic and water management, and that drought can be defined as a decrease in precipitation within a time period, a relation may be established between the time period in which these droughts occur and the impacts on soil moisture content, groundwater flow, stream flow and reservoir storage (Abreu, Guerreiro and Lajinha 2).

The main objectives of this study were: a) to evaluate the correlation between the SPI and the indices suggested by the World Climate Research Programme (CLIVAR), being SPI based on monthly precipitation and the CLIVAR indices based on daily precipitation; b) determine trends in both types of indices at the monthly time scale; c) and differences between the first and the second half of the series.

2. DATA AND METHODS

2.1 DATA

Chouto raingauge was selected for analysis, and daily precipitation records were downloaded from the water institute INAG (www.inag.pt) from 1911 to 1999. As indicated by Guerreiro, Abreu and Lajinha (74), a homogeneity test was performed on the annual data using the Shapiro-Wilk parametric hypothesis test of composite normality with a significance level of 5%, and no missing days were identified, emphasizing the good quality of the data set.

2.2 INDICES

The average monthly precipitation was determined for the periods 1911-1955 (45 years) and 1956-1999 (44 years) and a t-test was applied to evaluate the hypotheses of an equal mean. The relative precipitation for each month (RP_{Month}) in an hydrologic year $RP_{Month} = PPT_{Month} / PPT_{Hydrologic\ Year}$ was evaluated for the entire dataset.

Extreme frequency indices used in this study were related to total number of days, and associated precipitation above or below a certain threshold, their relative value (intensity), and duration of dry and wet spells, whereas, SPI was evaluated using the monthly precipitation values.

As already mentioned, these indices were suggested by the Climate Variability and Predictability project developed for the World Meteorological Organization (CLIVAR). These indices were further analyzed, monthly, for trends in extreme rainfall: intensity, frequency and respective relative values (Table 1).

Table 1. CLIVAR Indices used in the study

PPT	Monthly total precipitation	$PPT_j = \sum_i RR_{ij}$
PPT_{wet}	Monthly total precipitation when precipitation ≥ 1 mm	$PPT_{wetj} = \sum_{w=1}^{W} RR_{wj}$
Rx1day	Monthly maximum 1-day precipitation:	$Rx1day_j = \max(RR_{ij})$
Rx5day	Monthly maximum consecutive 5-day precipitation	$Rx5day_j = \max(RR_{kj})$
NDD	Monthly count of days with precipitation < 1 mm	$NDD_j = days(RR_{ij} < 1)$
NWD	Monthly count of days with precipitation ≥ 1 mm	$NWD_j = days(RR_{ij} \geq 1)$
N_p	Monthly count of days with precipitation ≥ P_p	$N_{pj} = days(RR_{ij} \geq p)$
CDD	Monthly maximum length of dry spell, maximum number of consecutive days with rainfall < 1mm	$CDD_j = \max(days(RR_{ij}) \leq 1)$
CWD	Monthly maximum length of wet spell, maximum number of consecutive days with RR ≥ 1mm	$CWD_j = \max(days(RR_{ij}) > 1)$
%NWD	Monthly percentage of days with precipitation ≥ 1 mm	$\%NWD_j = \frac{days(RR_{ij} \geq 1)}{n_j}$
SDII	Monthly simple daily intensity index	$SDDII_j = \frac{\sum_{w=1}^{W} RR_{wj}}{W}$

j - month in analysis
RR_{ij} – daily precipitation amount on day *i* in month *j*
RR_{kj} – precipitation amount for the 5-day interval ending day *k*, in month *j*
RRwj - daily precipitation amount on wet days, *w* (*RR* ≥ 1mm) in month *j*
W - number of wet days
p - user defined threshold (75, 90, and 95th percentiles)
P_p - precipitation ≥ 75, 90, 95 percentiles

As suggested by Bates et al. (28) and Nicholls, Trewin, and Haylock (1-22) percentiles of daily precipitation rather than a fixed value were used to evaluate extreme precipitation events, due to the spatial variation of rainfall intensity. The 75, 90 and 95 percentiles were evaluated using all data set and the indices were examined on a monthly basis as suggested by Silva et al.(1-4) and Guerreiro, Abreu and Lajinha (74-75).

The standardized precipitation index (SPI) was evaluated for different time scales: SPI 1-month, SPI 3-months, SPI 6-months and SPI 12-months.

2.3 TRENDS AND CORRELATIONS

Like a number of studies that have focused on the statistical significance of linear trends of extreme precipitation indices (Haylock and Goodess 760-64), a linear trend for RP_{Month}, CLIVAR indices and the SPI was evaluated for every month using regression analysis. The slope of the regression was tested for being equal to zero and identified whenever statistically different, considering a 5% significance level

The correlation between each CLIVAR index and each time scale SPI and its significance (p-value) were estimated and its degree of association determined (Table 2) based on the fact that a coefficient of determination r^2= 0.49 (r=0.7) means that approximately 50% of the variance of the dependant variable is explained by the variance of the independent variable, whereas a correlation coefficient of 0.3 corresponds to r^2=0.09.

Table 2. Correlation coefficient and degree of association (WEBSTER)

Correlation coefficient range	Degree of association
|0.0 – 0.3|	Little or no association
|0.3 – 0.7|	Weak association
|0.7 – 1.0|	Strong association

3. RESULTS AND DISCUSSION

The comparison of the monthly precipitation average values for the first and second half of the dataset (1911-1955 and 1956-1999) suggests that March is the only month in which the difference of the mean is statistically different to 5% significance. Figure 1 shows that, even though not statistically different (Table 3), all months have an average precipitation in the 1956-1999 period higher than the average precipitation in the 1911-1955 period, except for the month of March, that has had a significant decrease in average precipitation.

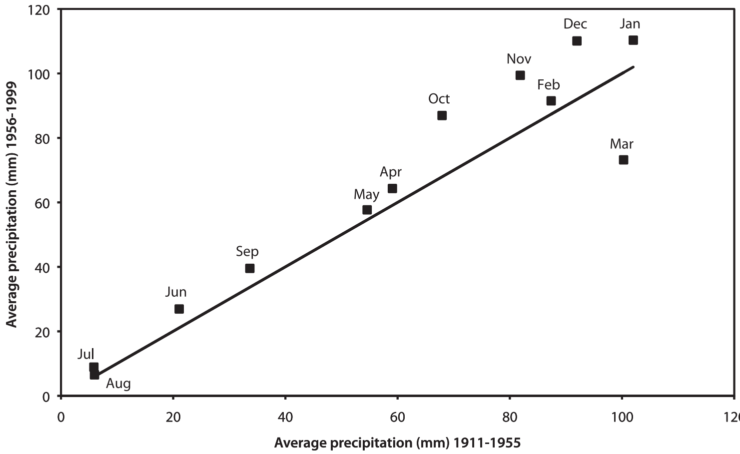

Figure 1. Average monthly precipitation 1911-1955 vs. 1956-1999

Table 3. Comparison of average monthly precipitation between 1911-1955 and 1956-1999

	p-value	% variation
Jan	0,649	8,1
Feb	0,8	4,7
Mar	0,043	-27
Apr	0,543	8,9
May	0,747	5,7
Jun	0,26	27,8
Jul	0,811	8,7
Aug	0,124	51,9
Sep	0,416	17,4
Oct	0,132	28
Nov	0,207	21,4
Dec	0,327	19,7

Considering the average precipitation values within the humid semester (October to March) and the dry semester (April to September), there is no significant difference between them (Table 4) in the two periods considered (1911-1955 and 1956-1999). However, if March is taken out of the humid semester, the difference between both periods is statistically significant at the 10% level of significance, which means that the humid semester is indeed more humid until March, which suggests that the dry semester is starting sooner.

Table 4. Comparison of precipitation 1911-1955 vs. 1956-1999: Apr-Sep, Oct-Mar and Oct-Feb

	April-September	October-March	October-February
1911-1955	30,02	88,57	86,22
1956-1999	33,95	95,24	99,65
p-value	0,22	0,3	0,06

The humid semester (October-March) accounts for 72.8% of annual precipitation (hydrologic year). From Table 5 it can be seen that there is a negative trend in February, March and July for relative precipitation in an hydrologic year, although only March is statistically significant to the 5% level. Interestingly, August shows a positive trend, with a p-value of 0.056 but representing only 1.1% of total annual precipitation. This result is also supported by the difference observed in % variation between periods 1911-1955 and 1956-1999 (Table 3) with a p-value of 0.124.

Table 5. Trend analysis of percentage of monthly precipitation in hydrologic year

	Average RP_{Month} (%)	slope	p-value
Jan	13,7	1,54E-05	0,969
Feb	11,8	-3,29E-04	0,346
Mar	11,7	-1,12E-03	0,001
Apr	8,7	1,51E-04	0,542
May	7,7	2,02E-04	0,376
Jun	3,2	8,28E-05	0,527
Jul	0,9	-2,39E-06	0,97
Aug	1,1	1,25E-04	0,056
Sep	5,4	6,17E-05	0,8
Oct	10,6	4,42E-04	0,187
Nov	11,9	3,00E-04	0,332
Dec	13,1	1,80E-04	0,65

As indicated by Durão et al. (248-49), a decrease in precipitation was observed, however, in this series, it was only verified for the month of March, and an increase in daily maximum precipitation and 5-day maximum precipitation was observed in October. However, unlike Durão et al. (241-42), the increase in frequency of heavy/intense rainfall events was not verified, as can be seen from the index N_{95} in Table 6. On the other hand, the increase in Rx1day and Rx5day in October was expected according to Bates et al. (106).

Table 6. Significant trends of CLIVAR precipitation indices

	slope												
	PPT	PPT_{wet}	Rx1day	Rx5day	NDD	NWD	N_{75}	N_{90}	N_{95}	CDD	CWD	%NWD	SDII
January	-	-	-	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-	-	-	-
March	-0,714	-0,722	-	-	0,069	-0,069	-	-	-	0,078	-0,041	-0,222	-
April	-	-	-	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-	-	-	-	-	-
October	-	-	0,240	0,335	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-	-	-	-

March exhibits a negative trend to total precipitation (PPT), as discussed above, but also for number of wet days (NWD), consecutive wet days (CWD), and monthly percentage of wet days (%NWD) and a positive trend to number of dry days (NDD) and number of consecutive dry days (CDD).

October shows a significant positive trend to monthly maximum 1-day (Rx1day) and 5-day (Rx5day) precipitation, whereas no significant trend was observed in the other indices. This suggests that precipitation in the other wet days is lower, since there is no significant difference neither in total precipitation (PPT_{wet}) nor in number of wet days (NWD) as already indicated by Guerreiro, Abreu and Lajinha (76).

Unlike Tank and Können (3665-80) and Bates et al. (67-107) which expect southern Europe to become drier, this trend was not observed except for the month of March, which was also identified by Norrant and Douguédroit (89-106) for the Mediterranean.

The precipitation index SPI-1 showed a slope significantly different from zero in the month of March (Table 7). This result implies that there is a tendency to a dryer March, in accordance with the results evidenced by the other indices, with an impact at the soil moisture content level and surface runoff. SPI-1 cannot be evaluated in the months of July, August, and September because there are years with zero monthly precipitation in these months.

Following the results obtained by Guerreiro, Abreu and Lajinha (74), in which no annual trend on precipitation was verified, the SPI-12 evaluated in this study does not show a significant trend as well.

The significant decrease in March wet periods (lower SPI-1 values) suggests that it is compensated by the non-significant increase in the other months.

On one hand, SPI-3 does not show any statistically significant trend whereas SPI-6 showed a significant increase in wet periods for the months of September, October and November. Because the increase is not significant at the monthly SPI scale, this increase needs to be accumulated in order to become significant, evidenced in SPI-6, and not in SPI-3. An increase in wet periods (SPI-6) may lead to impacts on soil erosion resulting in increased soil degradation risks (Durão et al. 241).

Table 7. SPI trends

	slope		
	SPI 1month	**SPI 3 months**	**SPI 6 months**
January	-	-	-
February	-	-	-
March	-0,013	-	-
April	-	-	-
May	-	-	-
June	-	-	-
July	n.a.	-	-
August	n.a.	-	-
September	n.a.	-	0,009
October	-	-	0,011
November	-	-	0,010
December	-	-	-

A strong correlation was obtained between SPI-1 and the CLIVAR variables in most months, because SPI is evaluated on monthly precipitation data alone, which somehow smoothes out the daily precipitation variation. This effect explains the weak association in Rx1day, N90, N95, CDD, CWD, and SDII (Table 8), being these indices more dependent on specific precipitation days and length of wet or dry spells. In fact, the trend observed in CLIVAR indices in March is also observed in SPI-1, being the majority of the CLIVAR indices strongly correlated to SPI (Table 8). The trend observed in October for Rx1day and Rx5day was not obtained in SPI-1, mostly because no trend was observed in other CLIVAR parameters in this month indicating the limitation in using SPI to reflect precipitation extreme indicators.

Rx1day and Rx5day and SDII may be useful indices for analysis of soil erosion susceptibility as they reflect precipitation intensity. Likewise, CDD and CWD will indicate a dryer or wetter soil, with implications on antecedent moisture content and respective tendency to surface runoff. Therefore, SPI is not a good indicator for analysis of these phenomena.

Even though SPI-3 does not present a statistically significant trend, it shows a strong association with monthly precipitation in September and October and Rx5day and N75 in the month of October.

As expected, there is a decrease in the strength of the association as SPI is evaluated for longer time scales.

Table 8. Monthly correlation coefficients between CLIVAR indices and SPI

							SPI-1						
	PPT	**PPT_{wet}**	**Rx1day**	**Rx5day**	**NDD**	**NWD**	**N_{75}**	**N_{90}**	**N_{95}**	**CDD**	**CWD**	**%NWD**	**SDII**
Jan	0,81	0,81	0,73	0,82	-0,81	0,81	0,75	0,65	0,56	-0,75	0,71	0,81	0,75
Feb	0,85	0,85	0,77	0,82	-0,85	0,85	0,77	0,65	0,56	-0,66	0,73	0,85	0,69
Mar	0,85	0,85	0,69	0,8	-0,8	0,8	0,75	0,59	0,44	-0,66	0,69	0,8	0,6
Apr	0,91	0,92	0,69	0,86	-0,76	0,76	0,8	0,56	0,4	-0,5	0,63	0,76	0,63
May	0,87	0,87	0,82	0,88	-0,87	0,87	0,78	0,57	0,54	-0,6	0,7	0,87	0,59
Jun	0,76	0,76	0,76	0,76	-0,71	0,71	0,56	0,45	0,32	-0,58	0,65	0,71	0,64
Jul	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Aug	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sep	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Oct	0,88	0,88	0,68	0,81	-0,78	0,78	0,78	0,67	0,62	-0,65	0,67	0,78	0,63
Nov	0,93	0,93	0,82	0,89	-0,89	0,89	0,86	0,76	0,61	-0,65	0,7	0,89	0,63
Dec	0,85	0,85	0,72	0,82	-0,84	0,84	0,81	0,72	0,66	-0,65	0,75	0,84	0,71
							SPI-3						
	PPT	**PPT_{wet}**	**Rx1day**	**Rx5day**	**NDD**	**NWD**	**N_{75}**	**N_{90}**	**N_{95}**	**CDD**	**CWD**	**%NWD**	**SDII**
Jan	0,63	0,63	0,61	0,66	-0,57	0,57	0,57	0,53	0,53	-0,49	0,51	0,57	0,58
Feb	0,58	0,58	0,47	0,54	-0,52	0,52	0,55	0,51	0,44	-0,35	0,49	0,52	0,32
Mar	0,61	0,61	0,43	0,53	-0,58	0,58	0,5	0,41	0,26	-0,41	0,48	0,58	0,28
Apr	0,33	0,33	0,24	0,33	-0,22	0,22	0,31	0,2	0,07	-0,06	0,22	0,22	0,22
May	0,53	0,53	0,48	0,52	-0,46	0,46	0,47	0,48	0,47	-0,33	0,31	0,46	0,34
Jun	0,5	0,5	0,48	0,49	-0,32	0,32	0,47	0,39	0,3	-0,16	0,34	0,32	0,34
Jul	0,32	0,32	0,29	0,34	-0,19	0,19	0,31	0,19	0,16	-0,17	0,18	0,19	0,26
Aug	0,39	0,39	0,33	0,36	-0,32	0,32	0,29	0,19	0,14	-0,21	0,27	0,32	0,26
Sep	0,74	0,74	0,67	0,69	-0,64	0,64	0,66	0,49	0,49	-0,58	0,56	0,64	0,61
Oct	0,81	0,81	0,61	0,73	-0,67	0,67	0,72	0,65	0,61	-0,46	0,55	0,67	0,55
Nov	0,64	0,64	0,49	0,6	-0,63	0,63	0,59	0,51	0,35	-0,43	0,51	0,63	0,44
Dec	0,67	0,67	0,55	0,66	-0,59	0,59	0,67	0,62	0,55	-0,4	0,54	0,59	0,54

						SPI-6							
	PPT	**PPT_{wet}**	**Rx1day**	**Rx5day**	**NDD**	**NWD**	**N_{75}**	**N_{90}**	**N_{95}**	**CDD**	**CWD**	**%NWD**	**SDII**
Jan	0,55	0,55	0,57	0,57	-0,49	0,49	0,47	0,46	0,45	-0,42	0,46	0,49	0,51
Feb	0,54	0,54	0,42	0,51	-0,5	0,5	0,52	0,5	0,38	-0,32	0,45	0,5	0,32
Mar	0,47	0,47	0,4	0,44	-0,41	0,41	0,39	0,37	0,21	-0,18	0,38	0,41	0,27
Apr	0,23	0,23	0,18	0,22	-0,07	0,07	0,2	0,07	0,05	0,02	0,09	0,07	0,31
May	0,31	0,31	0,4	0,32	-0,18	0,18	0,27	0,39	0,49	-0,11	0,11	0,18	0,3
Jun	0,25	0,26	0,25	0,28	-0,19	0,19	0,18	0,22	0,26	-0,15	0,21	0,19	0,18
Jul	0,15	0,15	0,15	0,14	0,02	-0,02	0,21	0,14	0,06	0,1	-0,04	-0,02	0,12
Aug	0,05	0,05	0,06	0,05	0,01	-0,01	0,06	0,22	0,04	-0,02	-0,07	-0,01	0,01
Sep	0,32	0,32	0,27	0,26	-0,27	0,27	0,3	0,26	0,3	-0,2	0,25	0,27	0,26
Oct	0,7	0,7	0,45	0,62	-0,54	0,54	0,62	0,56	0,5	-0,31	0,44	0,54	0,43
Nov	0,66	0,66	0,51	0,62	-0,62	0,62	0,63	0,54	0,38	-0,4	0,48	0,62	0,46
Dec	0,63	0,63	0,54	0,62	-0,54	0,54	0,64	0,57	0,51	-0,4	0,5	0,54	0,55
						SPI-12							
	PPT	**PPT_{wet}**	**Rx1day**	**Rx5day**	**NDD**	**NWD**	**N_{75}**	**N_{90}**	**N_{95}**	**CDD**	**CWD**	**%NWD**	**SDII**
Jan	0,29	0,29	0,31	0,35	-0,18	0,18	0,29	0,31	0,21	-0,08	0,2	0,18	0,34
Feb	0,1	0,1	0,09	0,06	-0,08	0,08	0,12	0,14	0,07	0,03	0,14	0,08	0
Mar	0,05	0,05	0,06	0,03	-0,03	0,03	0,08	0,08	-0,02	0,01	-0,02	0,03	-0,03
Apr	0,18	0,18	0,13	0,16	-0,05	0,05	0,24	0,07	0,04	0	0,04	0,05	0,26
May	0,15	0,15	0,19	0,14	-0,06	0,06	0,14	0,14	0,19	-0,07	0,09	0,06	0,24
Jun	0,09	0,09	0,12	0,1	-0,13	0,13	0,01	0,03	0	-0,23	0,08	0,13	0,13
Jul	-0,02	-0,01	0	-0,03	0,06	-0,06	0,04	-0,05	-0,06	-0,07	-0,13	-0,06	0,04
Aug	0,01	0,01	0,03	0	0,03	-0,03	0	-0,01	0,05	0,08	-0,03	-0,03	0,02
Sep	0,2	0,2	0,22	0,23	-0,14	0,14	0,18	0,17	0,14	-0,11	0,1	0,14	0,25
Oct	0,06	0,06	0,08	0,07	0	0	0,04	0,15	0,14	0,16	-0,08	0	0,11
Nov	0,24	0,24	0,22	0,27	-0,25	0,25	0,16	0,11	0,14	-0,17	0,19	0,25	0,13
Dec	0,17	0,17	0,18	0,17	-0,07	0,07	0,22	0,16	0,15	0	0,04	0,07	0,29

4. CONCLUSIONS

The analysis suggests that the dry semester (April-September) may be starting sooner, in March, with all the implications that this may have at the management of water resources, especially in agriculture.

SPI-1 noticed the decrease in precipitation in the month of March and SPI-6 did it for the increase in precipitation in the wet period.

CLIVAR indices noticed the decrease in precipitation in the month of March as well as other extreme indices related to an increase in the number of dry days and continuous dry days. It has not, however, perceived the increase in precipitation in the wet period.

SPI is not a good indicator for the indices that represent sub-monthly values of precipitation.

During the month of March there has been a significant reduction in water availability at the soil moisture content and surface runoff, with an increase in September, October and November with possible aquifer recharge.