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RESEARCH ARTICLE

AN ATTEMPT OF RAINFALL FORECAST USING THE DEFICIT OF THE VIRTUAL TEMPERATURE OF THE AIR IN SOME LOCALITIES OF CHAD

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ABSTRACT

The mismanagement of the rainy season observed these last years due to the global climate change has created a lot of disorder in programming of the agricultural activities in many countries, particularly the developing ones, putting them in front of permanent hunger constraints. To contribute in solving this problem the authors of this paper have elaborated a new method of forecasting the beginning and end of rainy season based on the deficit of the virtual temperature of the air using only two parameters, the atmospheric pressure and the temperature of the air registered during the period from 1986 to 2000 in the localities of Ndjamena; Moundou and Sarh in Chad. The acceptable results obtained indicate that the method can be operational. The obtained probabilities of realization of 66.7% and 83% in Sarh and Moundou give our method some strength and fairness. Probably that the method has to be improved using long and more accurate chronological data from other localities.

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INTRODUCTION

Many methods of rainfall forecast exist, numerical and synoptic. The most encountered are synoptic ones which need a lot of meteorological data, on the earth surface and at different altitudes. Usually these data are the atmospheric pressure, the air temperature, the relative humidity of the air, the wind, between others. It is not easy to collect all this information and archive it in a same secure place for eventual use, particularly in developing countries because of poverty and mismanagement. Here, forecast mainly serves aviation instead of inhabitants in their daily activities. Many reasons could explain this situation, between others, the next ones. Many meteorological stations are in the airports. Elsewhere, they are rare; poor equipped with instruments and qualified personnel. Also they seem to be abandoned. Consequently, meteorological data issued from some of these stations are not regular and fair. Today with the climate change, this situation becomes very dangerous, (Christian, 1974). Farmers do master neither the beginning nor the end of rainy seasons and for this reason they cannot elaborate a good program for their agricultural activities, particularly during these last twenty years. Almost every year, after around three weeks, and even more, of first regular and sometimes intensive rainfalls, farmers plant foods in their fields. When young plants start growing needing a lot of water, a relative small dry season occurs in some localities for even more than four weeks, (Romain *et al.,* 2015; Amani *et al.,* 2017). This seriously damages the cultures and drastically compromises the yields, putting populations under permanent hunger constraints (Idrissa, 2008; Ibra *et al.,* 2017). As they have not enough seeds to plant again, foods will not be sufficient for everybody and the international communities will be urgently called for help, as it uses to be. This paper is our contribution to the solution to that problem. It proposes a new sample and easily realizable method of forecast the period of rainfall in a locality. It is based on the following principle. For water to evaporate it should absorb a certain quantity of heat called the latent (or hidden) heat of evaporation. This absorbed heat creates an upside motion of the molecules from the water and earth surface to the atmosphere. These molecules in the atmosphere are called the water vapor. During this upside motion their temperature decreases by 1° every 100 meters if the volume of the air under motion is dry or wet dry or by 0.65° every 100 meters if it is wet. At a certain altitude the water vapor in motion starts condensing, liberating a quantity of energy equivalent to what absorbed before. This liberated energy is called the latent energy of condensation. It affects the surrounding air by increasing its temperature. As the condensation process goes progressively, the heating of the surrounding air is also progressive. The new temperature of the air after this process is called the virtual temperature. The result of the condensation of the water vapor in the air is the apparition of water drops. When theses ones reach a certain quantity and after the process of coagulation, some with already certain dimensions will start falling to the earth surface. So we have the rain. It is obvious that if the water drops are important, the virtual temperature will be high. As the quantity of water drops is almost constant in the atmosphere during the rainy season, the virtual temperature of the air remains nearly unchanged. When the dry season occurs they decrease, and the virtual temperature of the air falls to its relative minimal value. We call the difference between the virtual and initial temperatures of the air the deficit of the virtual temperature, Δt_v. It is clear that when Δt_v grows and reaches a certain value, say critical one, automatically the rain will follow. The authors are trying to determine this critical value which will be used to predict rainfall in some localities of Chad. For this investigation to be done, next meteorological data are needed: atmospheric pressure, air temperature and pluviometry. It is clear that this forecast concerns a locality compared to synoptic forecasts which cover large territories.

This paper has five sections. The first and present one introduces the problem. The second concerns the data and methodology. The results and analysis are presented in the third section. Conclusion and recommendation are in the fourth section. The bibliography in alphabetic order is in the fifth section.

DATA AND METHODOLOGY

Data: Our data comes from the direction of the national meteorological service in Ndjamena, Chad. It concerns the atmospheric and partial water vapor pressures, p and e, respectively, in hectoPascal (hPa), air temperature, T in degree Kelvin (K), and pluviometry, registered in the following localities: Ndjamena, Moundou and Sarh. All of them belong to the main set of the meteorological stations of the country and are well equipped with good instruments and acceptable qualified personnel. These data cover a 15 years period, from 1986 to 2000. This period was chosen because of very few missed information. Thus, it is clear that our results should be considered as fair and meaningful.

Methodology: After the condensation of water vapor and liberation of the energy of condensation in the air, its virtual temperature, T_v, is given by the expression:

$$T_v = T_0(1 + 0.378\frac{e}{p}), \quad (1)$$

where T_0 is the initial temperature of the air, in degree K measured with the thermometer at the station, p – the atmospheric pressure in hPa measured with the barometer at the station, e – the partial water vapor pressure in hPa determined from the psychometric table.

Recall the relationship between temperatures in degree Celsius (t) and Kelvin (T):

$$T = 273 + t. \quad (2)$$

Our parameter of analysis, the deficit of the virtual temperature of the air, ΔT_v, is given by the formula:

$$\Delta T_v = T_v - T_0 = 0.378\frac{e}{p}T_0. \quad (3)$$

For each year we compute the monthly values of ΔT_v and study their yearly trend. In association with the pluviometry we find out at which months and for which values of ΔT_v the rain has started and ended. We consider a period to be rainy when the pluviometry for consecutive months is at least 10 mm per month. For each station we counted how many times the rain has started at a given month then evaluated the probability of its realization as the ratio of that number over the total cases.

RESULTS AND ANALYSIS

For all the stations and years, the time trend of Δt_v was similar. In general, from January it started increasing to its maximal value around June from where it remained almost constant till October before decreasing to its relative minimal value. All the values of Δt_v were included in the interval [0.4°, 3.4°C]. The absolute minimum, 0.4°C, was registered in Ndjamena in February 1992, and its absolute maximum, 3.4°C, in Sarh in 1997 and Ndjamena in 1998. During the rainy period Δt_v oscillated around 3.0°C. To forecast the rainfall based on Δt_v we proceed locality by locality.

Locality of Ndjamena

$\Delta t_v \in$[1.3°, 1.8°C]. For this interval, the rain started four times in April. Thus we may predict the beginning of the rainy season in April with a probability of realization of $\frac{4}{15}$.100% = 27%. In this interval we also have two cases in May. So the probability of their realization was $\frac{2}{15}$.100% = 13%. Thus, we conclude that for this interval the beginning of the rainy season is more probable in April than in May. $\Delta t_v \in$[2.1°, 2.7°C]. For this interval, the rain started four times in May. The probability of their realization was $\frac{4}{15}$.100% = 27%. Here, also five cases were registered in June. The probability of their realization was $\frac{5}{15}$.100% = 33%. Thus, we conclude that for this interval the beginning of the rainy season is more probable in June than in May.

Locality of Moundou

For this locality, three years did not have data on the atmospheric pressure reducing the number of its total cases to 12 instead of 15. For Δt_v = 1.8°C we registered one case when the rain began in March 1986. Its probability of realization was $\frac{1}{12}$.100% = 8.5%. $\Delta t_v \in$[2.1°, 2.8°C]. For this interval, the rain started ten times in April. The probability of their realization was $\frac{10}{12}$.100% = 83%. For this interval, one rain started in May, corresponding to a probability of realization of $\frac{1}{12}$.100% = 8.5%. Thus, we conclude that for this interval the beginning of the rainy season is more probable in April than in March or May.

Table 1. Time distribution of the monthly deficit of the virtual temperature of the air and the monthly pluviometry for some years in some localities of Chad

Ndjamena		Jan.	Feb.	Mar.	Apr.	May	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1986	Δt_v	0.6	0.6	0.7	1.0	1.7	2.3	2.9	3.1	3.1	1.9	1.0	0.7
	RR	0	0	1.4	1.6	17.7	13.8	236.2	129.1	151.2	0.3	0	0
1989	Δt_v	0.6	0.5	0.5	1.1	2.1	2.7	3.0	3.2	3.1	2.2	0.9	0.8
	RR	0	0	0	0	1.6	84.0	180.4	186.3	62.1	79.3	0	0
1992	Δt_v	0.6	0.4	1.0	1.3	2.3	2.5	2.9	3.1	3.1	2.0	1.2	0.7
	RR	0	0	1.2	4.3	21.9	57.3	149.9	166.0	109.0	27.7	0	0
1995	Δt_v	0.9	0.8	1.0	1.5	2.0	2.4	2.5	-	3.1	2.2	0.8	0.8
	RR	0	0	0	4.0	2.6	30.4	147.1	119.6	118.5	22.8	0	0
1998	Δt_v	0.5	0.6	0.9	1.7	2.3	2.7	3.1	3.4	3.4	2.7	1.7-	
	RR	0	0	0	10.0	11.2	88.2	239.0	287.4	117.7	22.4	0	0
Mondou													
1986	Δt_v	0.9	1.0	1.8	2.3	-	-	3.1	3.1	3.0	3.1	2.9	1.2
	RR	0	0	23.4	35.4	54.2	119.2	368.5	250.1	218.5	55.3	0	0
1989	Δt_v	0.7	0.6	0.8	2.1	2.7	2.9	3.0	3.0	3.1	2.8	2.1	1.2
	RR	0	0	0	26.7	64.0	141.2	160.8	175.0	156.4	49.5	0	0
1992	Δt_v	0.9	0.8	1.7	2.5	3.1	3.1	3.0	3.0	3.0	3.0	2.0	1.3
	RR	0	0	4.4	27.3	114.5	149.0	148.4	305.5	247.5	75.8	0	0
1995	Δt_v	0.9	0.8	1.8	2.4	2.9	-	3.2	-	3.0	3.1	1.3	-
	RR	0	0	0	12.0	77.3	149.8	255.6	262.1	151.9	123.6	1.5	0
Sarh													
1986	Δt_v	1.0	1.3	2.1	2.1	2.7	3.1	3.1	3.2	3.2	3.1	2.4	1.1
	RR	0	4.8	0.3	9.0	23.0	80.8	305.6	202.2	180.4	12.5	0	0
1989	Δt_v	1.1	1.1	1.6	2.2	2.8	3.0	3.2	3.1	3.2	3.0	2.2	1.5
	RR	0	0	0	0.9	122.1	86.5	263.4	286.6	138.2	89.6	0	0
1992	Δt_v	1.0	0.9	1.9	2.8	3.2	3.0	3.1	3.1	3.2	3.2	2.3	1.5
	RR	0	0	0	17.4	78.0	38.2	145.3	286.5	293.7	15.2	3.2	0
1995	Δt_v	1.2	1.0	-	2.6	3.2	3.1	3.2	3.2	3.2	3.1	2.1	-
	RR	0	0	0	44.4	20.9	100.8	81.3	320.8	126.1	29.2	0	0
1998	Δt_v	1.1	1.2	1.3	2.5	3.1	3.2	3.2	3.3	3.2	3.3	2.5	1.7
	RR	0	0	0	3.3	56.0	121.5	237.3	330.8	143.2	224.4	0.9	0

Locality of Sarh

$\Delta t_v \in$[2.5°, 2.9°C]. For this interval, the rain started ten times in April. The probability of their realization was $\frac{10}{15}.100\% = 66.7\%$. $\Delta t_v \in$[2.7°, 3.1°C]. Here we have five cases when the rain started in May. The probability of their realization of was $\frac{5}{15}.100\% = 33.3\%$. Thus, we conclude that for these intervals the beginning of the rainy season is more probable for the first one with a probability of realization of 66.7%. The probabilities of realization were higher in the localities of Moundou and Sarh. They were almost equiprobable in Ndjamena because for each interval, different cases were registered. So, we can forecast the beginning of the rainy season in April with a probability of 83% in Moundou and 66.7% in Sarh. This sutdy shows that it is more probable for the rainy season to start in April or May. This study also indicates that the rainy period generally ended in October for all the localities. At this moment, Δt_v varied from 1.8° to 3.1°C. In particular, for the locality of Ndjamena Δt_v varied from 1.8° to 3.2°C, for the locality of Moundou, from 2.8° to 3.2°C and for the locality of Sarh, from 2.9° to 3.4°C. So it is clear that if Δt_v will be less than 1.8°C in Ndjamena, 2.8°C in Moundou and 2.9°C in Sarh, one should successfully predict the beginning of the dry season. Table 1 shows the time distribution of the monthly deficit of the virtual temperature and monthly pluviometry, RR, during some years in the concerned localities. Attention should be paid to the period from April - May to October when the pluviometry is over Δt_v, with $\Delta t_v \geq 3.0$°C. As one can remark, the elaborated method of forecast the beginning and end of the rainy season is sample and easily realizable. It does not need sophisticated instruments. The only needed data concerns two parameters, atmospheric pressure and air temperature as the partial water vapor is determined from the temperature of the air.

No doubt that implementing this method will help farmers to good and productive agricultural activities. It also will help authorities solving ecological problems. After determining by which month the rainy season starts or ends, we extend the forecast to the daily scale using daily instead of monthly data, proceeding the same way.

Conclusion and recommendation

It is obvious that the deficit of the virtual temperature of the air can be used in operative work to forecast the beginning and end of the rainy season in a locality. The authors think that their method should be very appreciated in developing countries. They recommend its large implementation in many countries because of its simplicity and easily feasibility.

REFERENCES

Amani Michel Kouassi, Koffi Fernand Kouamé, Yao Blaise Koffi, Kouakou Bernard Dje, Jean Emmanuel Paturel et Sekouba Oulare. *Analyse de la variabilité climatique et de ses influences sur les régimes pluviométriques saisonniers en Afrique de l'Ouest: cas du bassin versant du N'zi (Bandama) en Côte d'Ivoire.* Cybergeo: European Journal of Geography (En ligne) Environnement, Nature, Paysage, document 513, mise en ligne 07 decembre 2010, consulté 22 maai 2017, URL: http://journals.openedition.org/cybergeo23388; DOI: 124000/cybergeo:23388.

Christian Bouquet. *Le déficit pluviométrique au Tchad et ses principales conséquences*. Les cahiers d'Outre-Mer, 1974, 27-107, pp. 245-270.

Ibra Touré, Jean-Daniel Cesaro, Abdrahmane Wane, Guillaume Duteutre, Alexandre Ickowicz, Alioune Ndiaye, Issa Garba, Mahmat Cherif Abderahim, Simon Taugourdeau. *Analyse de la vulnérabilité climatique et* *environnementale des systèmes agropastoraux dans le centre ouest du Tchad*. CIRAD, FIDA, 19 mai 2017, 68p.

Idrissa Diatta. *Impact des fluctions pluviométriques sur la production agricole dans la région de Thionik-Essyl en Basse Casamance.* Mémoire de fin d'études pour l'obtention du Certificat d'Aptitude à l'Enseignement Moyen (CAM)sous la direction de Amadou Camara; Université Cheikh Anta Diop, Dakar, Juin 2008.

Romain Gouataine, Moctar Sina Foukai. *Impact de la variabilité pluviométrique sur la saison agricole à l'ouest du Tchad*. Afrique Sciences, vol. 11, n° 5, 2015.

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