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TIME TENDENCIES OF THE EARTH SURFACE ATMOSPHERIC PRESSURE IN SOME SOUTHERN LOCALITIES OF CHAD. PERIOD FROM 1986 TO 2005-2015

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ABSTRACT

This study has shown that the time tendencies of the earth surface atmospheric pressure in the southern part of Chad strictly occur in the interval 955.0 – 985.0 hPa and this variability is negligible as indicated by the low values of their standard deviation. It also indicates that one can accurately estimate missed data of the earth surface atmospheric pressure by the average values of its monthly or yearly means.

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INTRODUCTION

The time variation of the atmospheric pressure plays a very important role in the generation of many phenomena which occur in the atmosphere, between others, tropical cyclones which are very dangerous by their socio-economic consequences. Its impacts also concern the formation of clouds and precipitations. In general, meteorology indicates that the earth surface atmospheric pressure is always between 950.0 and 1100.0 hPa, meaning that for these phenomena to occur, the magnitude of the time variation of the atmospheric pressure should not be necessary high. These phenomena vary with latitudinal zones. For what concerns the tropical zone to which belongs the country Chad, the most encountered ones are droughts, flogs and tsunamis. All of them are catastrophic, socially and economically.

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So, frequent observations and control of the atmospheric pressure should be carried, whence the importance of this study. Recalling that any variation always starts at a small scale before covering a large territory, it is then understandable why our investigation has a local character as it concerns the localities of Moundou, Sarh and Ndjamena, all at the southern part of Chad. They were chosen because they have well equipped with instruments meteorological stations and good qualified personnel compared to other stations. Because of political instability and more than thirty years of civil war, academic research is not developed in Chad in general, and in the meteorological domain in particular. Among the few published works in the domain of the atmospheric physic, the recent ones could retain our attention, (Njipouakouyou *et al*., 2018, Njipouakouyou *et al*., May 2019, Njipouakouyou *et al*., August 2019). This paper has five sections. The first and present one is the introduction to the problematic of the study. The second concerns the data and methodology. In the third section are the results and their analysis.

Table 3.1. Distribution of the earth surface atmospheric pressure by sub periods (SP) and sub intervals (SI) in some southern localities of Chad

SP SI	[955.0;960.0[	[960.0;965.0[	[965.0;970.0[	[970.0;975.0[	[975.0;980.0[	[980.0;985.0[
Moundou						
I	9	49				
II	9	48				
III						
IV	6	36				
Ndjamena						
I				15	44	1
II			1	16	42	1
III				16	44	
IV				14	45	1
V				20	39	1
VI				18	29	1
Sarh						
I	1	3	48	7		
II			46	12		
III			51	9		
IV			27	14		

The conclusion and acknowledgement are in the fourth one. At last, the references presented in alphabetic order are in the fifth section.

DATA AND METHODOLOGY

Data: It concerns the earth surface atmospheric pressure registered in Moundou, Sarh and Ndjamena in the southern part of Chad during the period from 1986 to 2005 for the two firsts localities and 2015 for the last one. Attention was paid to these periods because of the regularity of the chronological series, whence their accuracy and the acceptance of the obtained results. These series are not primary, but already treated and presented in tabular form of monthly and yearly means.

Methodology: The periods of investigation are divided into sub periods of five years each such that I corresponds to sub period 1986 – 1990, II – to sub period 1991 – 1995, III – to sub period 1996 – 2000, IV – to sub period 2001 – 2005, V – to sub period 2006 – 2010 and VI – to sub period 2011 – 2015. The values of the earth surface atmospheric pressure were also divided into sub intervals each of length 5 hPa as follows: [955.0 ;960.0[; [960.0; 965.0[; [965.0; 970.0[; [970.0; 975.0[; [975.0; 980.0[; [980.0; 985.0[. In each sub period and sub interval we counted the number of atmospheric pressure registered and draw the table of its time distribution. This enabled us to determine the modal sub interval of the earth surface atmospheric pressure and its domain of variation during the considered laps of time. Sub period average values of the monthly means and their corresponding standard deviations were determined. This permitted us to analyze the time tendencies of these monthly means around the computed average values. Let x_i be yearly means of an atmospheric parameter. Its average value X and corresponding standard deviation σ_x were calculated. Experimental deviations Δx_i of x_i from X were determined by:

$$\Delta x_i = x_i - X. \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.1)$$

In order to avoid computations with big numbers, new time variable t was introduced with t = 0 for year 2000. Thus, further analysis was done for t and Δx_i. Plotting the points $M(t,\Delta x_i)$ with t on the abscissa, Δx_i on the ordinates and analyzing the configuration of the obtained clouds of points enabled us to find the form of the relationship $\Delta x_{th}(t)$ representing the dependence of Δx_i on t. This was done using the least square method. We have shown that based on $\Delta x_{th}(t)$, better estimates of missing x_i can be determined. Comparing the theoretical deviation, $\Delta x_{th}(t)$ with σ_x enabled us to appreciate the obtained model. In the next section x_i will be replaced by the earth surface atmospheric pressure p_i.

RESULTS AND ANALYSIS

The distribution of the earth surface atmospheric pressure by sub periods and sub intervals is presented in Table 3.1. A sub period with less than three year data was not taken into consideration. So, each sub period should have at least 36 data corresponding to three years and at most 60 data corresponding to five years. This remark also concerns the other tables. Table 3.1 shows that for all the localities and the periods of investigation, the values of the earth surface atmospheric pressure were concentrated in the interval [955.0; 985.0[in hPa. The modal intervals were [960.0; 965.0[, [975.0; 980.0[and [965.0; 970.0[in hPa, respectively in Moundou, Ndjamena and Sarh. In particular for Moundou, modal numbers of 49, 48 and 36 observations were registered in the first, second and fourth sub periods, respectively. For Ndjamena, these numbers were 44, 42, 44, 45, 39 and 29 in the first, second third fourth, fifth and sixth sub periods. And for Sarh, they were 48, 46, 51 and 27 for the first, second third an fourth sub periods. Moreover, the values of the earth surface atmospheric pressure were concentrated in more reduced intervals as follows [955.0; 965.0[hPa in Moundou, [970.0; 980.0[hPa in Ndjamena and [965.0; 975.0[hPa in Sarh. These values were decreasing from Ndjamena to Sarh and Moundou, more southern localities. This spatial repartition can be explained by the proximity to Ndjamena of the domain of Acores anticyclones. Ndjamena is in the northern part of the investigating area, Moundou is in the southern part, Sarh is located between the two previous ones. The average values of the sub period monthly means of the earth surface atmospheric pressure and their standard deviations are presented in Table 3.2. From Table 3.2 it comes that the minimal and maximal average values of the sub period monthly means of the earth surface atmospheric pressure (in hPa) were as follows; in Moundou: 959.1 (in April) and 963.8 (in July); in Ndjamena: 972.2 (in April) and 978.8 (in January); in Sarh: 964.4 (in March) and 970.9 (in July). In general, these average values slowly decreased from January to their minimum around April before started increasing till December.

Table 3.2. Average values of the sub period monthly means of the earth surface atmospheric pressure and their standard deviations in some southern localities of Chad

Moundou												
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
I	962.7 1.0	968.6 1.5	959.9 1.1	959.1 0.7	961.1 0.9	962.8 0.3	963.7 0.8	963.3 0.6	962.7 0.7	962.1 0.5	961.4 0.6	962.3 1.1
II	963.1 0.9	962.0 1.2	959.5 0.4	959.2 0.6	961.3 0.5	962.7 0.2	963.6 0.7	964.1 0.3	963.0 0.3	962.0 0.2	962.1 0.2	962.9 0.9
III	-	-	-	-	-	-	-	-	-	-	-	-
IV	962.9 1.1	961.9 0.3	959.6 0.1	959.0 0.7	961.2 0.5	963.3 0.7	963.8 0.3	963.7 0.6	962.9 0.2	962.4 0.2	961.8 0.4	961.9 1.3
Period	962.9 0.9	961.8 1.1	959.6 0.6	959.1 0.6	961.2 0.6	962.9 0.5	963.7 0.6	963.7 0.6	962.9 0.5	962.1 0.4	961.7 0.5	962.3 1.1
Ndjamena												
I	978.4 1.3	977.1 1.9	974.7 1.7	972.5 1.5	973.7 0.8	975.4 0.6	976.5 0.8	976.7 0.5	975.9 0.7	975.4 0.6	975.9 0.8	977.5 1.5
II	978.8 1.2	977.8 1.5	974.3 0.3	972.5 0.4	972.3 3.3	975.3 0.4	976.5 1.1	977.2 0.8	976.3 0.4	975.3 0.2	976.5 1.1	978.3 0.9
III	976.8 1.1	977.1 2.6	974.1 1.7	972.7 0.7	974.0 0.7	975.4 0.5	976.4 0.4	976.9 0.7	975.9 0.3	975.6 0.4	975.9 0.5	977.2 0.5
IV	978.6 1.2	976.4 1.5	974.7 0.6	972.2 0.7	973.9 0.5	975.9 0.6	976.8 0.4	977.2 0.3	976.4 0.4	975.8 0.6	976.2 0.5	977.3 1.4
V	977.6 2.0	975.9 1.9	974.2 1.1	972.7 0.3	973.7 0.7	975.3 0.4	976.3 0.2	976.4 0.3	976.4 0.3	975.3 0.4	975.7 1.0	977.3 1.3
VI	977.5 0.4	975.0 0.9	974.1 1.0	972.5 0.9	973.6 0.3	975.0 0.5	976.0 0.4	976.6 0.6	976.6 0.5	975.3 0.5	975.7 0.7	978.5 1.9
Period	978.0 1.4	976.6 1.9	974.3 1.1	972.5 0.8	973.5 1.5	975.9 0.5	976.5 0.6	976.8 0.6	976.2 0.5	975.4 0.5	976.0 0.8	977.8 1.3
Sarh												
I	968.7 1.0	967.6 1.7	964.4 2.7	965.3 0.9	967.6 0.8	969.3 0.6	970.1 0.7	968.0 4.3	969.1 0.8	968.6 0.4	967.8 0.6	968.5 1.0
II	969.1 1.1	968.5 1.1	966.2 0.5	965.9 0.4	967.9 0.3	969.3 0.4	970.3 0.7	970.6 0.6	970.0 0.8	968.7 0.2	968.6 0.4	969.0 1.0
III	968.0 0.9	968.0 1.7	965.9 0.9	966.3 0.7	968.1 0.6	969.4 0.6	970.2 0.6	970.3 0.5	969.4 0.4	969.2 0.4	968.1 0.4	968.9 0.4
IV	969.5 1.4	967.8 0.5	966.4 0.4	966.0 0.8	967.9 0.2	970.4 0.3	970.8 0.9	970.9 0.5	969.9 0.5	968.9 0.8	968.2 0.7	968.5 0.7
Period	968.8 1.1	968.0 1.3	965.6 1.6	965.9 0.7	967.9 0.5	969.5 0.6	970.3 0.7	969.9 2.4	969.6 0.7	968.8 0.4	968.2 0.6	968.7 0.8

Table 3.3. Simulation of the deviation of the yearly means of the earth surface atmospheric pressure from their average values in some southern localities of Chad

Moundou				Ndjamena			Sarh		
t	p_i	Δp_i	Δp_{th}	p_i	Δp_i	Δp_{th}	p_i	Δp_i	Δp_{th}
-14	962.2	0.2	-0.0	975.7	0.0	0.3	968.2	-0.4	-0.2
-13	961.8	-0.2	-0.0	975.9	0.2	0.2	968.3	-0.3	-0.2
-12	961.5	-0.5	-0.0	975.4	-0.3	0.2			-0.2
-11	962.1	0.1	-0.0	976.3	0.6	0.2	968.5	-0.1	-0.1
-10	961.9	-0.1	-0.0	975.7	0.0	0.2			-0.1
-9	962.1	0.1	-0.0	976.0	0.3	0.2	968.5	-0.1	0.1
-8	962.3	0.3	-0.0	976.3	0.6	0.2	968.8	0.2	-0.1
-7	962.1	0.1	0.0	976.1	0.4	0.2	968.7	0.1	-0.0
-6	962.1	0.1	0.0	975.5	-0.2	0.1	968.8	0.2	-0.0
-5	961.7	-0.3	0.0	975.7	0.0	0.1	968.6	0.0	-0.0
-4			0.0	975.3	-0.4	0.1	968.2	-0.4	0.0
-3			0.0	975.3	0.6	0.1	969.0	0.4	0.0
-2			0.0	976.1	0.4	0.1	968.8	0.2	0.1
-1			0.0	975.3	-0.4	0.1	968.1	-0.5	0.1
0			0.0	975.6	-0.1	0.0	968.3	-0.3	0.1
1	962.1	0.1	0.1	976.0	0.3	0.0	969.2	0.6	0.1
2	962.4	0.4	0.1	976.2	0.5	0.0	969.2	0.6	0.2
3	962.0	0.0	0.1	976.0	0.3	-0.0	969.1	0.5	0.2
4	961.8	-0.2	0.1	975.9	0.2	-0.0	968.2	-0.4	0.2
5				975.7	0.0	-0.0			
6				975.7	0.0	-0.1			
7				975.7	0.0	-0.1			
8				975.7	0.0	-0.1			
9				975.4	-0.3	-0.1			
10				975.3	-0.4	-0.1			
11				975.3	-0.4	-0.1			
12				975.6	-0.1	-0.1			
13				975.3	-0.4	-0.2			
14				975.6	-0.1	-0.2			

This conclusion was also valid for the standard deviation. Allover the standard deviation was 10^{-4} (in January – March) - 10^{-3} (during the remaining time of the year) times smaller the average values, indicating that the monthly means of the earth surface atmospheric pressure were concentrated closer to their average values.

Average values of the yearly means of the earth surface atmospheric pressure and their standard deviations were calculated. They were respectively: for Moundou: 962.0 and 0.2 hPa; Ndjamena: 975.7 and 0.3 hPa; Sarh: 968.6 and 0.4 hPa. Δp_i were calculated and experimental points $M(t,px_i)$ plotted. The analysis of their configuration indicated a linear relationship $\Delta p_{th}(t)$ whose analytic expressions were:

For Moundou: $\Delta p_{th}(t) = 0.00663t + 0.04739$. ….(3.1)

For Ndjamena: $\Delta p_{th}(t) = -0.015t + 0.045$. …….(3.2)

For Sarh: $\Delta p_{th}(t) = 0.024t + 0.119$. …..(3.3)

The results of simulation are in Table 3.3, with p_i, Δp_i and Δp_{th} all in hPa.

Table 3.3 shows that allover, experimental Δp_i and theoretical Δp_{th} deviations of p_i from their average values were of the same order, 10^{-1} and almost closer to corresponding one another. -0.0 means that the computed number was negative and of order at most 10^{-2}. As the earth surface atmospheric pressure was of order 10^3 and the deviations, of order 10^{-1}, it is clear that a missed yearly mean of the earth surface atmospheric pressure could be estimated with its average value. Error made by this approach is of order 10^{-4} what is negligible. This method could be used to complete missed information during operational works.

Conclusion

This study has shown that the time variation of the earth surface atmospheric pressure in the southern part of Chad was not significant and occured in small intervals containing in 955.0 – 985.0 hPa. Missed data could be accurately estimated by its corresponding average values, for example monthly or yearly ones. The authors sincerely thank the "Laboratoire de Physique de l'Atmosphère, Climat et Environnement », LAPACE, of the Department of Physic, Faculty of Pure and Applied Sciences of University of Ndjamena – Chad, which entirely has supported this study till its publication, hopping that such a collaboration will always go forward.

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