DETECTION OF POSSIBLE ALTERATIONS (TRENDS) IN THE TEN DAY PERIOD RATIO BETWEEN ACTUAL AND POTENTIAL EVAPOTRANSPIRATION DURING THE YEARS 1890 TO 2005 IN THE REGION OF CAMPINAS, SÃO PAULO STATE, BRAZIL

Gabriel Constantino Blain, Marcelo Bento Paes de Camargo, Antônio Roberto Pereira

1 Eng. Agrícola, PqC-I, Centro de Ecofosiologia e Biofísica, Instituto Agronômico, Campinas, Fone:(19)32425230, gabriel@iac.sp.gov.br

2 Eng. Agrônomo, PqC-I Doutor, Centro de Ecofosiologia e Biofísica, Instituto Agronômico, Campinas

3 Eng. Agrônomo, Prof. Doutor, Departamento de Ciências Exatas, Universidade de São Paulo, Piracicaba

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Abstract:The aim of the work was to detect continuous trend or discontinuity in the variability of the ER/EP series, in ten day period, in the region of Campinas-SP from 1890 to 2005 (116 years). Precipitation and air temperature data were used to estimate the water balance. The ER/EP series temporal variability was evaluated based on beta probability density function. Continuous trend were detected in the variability of ER/EP ten day period series in the months of August. Those tendencies are related to a water deficit intensifications conditions at this month observed at the last twenty nine years of the study. In other months and periods, the alterations stayed inside of the inherent climatic variability of the tropical/subtropical region of Campinas-SP. Any trend could be detected on those others months.

Key words: Climate change, climate variability, Agronomic Institute

DETECÇÃO DE POSSÍVEIS ALTERAÇÕES NA VARIABILIDADE TEMPORAL DA RAZÃO ENTRE EVAPOTRANSPIRAÇÃO REAL E POTENCIAL NOS ANOS DE 1890 A 2005 NA REGIÃO DE CAMPINAS-SP

Resumo: O objetivo do trabalho foi detectar tendências contínuas ou descontinuidades na variabilidade das séries decendiais da relação ETR/ETP, na região de Campinas-SP entre os anos de 1890 a 2005 (116 anos). Dados de temperatura média do ar e de precipitação pluvial foram utilizados na estimação do balanço hídrico. A variabilidade temporal da razão ETR/ETP foi avaliada por meio da função densidade de probabilidade beta. Tendências contínuas foram detectadas nos meses de agosto nos anos de 1977 a 2005. Essa alteração apontou para intensificação nas condições de deficiência hídrica. Nos demais meses e períodos as alterações permaneceram dentro da variabilidade climática inerente a região de Campinas-SP, não sendo, portanto detectada nenhuma alteração na variabilidade dos valores de ETR/ETP.

Palavras Chave: Mudança climática, variabilidade climática, Instituto Agronômico

INTRODUCTION

The water deficiency is responsible for approximately 56% of the Brazilian productivity breaks. Its limits the photissintetical process by promoting the estamatal closing. Considering that premise, several productivity break estimate models use the ratio between actual evapotranspiration and potential evapotranspiration (ER/EP) to quantify the water factor influence in the final production of the cultures. As examples, it can be mentioned the FAO model productivity break proposed by DOORENBOS & KASSAM (1994) that relates cultures productivity break to the ER/EP relationship. Therefore, It becomes evident the importance of detecting possible changes (or trends) in the variability of ER/EP values over a historical series.

Existent since 1886, the Agronomic Institute of Campinas (IAC) of the State of São Paulo, is one of the Brazilian research centers pioneers in the meteorological data collection. Since 1890, it is collected air temperature and rainfall daily data originating one of the most longer continuous meteorological series of the country. Therefore, considering the agricultural importance of the ER/EP ratio and reading the meteorological data series readiness of IAC, that allows the estimation of THORNTHWAITE & MATHER (1955) water balance model, the aim of the work was to detect continuous trend or discontinuity in the variability of the ER/EP series, in ten day period, in the region of Campinas-SP from 1890 to 2005 (116 years).

MATERIAL AND METHODS

Precipitation and air temperature daily data of the representative weather station of the City of Campinas-SP (22º54'S; 47º05'W; 669m) were used. THORNTHWAITE & MATHER (1955) water balance model were used to estimate ER and EP values in ten day period from 1890 to 2005. After that, the thirty six ER/EP series was divided into four equally spaced periods of twenty nine years, such as: 1890 to 1918 (P1), 1919 to 1947 (P2), 1948 to 1976 (P3), and 1977 to 2005 (P4). The periods were certain based on the available data series (116 years) and on the recommendations of World Meteorological Organization for the minimum necessary interval of time for climatic characterization of a region (30 years).

To evaluate distributions possible temporal changes in the occurrence of ER/EP values, P1, P2, P3 and P4 of each ten day period were compared estimating beta probability density function (BPDF) and their parameters (p and q) in the 144 groups.

The BPDF is a very flexible function, taking on many different shapes depending on the values of its two parameters. In general, for $p \leq 1$ probability is concentrated near zero, and for $q \leq 1$ probability is concentrated near 1. If both parameters are less than one the distribution is U-shaped. For $p>1$ and $q>1$ the distribution has a single mode, with more probability shifted to the right for $p>q$, and more probability shifted to the left for $q>p$. The distribution will be symmetric for $p=q$. Beta distribution parameters were fitted using the method of moments.

Kolmogorov-Smirnov (KS) test was used to verify the ER/EP temporal distribution degree of adherence to the BPDF.

Considering the statements of IPCC (2001), that indicates strong evidences of climatic variability change due man influence, the ER/EP series variability, between the years 1996 and 2005, was also evaluated. It is important to relate that the City of Campinas, one of the most important technological centers of Brazil, has one million inhabitants and shows, especially in the last two decades, impressive urban and demographic growth (VICENTE & NUNES, 2004).

RESULTS AND DISCUSSION

Evaluating the KS test, it is noted that there are good adjustments for the ER/EP distributions to BPDF.

At Table 1 are shown the p and q beta distribution parameters of each thirty six ten day period of each period.

Table 1 p and q beta distribution parameters of each thirty six decades of each period 1890 to 1918, 1919 to 1947, 1948 to 1976 e 1977 to2005 -Campinas-SP

		1890 a 1918		1919 a 1947		1948 a 1976		1977 a 2005	
Month	Ten Day	q	p	q	p	q	p	q	p
Jan	1	0.11	7.86	0.05	1.57	0.14	2.99	0.12	4.81

Jan	2	0.1	7.82	0.14	6.38	0.09	3.01	0.24	7.89
Jan	3	0.07	3.29	0.21	7.75	0.29	9.77	0.1	3.26
Feb	4	0.07	8.18	0.15	4.36	0.11	5.75	0.15	3.75
Feb	5	0.19	7.65	0.31	9.88	0.15	4.06	0.18	3.26
Feb	6	0.16	5.98	0.11	2.47	0.23	4.38	0.29	4.24
Mar	7	0.18	6.33	0.26	10.25	0.27	5.55	0.27	5.01
Mar	8	0.16	5.97	0.21	5.08	0.29	3.91	0.18	2.34
Mar	9	0.32	4.25	0.37	3.51	0.22	5.21	0.27	2.78
Apr	10	0.46	3.76	0.42	3.54	0.17	2.15	0.39	3.63
Apr	11	0.67	3.9	0.5	2.36	0.98	7.91	0.51	3.94
Apr	12	0.57	2.75	0.81	2.55	0.63	2.6	0.63	2.32
May	13	0.33	1.4	0.4	1.22	0.46	2.24	0.29	1.41
May	14	0.43	1.99	0.4	1.56	0.46	1.7	0.18	1.02
May	15	0.21	1.29	0.62	1.51	0.47	1.4	0.24	1.69
Jun	16	0.32	1.61	0.39	1.4	0.36	1.51	0.51	2.33
Jun	17	0.35	1.92	0.34	1.04	0.33	1.08	0.5	1.78
Jun	18	0.36	1.78	0.42	1.16	0.45	1.26	0.49	1.93
Jul	19	0.35	1.44	0.6	1.51	0.29	1.06	0.9	2.03
Jul	20	0.55	1.6	0.45	1.16	0.61	1.32	0.71	1.88
Jul	21	0.76	1.74	0.65	1.15	0.77	1.3	0.8	1.82
Aug	22	0.39	1.19	0.45	0.99	0.63	1.11	1.66	2.72
Aug t	23	0.5	1.44	0.67	1.26	1.05	1.33	1.14	1.48
Aug	24	0.83	2.11	0.42	0.93	0.73	0.98	0.56	0.99
Sep	25	0.63	2.21	0.48	1.02	0.43	0.63	0.31	0.63
Sep	26	0.46	1.36	0.24	0.78	0.43	0.51	0.29	0.99
Sep	27	0.1	0.63	0.34	1.09	0.33	0.66	0.2	0.56
Oct	28	0.28	2.08	0.16	0.58	0.31	0.84	0.25	0.99
Oct	29	0.12	1.61	0.2	1.12	0.12	0.89	0.15	0.7
Oct	30	0.16	2.44	0.12	0.73	0.18	2.39	0.37	1.61
Nov	31	0.24	3.61	0.12	1.32	0.19	1.25	0.47	2.21
Nov	32	0.16	6.16	0.08	1.71	0.09	0.96	0.1	1.45
Nov	33	0.3	4.82	0.11	3	0.19	1.7	0.15	1.91
Dec	34	0.1	3.6	0.12	3.48	0.05	1.57	0.17	2.26
Dec	35	0.14	5.12	0.14	3.42	0.13	4.37	0.07	2.77
Dec	36	0.04	1.71	0.06	2.46	0.1	2.6	0.15	5.75

According to ORTOLANI & CAMARGO (1987), considering the climatic normal patterns of the state of São Paulo, from October to March the precipitation exceeds the evapotranspiration; from April to September, after equilibrium among those variables, the evapotranspiration becomes larger than the rainfall, resulting in normal periods of water deficiency in most part of the state. It is noticed, through Tables 1, that the region of Campinas follows that climatic tendency mentioned by those two authors. In general, from April to August, there is an increase in the value of q, evidencing a displacement to the left of the distributions. In other words, the number of cases that the actual evapotranspiration reach the potential values decreases. This dry period has it apex in August when are observed the lowest probabilities for ER/EP =1 cases. After this month, the q parameter values begging to decrease with the smallest values being observed in December, January and, February.

A very important consideration that should be discussed is that the analysis of p and q values variation, between P1, P2, P3 and, P4 in each ten day period (presented on Table 1), must carry on the subjectivity definition of the terms “climate” and (consequently) “climatic change”. This subjectivity will be present on every statistical analyses related to this theme. In this case, it is possible, through the BPDF parameters, detect differences in the frequency (probability density) of the ER/EP occurrence values between the different historical periods. However, to determine an exact landing that settles down if such differences are relative to the natural variability of the climatic conditions of the area or if they are relative to an alteration in the expected dynamic of the elements under analysis (trend) is practically unviable.

On this sense, in spite of its statistical basis, the analyses accomplished in the study possess the same subjectivity degree that the terms “climate” and “climatic changes” presents. It also should be reminded that the region of Campinas stays in a transition area tropical/subtropical suffering influence of tropical and polar air masses systems. In that aspect, the separation between variability and climatic alteration becomes still more subjective.

According to KATZ (1991) a change in the variability of a variable that has an asymmetrical distribution will result in a transformation of such graphic representation (change on the shape of the distribution). On this sense, PITTOCK et al. (1978), affirms that a climatic alteration should contain continuous trend or discontinuity in the variability of some meteorological elements. Therefore, the paper will adopt that a climatic alteration in the expected dynamic of ER/EP series (continuous trend or discontinuity in the variability of the ER/EP series) will result in a transformation of such graphic representation (change on the shape of the distribution).

In the present study, changes in the beta distribution shape occur whenever the q parameter value overcomes the unit. On this sense, evaluating the p and q parameters presented in Table 1, it is notice, at the month of August, transformation in the graphic shape of ER/EP series. Unlike it was observed in all other analyzed series, the maximum ER/EP value (ER/EP = 1) did not present the largest absolute frequency. This indicates water deficit conditions intensification at the month of August between the years 1977 and 2005. In a more detailed analysis, it is observed in P4 strong probability density increase of the ER/EP values 0.5; 0.6; 0.7 and 0.8 and strong fall in the density of the ER/EP maximum value. According to PITTOCK et al. (1978) and KATZ (1991) it can be considered that in P4 there was alteration in the climatic dynamic of ER/EP series.

The comparison between P1, P2, P3 and P4 in the ten day periods at the others months did not evidence changes in the ER/EP series shapes. Consequently, through the proposed method, there is no possibility to detect climatic alterations in the ER/EP series among the different periods. In that way, the observed alterations can be attributed to the expected climatic variability for the region of Campinas.

In order to observe the ER/EP series variability during a period which present strong level of urbanization, it is demonstrated, at Table 2, the beta distribution parameters (q and p), adjusted at the years between 1996 and 2005. It is important to stand out that, for a study about climatic characterization, the fifteen years time interval is insufficient to establish any conclusion, and only describes the weather condition that was observed at the period.

Table 2 Beta probability density function parameters (q and p) adjusted to ER/EP series between the years of 1996 to 2005.

Month	TenDay	q	p	Month	TenDay	q	p	Month	TenDay	q	p
	1	0.13	5.40		4	0.20	9.19		7	0.30	4.34
Jan	2	0.27	11.92	Feb	5	0.07	3.31	Mar	8	0.33	10.61
	3	0.17	6.21		6	0.52	11.38		9	0.24	4.06
Apr	10	0.95	9.63	May	13	0.26	1.18	Jun	16	0.72	2.33

	11	0.72	5.21		14	0.17	0.78		17	0.51	1.34
	12	0.83	2.65		15	0.14	1.21		18	0.22	0.94
	19	0.71	1.56		22	2.31	3.46		25	0.39	0.54
Jul	20	0.86	2.48	Aug	23	2.15	1.94	Sep	26	0.25	1.03
	21	0.89	1.66		24	0.76	0.98		27	0.23	0.56
	28	0.13	0.62		31	0.59	2.80		34	0.13	1.85
Oct	29	0.12	0.44	Nov	32	0.15	6.74	Dec	35	0.06	7.47
	30	0.29	1.56		33	0.25	3.32		36	0.14	5.64

In general way, the description presented in Table 2 follows the same tendencies presented in Table 1. However, It is Observed, intensification in the changes in the BPDF shapes in the month of August. The parameter q, in the second Augusts ten day period, overcame parameter p value (q=2.15 and p=1.94). Consequently, for the first time, it is observed a distribution witch has a single mode with more probability shifted to the left.

CONCLUSION

Being considered the statistical methods and the period under analysis (1890 to 2005), continuous trend were detected in the variability of ER/EP ten day period series in the months of August. Those tendencies are related to a water deficit intensifications conditions at this month observed at the last twenty nine years of the study. In other months and periods, the alterations stayed inside of the inherent climatic variability the tropical region of Campinas-SP. Any trend could be detected on those others months.

In spite of the August related continuous trend, in a general way, the presented results do not indicate, under the agricultural water surplus point of view, strong evidences of changes in the climatic variability in the region of Campinas between the years 1890 and 2005.

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