STUDY OF THE VARIATION OF THE RAINY SEASON AND THE EVOLUTION OF THE QUANTITY OF RAINFALL IN THE EXTREME NORTH REGION OF MADAGASCAR

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ABSTRACT:

The study of variation of the rainy season and the evolution of the amount of precipitation is defined by two main methods, self-organizing maps (Kohonen Networks) and Anomalous Accumulation. Our study area is delimited by the latitude between 12° to 15° South and the longitude between 47° to 51° East. The regionalization by Kohonen networks revealed twenty homogeneous zones according to the precipitation of our study area from 1979 to 2017. The Anomalous accumulation showed that the rainy season in the northern part of Madagascar begins on average at the beginning of the month of December, generally ends at the beginning of April. It lasts on average for 127 days, or 3 months a little more. We observe a downward trend in the duration of the rainy seasons. But the amount of precipitation has increased for most areas except in the eastern maritime parts of our study area.

Keywords: *rainy season, precipitation, Kohonen Networks, Anomalous Accumulation, start, end, duration, from north, Madagascar*

1. INTRODUCTION

Climate change is currently affecting the whole world, Madagascar is no exception. Indeed, agriculture, one of the important pillars of the island's economy, is the most affected by the repercussions of climate change. Most of the export earnings come from agriculture and the latter represents an important part of the life of most of the Malagasy population. However, the cropping calendar is turned upside down, because of climate variability and change. Faced with this, the Madagascar Weather through the Ministry of Transport, Tourism and Meteorology (MTTM) in collaboration with the Ministry of Agriculture, Livestock and Fisheries (MAEP) produces a crop calendar at the start of each rainy season, following the seasonal forecasts intended especially for farmers in order to assist them in decision-making in order to reduce risks and for better profitability. [1](Madagascar Weather, 2019)

In reality, the geographical location, the shape of the relief, the maritime influence and the wind regime are the causes of the very varied climatic conditions encountered on the island. There are mainly two seasons in Madagascar: the dry and cool season, from April 15 to October 15, the rainy and hot season, from October 15 to April 15. The 2 dates of April 15 and October 15 are the normal temporal markers of the climate of Madagascar for the separation of these 2 seasons. Two short off-seasons separate them and each last about a month.

Our research is based on the study of variation of the rainy season (beginning and end of the rainy season) and the evolution of the amount of precipitation from 1979 to 2017 in the extreme northern region of Madagascar more precisely, the latitude between 12° to 15° South and longitude between 47° to 51° East.

This work is subdivided into two parts. We will see throughout the first part some methods and materials. Then, the next part, we will focus on the results and interpretations.

2. MATERIAL AND METHODS

2.1 Data base and materials used

2.1.1 Data :

We used rainfall data. These are daily reanalyzed data, for a spatial resolution of 1° x 1° over the period from 1979 until 2018 download in ECMWF. We used in our study software such as: MATLAB, for programming codes on statistical and mathematical studies and data preparation; Microsoft Office Excel, for certain operations.

2.1.2 Presentation of study area:

Precipitation data is presented in the form of a rectangular table. Each observation or individual is an intersection point of a longitude with a latitude. In the area considered, there are therefore 69 individuals. To make the table easier to read, the individuals are named as shown in the figure below. The variables are the monthly average precipitation. Each individual is represented by a point located in a 12-dimensional space whose coordinates are the average monthly precipitation for the years 1979 to 2017. We then have a table of 69 rows and 12 columns

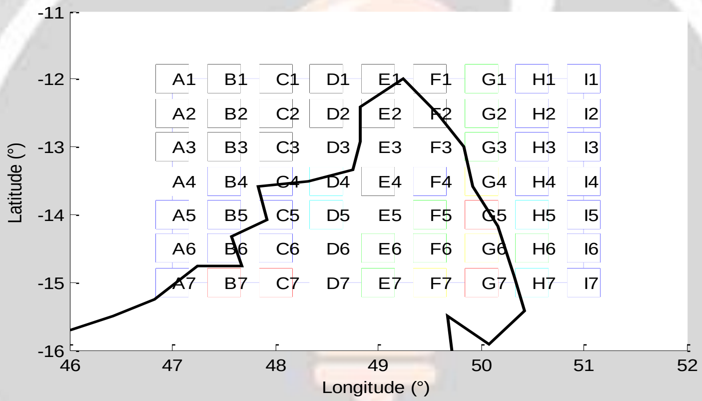


Figure 1: Presentation of individuals in our study area

2.2 Methods

2.2.1 Kohonen network

Self-adaptive maps, self-organizing maps or topological maps form a class of artificial neural network based on unsupervised learning methods. The self-organizing maps commonly referred to as SOM (for Self-Organizing Maps) were introduced by T. Kohonen in 1981 (Dreyfus et al, 2004; Kohonen, 1990; El Golli, 2004; Boinee, 2006; kolehmainen, 2004).

2.2.1.1 Architecture of Kohonen maps

The SOM is a low-dimensional grid (or network) which contains a number M of neurons. Neurons are usually arranged either in a hexagon or in a rectangle. The Kohonen map is usually composed of two layers of neurons, an input layer (in our case, the meteorological parameters) and an output layer (topological layer). (Soufiane khedairia, 2014)

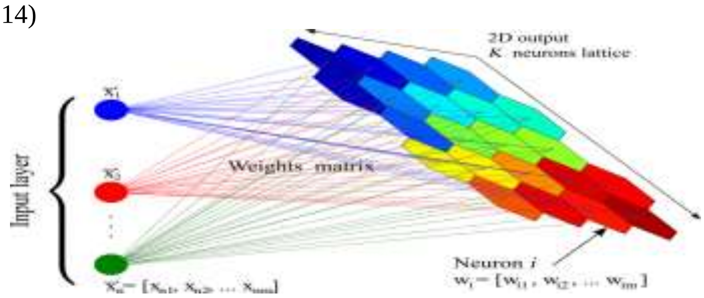


Figure 2: Structure of a self-organizing map.

An input vector x(t) is projected to the output layer. Each input of the SOM is connected to all neurons by corresponding weights (w_{ji}). Thus, to each neuron of the SOM a weight vector of dimension M is assigned

$$w_j = [w_{j1}, ..., w_{jM}]^T$$

2.2.1.2 Learning the SOM

Once the referent vectors or prototypes are initialized, learning begins. The SOM is very robust with respect to initialization parameters, but a good initialization allows the learning algorithm to converge faster to a good solution. The set of training individuals is presented to the SOM algorithm, this process is repeated for t training steps. A complete round of training (when all samples have been presented) is called an "epoch". The number of iterations t of learning is an integer multiple of the number of epochs. Each iteration is composed of two steps: a step of competition between the neurons which determines the region of the grid to be adjusted, and a step of adaptation of the weights of the selected area to the projected individual. (Pölzlbauer, 2004; Dreyfus et al, 2004).

Competition stage

The competition phase between neurons is based on a discriminant function. This competition amounts to seeking the winning neuron, that is to say, the closest to the input vector. In other words, among all the neurons in the map, the winning neuron, denoted c, is the one whose distance between its synaptic weight vector and the input vector is the lowest. This neuron is called "winning neuron" and often noted by BMU (Best Matching Unit). Formally, the BMU is defined as the neuron that verifies the following equation:

$$\left| x(t) - w_j(t) \right| = \min_{j \in m} \left\| x(t) - w_j(t) \right\|$$

Where $\|.\|$ is a measure of distance.

The winning neuron for an input vector is also called the excitation center of the map. The generally used distance between the x and w vectors is the Euclidean distance, but any other type of distance can be used.

Adaptation phase

For similar input vectors to be mapped to the same neuron or to neurons close to the map, not only the winner neuron, but also its neighboring neurons must be updated. This action aims to remove the weights of neighboring neurons to get closer to the input vector, thus providing more similar weight vectors and therefore similar inputs are mapped to nearby neurons in the map. The synaptic weight vectors w_j of the neuron with index j and its neighbors of the self-organizing map are updated by error correction (the error is defined as the distance between the vector x and the reference vector w_j of the neuron considered):

$$w_j(t+1) = w_j(t) + \Delta w_j(t)$$

$$= w_j(t) + a(t) h_{cj}(r(t)) [x(t) - w_j(t)]$$

With a(t) represents the learning coefficient which decreases over time to allow a better adjustment of the weights. is the neighborhood core around the winner neuron c, with neighborhood radius r(t). The weights of each neuron are adapted according to the position of the neuron in the grid with respect to the winning neuron.

During learning, the neighborhood size of the BMU, which determines the active area, decreases with time. Thus, the learning parameters are gradually modified starting with a coarser initial phase with a large area of influence and rapid evolution of the prototype vectors until arriving at a fine update phase with a small neighborhood radius and prototype vectors that slowly adapt to samples.

The neighborhood function generally used is the Gaussian function. The neighborhood function takes into account the distance of the neurons from the position of the winning neuron to weight the correction of the delta synaptic weights of neuron i at time t. Let δ_{ci} be the distance between the winner neuron with index c and a neighboring neuron with index i. This distance is not calculated in the entry space but in the topological space of the map:

$$\delta_{ci}^2 = \left\| c - i \right\|^2$$

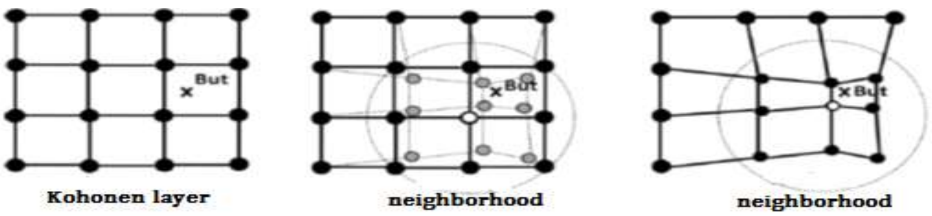
he neighborhood function $h_{cj}(t)$ is then written:

$$h_{ci}(t) = \exp\left(-\frac{\delta_{ci}^2}{2r(t)^2}\right)$$

Where r(t) is the neighborhood radius. This radius can be expressed by the following expression:

$$\delta_k = \delta_i \left(\frac{\delta_f}{\delta_i} \right)^{\frac{k}{k_{\max}}}$$

The learning process is interrupted if one of the conditions is met: the maximum number of epochs is reached, the performance is minimized to a goal, or a maximum learning time is exceeded.



(a) **(b)** **(c)**

Figure 3: Illustration of learning the SOM method: (a) Initial state, (b) state at step k, (c) state at step k+1.

Kohonen maps have proven their usefulness for the classification of multidimensional databases dealing with nonlinear problems. The SOM algorithm is able to extract the statistical properties of the meteorological parameters present in the input database and this is the reason why this type of network was chosen for the present study. In order to obtain good results, a training of the network by data statistically representative of the totality of the data must be carried out. In our case, the statistical properties of meteorological data are not clear, so the entire database is needed for good modeling.

The algorithm described above is called "sequential learning" or "basic SOM". Another important rule of learning is called "batch learning", which is based on fixed point iteration, is significantly faster in terms of computation time.

At each step, the BMUs for all input samples are calculated at once, and the prototype vectors are updated as follows

$$m_i(t+1) = \frac{\sum_{j=1}^{n} h_{ic(j)}(t)\, x_j}{\sum_{j=1}^{n} h_{ic(j)}(t)}$$

2.2.1.3 Cluster visualization

The technique most commonly used to visualize clusters on the SOM is the distance matrix. In these techniques, the distances between each unit i and the units which are in its vicinity N_i are calculated as follows:

$$D_i = \left\{ \left\| m_i - m_j \right\| \right\} \; j \in N_i,\, j \neq i$$

The distances, or the average of the distances, for each map unit are usually visualized using colors.

2.2.2 Anomalous accumulation

Liebmann (2006) proposes a method based on the definition of an index called "Anomalous Accumulation" (AA) which consists in calculating the difference between the accumulation of daily precipitation and an average theoretical accumulation during which it would precipitate daily the average daily rate. The following equation describes the relationship corresponding to this method:

$$AA(t) = \sum_{n=1}^{t} R(n) - \overline{R} \times t$$

With: AA(t): Anomalous Accumulation on day t;
A: The average daily precipitation (calculated by Liebmann as the relationship between the annual cumulative precipitation and the number of days in the year);
R(n): precipitation on days n

In this work, we used this method to determine the start and end date of rain. For example, in Figure 4, the increasing parts of the curve represent the rainy season and the decreasing part of the curve represents the dry season. The end of the rainy season and the beginning of the dry season correspond to the maximum of the curve. The minimum represents the end of the dry season and the beginning of the rainy season. This method is very useful in the temporal distribution of the dry and wet season [Niry].

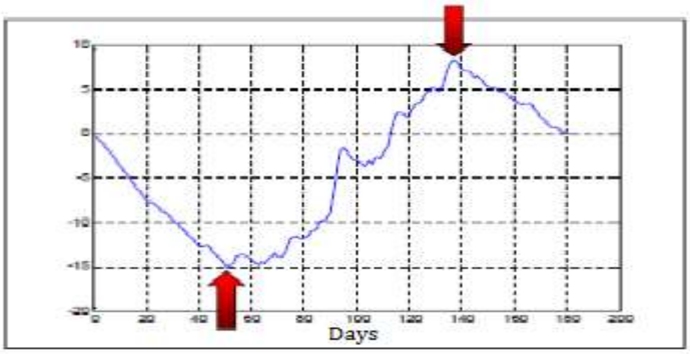


Figure 4: Curve of anomalous accumulation

3. RESULT AND DISCUSSION

3.1 Rainfall classification by Kohonen networks

3.1.1 Map of individuals

The observations classified by the neuron (shown by a hexagon) are listed on the map. Similar observations have the same projection. The size of the hexagon is proportional to the number of individuals classified by the neuron (see Figure 5)

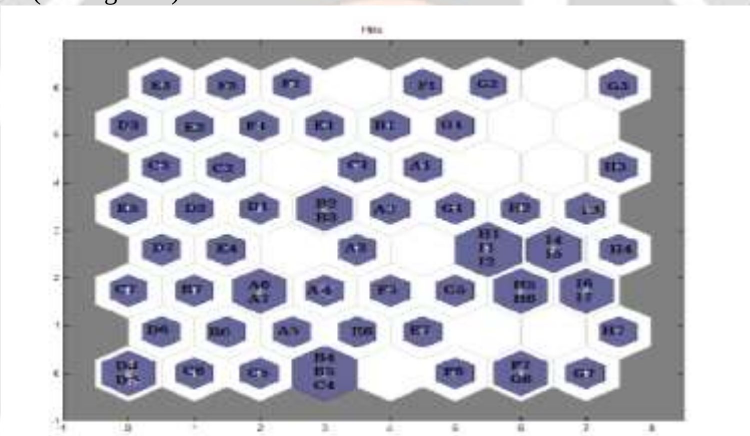


Figure 5: Map of individuals

3.1.2 Distance map

Figure 6 shows the Euclidean distances between neighboring neurons in the map. In the figure, the distance between this neuron increases with the color bar. A red color indicates a boundary zone, A blue color indicates that the distances between neurons are small and characterizes a homogeneous zone in the map (set of neurons with little difference).

There are clearly 20 distinct clusters with boundaries between them indicating measurable dissimilarity between 63 individuals (area).

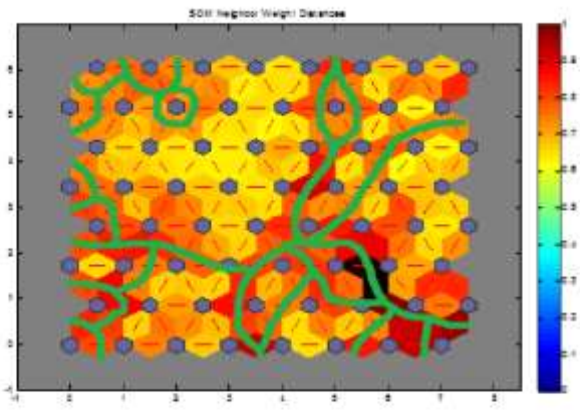


Figure 6: Euclidean distances between neighboring neurons

3.1.3 Maps of weights by input dimension

Figure 7 shows the weight map by input dimension. This map allows you to see how each area of the map reacts with respect to each variable. This will be very useful when interpreting the classes obtained after classification:

- Every month, abundant rains were found in zone 5, even during the dry season (very light color of the variable in the South-East corner of the map)
- In January and February: all areas are manifested by very heavy rains except G3 (dark color of these variables in the northeast corner of the map)
- During the dry season (May, June, July, August, September), the maritime part and the northeast coast of Madagascar receive considerable rain (light color in the east of the map).

The map of weights by input dimension also makes it possible to study the correlations between variables in the sense of the map of individuals. In our case, similar variables have the same projection. The variables (months) of June, July, August September are highly correlated. The months of December and January are moderately correlated. And the months of May and April are very correlated.

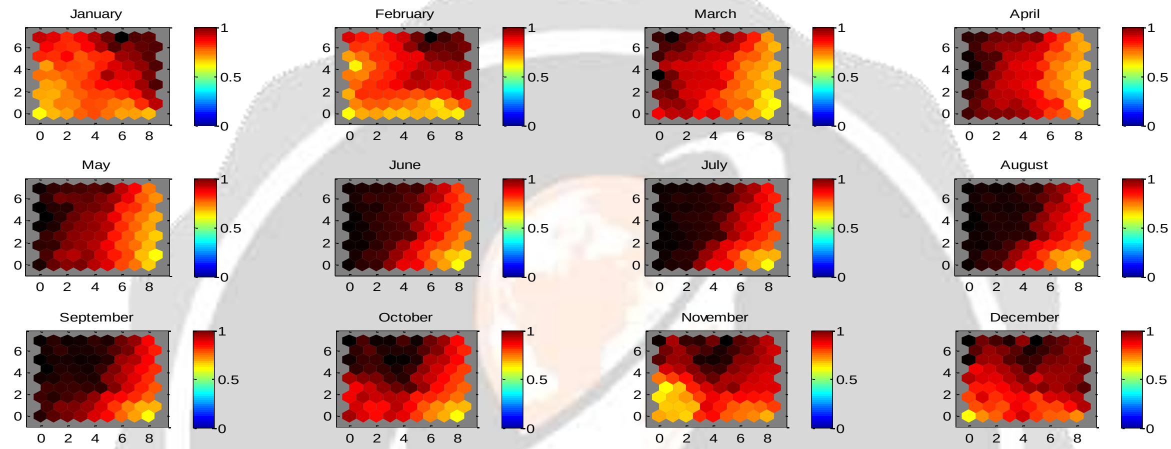


Figure 7: weight map by input dimension (or input variables)

Taking into account the relationship between individuals and precipitation variables. We can categorize our study area into 20 different areas. The distribution of these 20 zones is shown in Figure 8

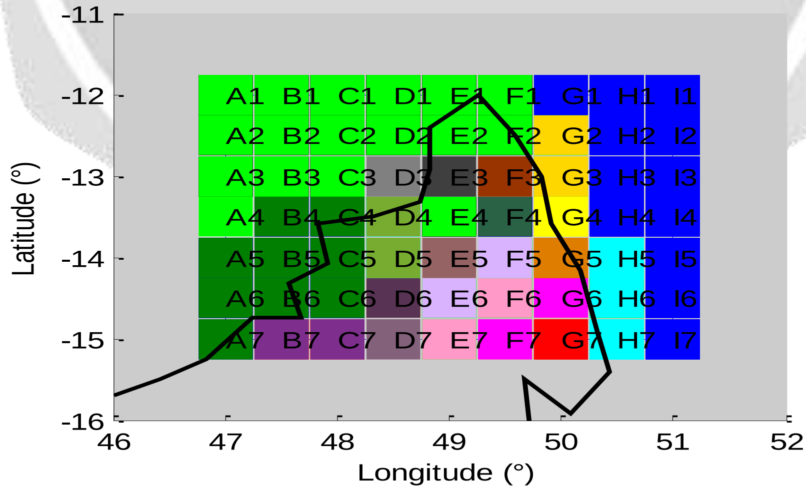


Figure 8: Distribution of the homogeneous zone of precipitation by Kohonen network

3.2 Detection of the start and end dates of the rainy seasons in the northern part of Madagascar

For the calculation of the start and end dates of the rainy season, we used the Anomalous Accumulation (A.A) method. The zero-precipitation threshold was set at 1mm. That is to say, any amount of rain less than 1mm is considerably like zero. The beginning (end) of the rainy season is determined by the date of minimum (maximum) of the curve of A.A.

the Anomalous Accumulation method of season 1979-1980 from zone 1 lead to the next results.

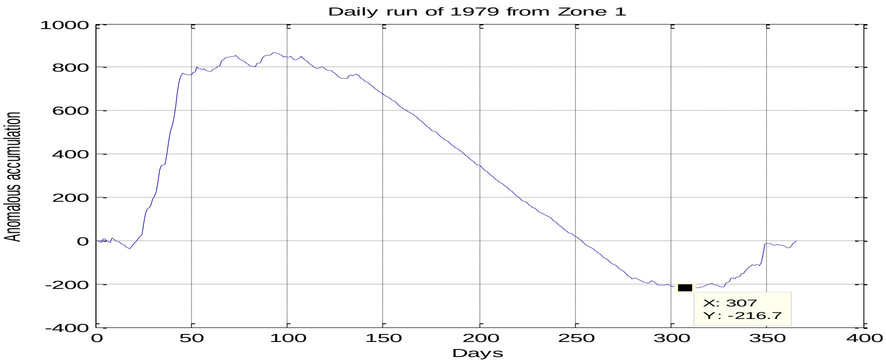


Chart- 1 : Curve of anomalous accumulation of 1979 from zone 1

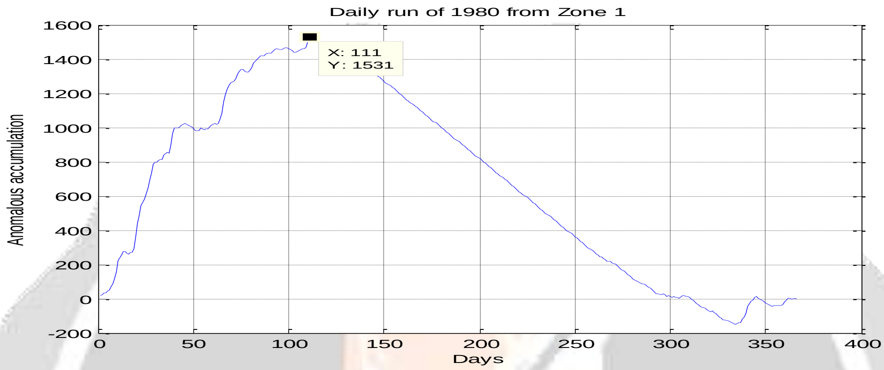


Chart- 2: Curve of anomalous accumulation of 1980 from zone 1

The dates of the beginnings and ends of the rainy seasons between 1979 and 2017 are summarized for the twenty zones in Table 3, Table 4, Table 5.

Table 1 : Dates of the start of the rainy season in each zone from 1979 to 2017

	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8	ZONE 9	ZONE 10	ZONE 11	ZONE 12	ZONE 13	ZONE 14	ZONE 15	ZONE 16	ZONE 17	ZONE 18	ZONE 19	ZONE 20
1979-1980	2-Nov	23-Nov	23-Nov	5-Dec	6-Dec	31-Oct	23-Nov	26-Nov	6-Dec	22-Nov	22-Oct	24-Nov	24-Nov	23-Nov	22-Nov	23-Nov	23-Nov	24-Nov	24-Nov	23-Nov
1980-1981	29-Nov	26-Nov	28-Nov	9-Dec	26-Nov	30-Nov	26-Nov	26-Nov	9-Dec	26-Nov	29-Nov	26-Nov	27-Nov	29-Nov	30-Nov	26-Nov	28-Nov	27-Nov	27-Nov	26-Nov
1981-1982	11-Nov	24-Nov	23-Nov	26-Nov	25-Nov	21-Nov	24-Nov	25-Nov	25-Nov	25-Nov	24-Oct	25-Nov	25-Nov	24-Nov	23-Nov	24-Nov	24-Nov	24-Nov	25-Nov	25-Nov
1982-1983	23-Nov	28-Oct	27-Nov	26-Oct	16-Dec	23-Nov	28-Oct	28-Oct	16-Dec	27-Oct	23-Nov	26-Oct	27-Oct	24-Nov	24-Nov	29-Oct	29-Nov	25-Nov	25-Nov	28-Oct
1983-1984	12-Nov	16-Nov	22-Nov	30-Nov	16-Nov	12-Nov	16-Nov	16-Nov	30-Nov	30-Nov	11-Nov	16-Nov	16-Nov	15-Nov	14-Nov	16-Nov	24-Nov	23-Nov	16-Nov	28-Nov
1984-1985	2-Dec	11-Dec	15-Nov	14-Nov	15-Dec	11-Nov	13-Dec	12-Dec	11-Dec	14-Nov	6-Nov	14-Nov	14-Nov	13-Dec	31-Dec	13-Dec	13-Nov	15-Dec	14-Dec	6-Nov
1985-1986	23-Nov	25-Nov	11-Dec	4-Dec	26-Nov	23-Nov	26-Nov	25-Nov	5-Dec	30-Nov	21-Nov	26-Nov	26-Nov	25-Nov	26-Nov	25-Nov	11-Dec	12-Dec	11-Dec	26-Nov
1986-1987	28-Nov	30-Nov	1-Dec	30-Oct	30-Nov	30-Nov	30-Nov	27-Oct	16-Nov	18-Nov	29-Nov	17-Nov	27-Oct	30-Nov	9-Dec	30-Nov	30-Nov	8-Dec	30-Nov	28-Oct
1987-1988	1-Dec	29-Dec	18-Dec	29-Dec	29-Dec	1-Dec	29-Dec	29-Dec	28-Dec	29-Dec	1-Dec	29-Dec	29-Dec	15-Dec	30-Dec	30-Dec	11-Dec	17-Dec	17-Dec	30-Dec
1988-1989	24-Nov	13-Nov	14-Nov	5-Dec	13-Nov	16-Nov	13-Nov	13-Nov	6-Dec	6-Dec	16-Nov	13-Nov	13-Nov	13-Nov	13-Nov	13-Nov	15-Nov	21-Dec	15-Dec	14-Nov
1989-1990	9-Nov	26-Nov	9-Dec	7-Dec	27-Nov	9-Dec	27-Nov	26-Nov	29-Nov	7-Dec	8-Nov	27-Nov	26-Nov	10-Dec	27-Nov	30-Nov	8-Dec	5-Dec	5-Dec	29-Nov
1990-1991	19-Nov	6-Nov	6-Dec	27-Oct	4-Dec	24-Oct	6-Nov	5-Dec	28-Oct	9-Nov	18-Nov	5-Dec	5-Dec	5-Nov	20-Nov	5-Nov	19-Nov	5-Dec	5-Dec	5-Dec
1991-1992	21-Nov	4-Dec	10-Dec	7-Dec	9-Dec	15-Nov	9-Dec	11-Dec	9-Dec	8-Dec	14-Dec	8-Dec	9-Dec	12-Dec	11-Dec	11-Dec	22-Nov	11-Dec	10-Dec	10-Dec
1992-1993	4-Nov	21-Dec	22-Dec	28-Nov	22-Dec	4-Nov	22-Dec	22-Dec	27-Nov	20-Nov	4-Nov	22-Dec	23-Dec	4-Nov	29-Dec	22-Dec	23-Dec	23-Dec	22-Dec	22-Dec
1993-1994	25-Oct	21-Dec	23-Dec	21-Dec	22-Dec	27-Oct	22-Dec	22-Dec	22-Dec	21-Dec	23-Oct	20-Dec	21-Dec	19-Dec	21-Dec	21-Dec	19-Dec	22-Dec	22-Dec	22-Dec
1994-1995	24-Nov	26-Dec	24-Nov	2-Dec	26-Dec	26-Dec	26-Dec	25-Dec	3-Dec	1-Dec	22-Nov	1-Dec	30-Nov	29-Dec	29-Dec	27-Dec	25-Dec	30-Nov	30-Nov	30-Nov
1995-1996	12-Nov	4-Dec	25-Nov	22-Dec	3-Dec	25-Nov	7-Dec	4-Dec	3-Dec	12-Dec	23-Nov	7-Dec	7-Dec	24-Nov	23-Nov	30-Nov	25-Nov	8-Dec	8-Dec	8-Dec
1996-1997	22-Nov	11-Dec	4-Dec	14-Dec	8-Dec	26-Nov	5-Dec	6-Dec	10-Dec	4-Dec	23-Nov	11-Dec	7-Dec	28-Nov	28-Nov	29-Nov	26-Nov	3-Dec	5-Dec	6-Dec
1997-1998	7-Dec	7-Dec	25-Nov	30-Nov	8-Dec	9-Dec	30-Nov	8-Dec	14-Dec	21-Nov	8-Nov	29-Nov	8-Dec	30-Nov	14-Nov	30-Nov	7-Dec	8-Dec	8-Dec	8-Dec
1998-1999	4-Dec	2-Dec	4-Dec	30-Dec	17-Dec	3-Dec	1-Dec	2-Dec	30-Dec	3-Dec	29-Nov	3-Dec	3-Dec	2-Dec	2-Dec	2-Dec	3-Dec	4-Dec	2-Dec	3-Dec
1999-2000	6-Dec	8-Dec	6-Dec	27-Dec	27-Dec	21-Oct	8-Dec	28-Dec	28-Dec	28-Dec	5-Dec	27-Dec	26-Dec	8-Dec	8-Dec	8-Dec	5-Dec	16-Dec	29-Dec	28-Dec
2000-2001	16-Nov	17-Nov	26-Nov	15-Dec	18-Dec	16-Nov	17-Nov	19-Dec	20-Jan	13-Dec	16-Nov	17-Nov	17-Nov	30-Nov	30-Nov	30-Nov	24-Nov	30-Nov	13-Dec	17-Nov
2001-2002	12-Nov	20-Dec	22-Dec	24-Dec	24-Dec	23-Nov	20-Dec	20-Dec	9-Jan	22-Dec	29-Nov	20-Dec	20-Dec	29-Nov	5-Dec	16-Dec	22-Dec	19-Dec	20-Dec	20-Dec
2002-2003	3-Dec	8-Dec	14-Dec	17-Dec	7-Dec	5-Dec	8-Dec	7-Dec	16-Dec	16-Dec	5-Dec	7-Dec	7-Dec	10-Dec	10-Dec	9-Dec	2-Dec	12-Dec	12-Dec	7-Dec
2003-2004	23-Nov	6-Dec	7-Dec	6-Dec	6-Dec	7-Dec	6-Dec	7-Dec	6-Dec	6-Dec	23-Nov	30-Nov	6-Dec	7-Dec	9-Dec	5-Dec	30-Nov	7-Dec	7-Dec	6-Dec
2004-2005	25-Nov	1-Dec	15-Dec	21-Dec	2-Dec	24-Nov	2-Dec	2-Dec	2-Dec	20-Dec	10-Dec	2-Dec	1-Dec	25-Nov	3-Dec	10-Dec	15-Dec	16-Dec	12-Dec	11-Dec
2005-2006	21-Nov	10-Dec	10-Dec	27-Dec	22-Dec	21-Nov	10-Dec	22-Dec	26-Dec	8-Dec	21-Nov	8-Dec	11-Dec	3-Dec	10-Dec	9-Dec	1-Dec	11-Dec	11-Dec	11-Dec
2006-2007	5-Nov	16-Nov	23-Nov	23-Nov	10-Dec	5-Dec	15-Nov	30-Nov	23-Nov	23-Nov	5-Nov	23-Nov	24-Nov	11-Dec	10-Dec	16-Nov	28-Nov	30-Nov	23-Nov	16-Nov

2007-2008	16-Nov	14-Dec	24-Nov	26-Dec	20-Dec	22-Nov	15-Dec	14-Dec	20-Dec	14-Dec	22-Nov	14-Dec	15-Dec	14-Dec	14-Dec	14-Dec	21-Nov	24-Nov	14-Dec	14-Dec
2008-2009	6-Nov	15-Nov	16-Nov	30-Nov	21-Nov	7-Nov	17-Nov	18-Nov	21-Nov	23-Nov	7-Nov	17-Nov	21-Oct	7-Nov	7-Nov	8-Nov	7-Nov	17-Nov	17-Nov	17-Nov
2009-2010	14-Nov	23-Nov	15-Nov	12-Dec	19-Nov	14-Nov	22-Nov	19-Nov	19-Nov	22-Nov	22-Nov	22-Nov	19-Nov	10-Dec	29-Dec	15-Nov	11-Nov	15-Nov	15-Nov	16-Nov
2010-2011	28-Nov	18-Dec	28-Nov	24-Dec	30-Dec	25-Nov	30-Dec	18-Dec	23-Dec	10-Dec	27-Nov	10-Dec	18-Dec	13-Dec	13-Dec	30-Dec	27-Nov	15-Dec	15-Dec	17-Dec
2011-2012	1-Nov	29-Nov	30-Nov	22-Dec	13-Dec	1-Nov	1-Dec	15-Dec	20-Dec	29-Nov	24-Nov	30-Nov	16-Dec	1-Nov	27-Dec	25-Nov	17-Nov	29-Nov	1-Dec	1-Dec
2012-2013	25-Dec	9-Dec	13-Dec	11-Dec	10-Dec	18-Nov	10-Dec	10-Dec	10-Dec	27-Dec	8-Dec	10-Dec	10-Dec	31-Dec	9-Dec	9-Dec	18-Nov	12-Dec	12-Dec	8-Dec
2013-2014	8-Nov	22-Nov	30-Nov	20-Dec	23-Nov	19-Nov	21-Nov	22-Nov	19-Dec	11-Nov	8-Nov	11-Nov	23-Nov	21-Nov	22-Nov	24-Nov	9-Nov	1-Dec	2-Dec	24-Nov
2014-2015	7-Dec	22-Nov	17-Dec	24-Dec	22-Nov	15-Nov	16-Dec	21-Nov	9-Jan	24-Dec	16-Oct	22-Dec	22-Nov	15-Dec	15-Dec	15-Dec	15-Nov	27-Nov	17-Dec	24-Dec
2015-2016	21-Nov	22-Dec	21-Nov	7-Dec	22-Dec	19-Nov	5-Dec	22-Dec	7-Dec	6-Dec	21-Nov	5-Dec	5-Dec	21-Nov	5-Dec	21-Nov	20-Nov	21-Nov	5-Dec	5-Dec
2016-2017	12-Nov	31-Dec	30-Dec	30-Dec	31-Dec	18-Nov	31-Dec	31-Dec	2-Jan	3-Jan	28-Oct	2-Jan	2-Jan	26-Nov	30-Dec	30-Dec	21-Dec	29-Dec	31-Dec	2-Jan
2017-2018	7-Dec	9-Dec	9-Dec	11-Dec	9-Dec	9-Nov	9-Dec	9-Dec	11-Dec	11-Dec	9-Nov	11-Dec	11-Dec	10-Nov	19-Dec	12-Nov	15-Nov	9-Dec	10-Dec	15-Nov

Table 2 : Dates of the end of the rainy season for each Zone over the period from 1979 to 2017

	ZONE 1	**ZONE 2**	**ZONE 3**	**ZONE 4**	**ZONE 5**	**ZONE 6**	**ZONE 7**	**ZONE 8**	**ZONE 9**	**ZONE 10**	**ZONE 11**	**ZONE 12**	**ZONE 13**	**ZONE 14**	**ZONE 15**	**ZONE 16**	**ZONE 17**	**ZONE 18**	**ZONE 19**	**ZONE 20**
1978-1979	2-Apr	4-Mar	3-Apr	9-May	25-Mar	10-Mar	29-Mar	27-Mar	25-Mar	8-Apr	20-Feb	29-Mar	27-Mar	4-Mar	30-Mar	30-Mar	11-Mar	29-Mar	30-Mar	29-Mar
1979-1980	20-Apr	7-May	30-Apr	21-May	21-May	20-Apr	7-May	14-May	21-May	14-May	19-Apr	10-May	10-May	28-Apr	27-Apr	28-Apr	2-Apr	20-Apr	7-May	7-May
1980-1981	3-Apr	28-Apr	29-Apr	17-May	18-May	30-Mar	27-Mar	30-Apr	17-May	29-Apr	3-Apr	30-Apr	30-Apr	27-Mar	28-Mar	27-Mar	3-Apr	9-Apr	29-Apr	27-Mar
1981-1982	20-Mar	20-Mar	5-Apr	12-Apr	20-Mar	19-Mar	20-Mar	20-Mar	5-Apr	14-Apr	20-Mar	1-Apr	20-Mar	19-Mar	25-Mar	20-Mar	19-Mar	20-Mar	5-Apr	5-Apr
1982-1983	23-Feb	20-Mar	20-Apr	25-Apr	15-Apr	21-Mar	21-Mar	16-Apr	24-Apr	25-Apr	17-Mar	24-Apr	20-Apr	21-Mar	20-Mar	21-Mar	3-Apr	21-Mar	16-Apr	16-Apr
1983-1984	14-Apr	18-Apr	13-Apr	27-Apr	27-Apr	13-Mar	18-Apr	19-Apr	27-Apr	13-Apr	10-Mar	18-Apr	18-Apr	13-Mar	16-Apr	16-Apr	13-Apr	16-Apr	18-Apr	18-Apr
1984-1985	14-Mar	22-Mar	30-Mar	5-May	30-Apr	10-Mar	22-Mar	26-Apr	23-Apr	23-Apr	4-Mar	30-Apr	30-Apr	4-Mar	4-Mar	22-Mar	13-Mar	10-Mar	31-Mar	3-Apr
1985-1986	4-May	1-May	28-Mar	2-May	1-May	17-Mar	20-Mar	2-May	2-May	2-May	17-Mar	5-May	5-May	17-Mar	20-Mar	17-Mar	17-Mar	17-Mar	17-Mar	2-May
1986-1987	19-Apr	19-Apr	20-Apr	22-May	19-Apr	19-Apr	18-Apr	19-Apr	22-May	18-Apr	4-Apr	18-Apr	19-Apr	19-Apr	19-Apr	19-Apr	19-Apr	19-Apr	19-Apr	19-Apr
1987-1988	14-Mar	30-Mar	19-Mar	9-May	5-May	29-Mar	30-Mar	1-Apr	6-May	9-Apr	12-Mar	1-Apr	1-Apr	19-Mar	30-Mar	30-Mar	23-Mar	30-Mar	1-Apr	1-Apr
1988-1989	1-Apr	1-Apr	1-Apr	8-May	2-Apr	1-Apr	1-Apr	1-Apr	2-Apr	4-Apr	31-Mar	1-Apr	1-Apr	1-Apr	1-Apr	1-Apr	9-Apr	1-Apr	1-Apr	1-Apr
1989-1990	6-May	24-Apr	25-Apr	19-May	24-Apr	12-Mar	2-May	25-Apr	24-Apr	25-Apr	12-Mar	27-Apr	26-Apr	20-Apr	18-Apr	2-May	12-Mar	17-Apr	25-Apr	25-Apr
1990-1991	17-Apr	25-Apr	26-Apr	25-Apr	25-Apr	18-Apr	25-Apr	25-Apr	25-Apr	25-Apr	4-Apr	25-Apr	25-Apr	17-Apr	17-Apr	25-Apr	30-Mar	18-Apr	25-Apr	25-Apr
1991-1992	15-Apr	15-Apr	16-Apr	7-May	26-Apr	15-Apr	15-Apr	26-Apr	7-May	7-May	10-Mar	26-Apr	26-Apr	10-Mar	10-Mar	15-Apr	14-Apr	15-Apr	15-Apr	15-Apr
1992-1993	29-Mar	27-Apr	17-May	31-May	13-May	6-Apr	12-May	13-May	13-May	31-May	12-Mar	13-May	13-May	27-Mar	27-Mar	6-Apr	2-Apr	3-Apr	23-Apr	13-May
1993-1994	23-Mar	24-Mar	24-Mar	23-May	26-Mar	23-Mar	24-Mar	24-Mar	23-May	23-May	23-Mar	26-Mar	26-Mar	24-Mar	24-Mar	24-Mar	23-Mar	24-Mar	25-Mar	24-Mar

1994-1995	14-Apr	23-Mar	20-Apr	9-May	17-May	23-Mar	24-Mar	25-Apr	23-May	9-May	23-Mar	9-May	9-May	23-Mar	22-Mar	24-Mar	5-Apr	15-Apr	19-Apr	24-Apr
1995-1996	31-Mar	25-Mar	3-Apr	16-May	3-Apr	29-Mar	28-Mar	29-Mar	4-Apr	4-Apr	28-Mar	3-Apr	3-Apr	28-Mar	28-Mar	28-Mar	1-Apr	30-Mar	29-Mar	29-Mar
1996-1997	17-Mar	11-Mar	26-Apr	1-Jun	23-Apr	17-Mar	11-Mar	26-Mar	23-Apr	24-Apr	20-Mar	24-Apr	23-Apr	12-Mar	18-Mar	11-Mar	11-Mar	13-Mar	24-Apr	24-Apr
1997-1998	13-Mar	6-Mar	25-Apr	1-May	1-May	29-Mar	30-Apr	1-May	1-May	30-Apr	6-Mar	25-Apr	1-May	6-Mar	6-Mar	6-Mar	16-Apr	14-Apr	24-Apr	25-Apr
1998-1999	25-Mar	1-Apr	7-Apr	17-May	29-Apr	25-Mar	6-Apr	6-Apr	2-Jun	6-Apr	25-Mar	6-Apr	6-Apr	25-Mar	25-Mar	25-Mar	25-Mar	25-Mar	6-Apr	6-Apr
1999-2000	9-Mar	3-Apr	4-Apr	7-Apr	5-Apr	9-Mar	3-Apr	3-Apr	6-Apr	4-Apr	8-Mar	4-Apr	5-Apr	9-Mar	7-Mar	3-Apr	10-Mar	4-Apr	4-Apr	3-Apr
2000-2001	25-Mar	29-Mar	2-Apr	31-May	19-May	25-Mar	30-Mar	2-Apr	20-May	19-May	25-Mar	2-Apr	1-Apr	25-Mar	25-Mar	29-Mar	24-Mar	27-Mar	30-Mar	1-Apr
2001-2002	14-Mar	9-Mar	11-May	11-May	23-May	15-Mar	11-Mar	9-Mar	11-May	11-May	14-Mar	12-May	13-May	12-Mar	12-Mar	11-Mar	15-May	15-May	13-May	11-May
2002-2003	8-Apr	8-Apr	27-Apr	2-May	5-Apr	8-Apr	9-Apr	8-Apr	2-May	27-Apr	25-Mar	26-Apr	8-Apr	9-Apr	9-Apr	9-Apr	25-Mar	10-Apr	26-Apr	9-Apr
2003-2004	13-Mar	7-Mar	18-Apr	12-May	18-Apr	15-Mar	8-Mar	18-Apr	12-May	18-Apr	13-Mar	18-Apr	18-Apr	13-Mar	13-Mar	12-Mar	13-Mar	15-Mar	8-Mar	18-Apr
2004-2005	18-Apr	31-Mar	3-May	22-May	22-May	18-Apr	31-Mar	20-Mar	22-May	22-May	29-Mar	22-May	18-Apr	31-Mar	30-Mar	31-Mar	18-Apr	18-Apr	21-Apr	18-Apr
2005-2006	29-Mar	21-Mar	16-Apr	4-May	21-Mar	26-Mar	21-Mar	21-Mar	3-May	16-Apr	21-Mar	16-Apr	21-Mar	21-Mar	21-Mar	21-Mar	29-Mar	21-Mar	21-Mar	21-Mar
2006-2007	23-Mar	15-Mar	5-Apr	28-May	18-Mar	23-Mar	16-Mar	17-Mar	29-May	5-Apr	17-Mar	4-Apr	4-Apr	22-Mar	15-Mar	16-Mar	3-Apr	4-Apr	4-Apr	4-Apr
2007-2008	24-Feb	7-Mar	11-Apr	16-Apr	12-Mar	7-Mar	7-Mar	9-Mar	21-Mar	16-Apr	24-Feb	25-Mar	9-Mar	24-Feb	24-Feb	7-Mar	23-Feb	30-Mar	30-Mar	30-Mar
2008-2009	14-Apr	18-Apr	22-Apr	16-May	24-Apr	13-Apr	18-Apr	24-Apr	28-Apr	24-Apr	13-Apr	23-Apr	24-Apr	13-Apr	13-Apr	13-Apr	13-Apr	7-Apr	5-Apr	22-Apr
2009-2010	17-Mar	19-Mar	3-Apr	27-Apr	23-Apr	18-Mar	19-Mar	25-Mar	27-Apr	10-Apr	17-Mar	6-Apr	6-Apr	17-Mar	18-Mar	19-Mar	18-Mar	19-Mar	24-Mar	19-Mar
2010-2011	7-Mar	16-Apr	19-Apr	3-May	17-Apr	16-Mar	16-Apr	17-Apr	30-Apr	27-Apr	12-Mar	18-Apr	16-Apr	16-Mar	14-Apr	16-Apr	16-Mar	15-Apr	19-Apr	18-Apr
2011-2012	8-Apr	14-Apr	24-Apr	24-May	10-May	6-Apr	14-Apr	22-Apr	20-May	24-May	5-Mar	22-Apr	22-Apr	4-Mar	14-Apr	12-Apr	23-Apr	22-Apr	21-Apr	21-Apr
2012-2013	24-Mar	26-Feb	28-Apr	30-Apr	29-Apr	28-Feb	27-Feb	10-Apr	28-Apr	10-Apr	27-Feb	8-Apr	6-Apr	27-Feb	25-Mar	27-Feb	15-Apr	14-Apr	14-Apr	8-Apr
2013-2014	31-Mar	24-Mar	8-Apr	10-May	24-Mar	24-Mar	23-Mar	24-Mar	10-May	24-Mar	28-Feb	24-Mar	24-Mar	23-Mar	23-Mar	23-Mar	21-Mar	23-Mar	24-Mar	24-Mar
2014-2015	11-Mar	12-Mar	12-Apr	19-May	19-Mar	11-Mar	12-Mar	12-Mar	18-May	7-May	11-Mar	20-Mar	12-Mar	11-Mar	15-Mar	12-Mar	13-Mar	12-Mar	12-Mar	12-Mar
2015-2016	4-Apr	4-Apr	5-Apr	26-Apr	25-Apr	4-Apr	4-Apr	18-Apr	26-Apr	26-Apr	26-Mar	26-Apr	18-Apr	28-Mar	28-Mar	4-Apr	4-Apr	4-Apr	18-Apr	4-Apr
2016-2017	31-Mar	6-May	12-Apr	9-May	9-May	29-Mar	30-Mar	5-May	9-May	9-May	30-Mar	7-May	5-May	30-Mar	30-Mar	30-Mar	30-Mar	1-Apr	12-Apr	13-Apr

Table 3: Duration (days) of the rainy season in each Zone over the period from 1979 to 2017

season	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**	**Zone 7**	**Zone 8**	**Zone 9**	**Zone 10**	**Zone 11**	**Zone 12**	**Zone 13**	**Zone 14**	**Zone 15**	**Zone 16**	**Zone 17**	**Zone 18**	**Zone 19**	**Zone 20**
1979-1980	169	165	158	167	166	171	165	169	166	173	179	167	167	156	156	156	130	147	164	165
1980-1981	126	154	153	160	174	121	122	156	160	155	126	156	155	119	119	122	127	134	154	122
1981-1982	129	116	133	137	115	118	116	115	131	140	147	127	115	115	122	116	115	116	131	131
1982-1983	91	143	144	181	120	118	144	170	129	180	114	180	175	117	116	143	125	116	142	170

1983-1984	153	153	142	148	162	121	153	154	148	134	119	153	153	118	153	151	140	144	153	141
1984-1985	103	102	136	173	137	120	100	136	134	161	119	168	168	82	64	100	121	86	108	149
1985-1986	162	157	107	149	156	114	114	158	148	153	116	160	160	112	114	112	96	95	96	157
1986-1987	142	140	140	204	140	140	139	174	187	151	126	152	174	140	131	140	140	132	140	173
1987-1988	103	91	91	131	127	118	91	93	129	101	101	93	93	94	90	90	102	103	105	92
1988-1989	129	140	139	155	141	137	140	140	118	120	136	140	140	140	140	140	146	102	108	139
1989-1990	178	149	137	163	148	93	156	150	146	139	124	151	151	131	142	153	94	133	141	147
1990-1991	149	170	141	180	142	176	170	141	179	167	137	141	141	163	148	171	131	134	141	141
1991-1992	145	132	127	151	138	151	127	136	149	150	86	139	138	88	89	125	143	125	126	126
1992-1993	146	128	147	185	143	154	142	143	168	193	129	143	142	144	89	106	101	102	123	143
1993-1994	149	93	91	153	94	147	92	92	152	153	151	96	95	95	93	93	94	92	93	92
1994-1995	141	87	147	158	142	87	88	121	171	159	121	159	160	84	83	87	101	136	140	145
1995-1996	139	111	129	145	121	124	111	115	122	113	125	117	117	124	125	118	127	112	111	111
1996-1997	116	91	144	170	137	112	97	111	135	142	118	135	138	105	111	103	106	101	141	140
1997-1998	96	89	151	152	144	110	151	144	138	160	118	147	144	96	112	96	130	127	137	138
1998-1999	111	120	124	138	133	112	126	125	154	124	116	124	124	113	113	113	112	111	125	124
1999-2000	93	116	119	101	99	139	116	96	99	97	93	98	100	91	89	116	95	109	96	96
2000-2001	130	133	128	168	153	130	134	105	121	158	130	137	136	116	116	120	121	118	108	136
2001-2002	122	79	140	138	150	112	81	79	122	140	105	143	144	103	97	85	144	147	144	142
2002-2003	126	121	134	136	119	124	122	122	137	132	110	140	122	120	120	121	113	119	135	123
2003-2004	110	91	132	157	133	98	92	132	157	133	110	139	133	96	94	97	103	98	91	133
2004-2005	145	121	140	153	172	146	120	109	172	154	110	172	139	127	118	112	125	124	131	129
2005-2006	128	101	127	128	89	125	101	89	128	129	120	129	100	108	101	102	118	100	100	100
2006-2007	138	119	133	186	98	108	121	107	187	133	132	132	131	101	95	120	126	125	132	139
2007-2008	99	83	138	111	82	105	82	85	91	123	93	101	84	71	71	83	93	126	106	106
2008-2009	160	155	158	168	155	158	153	158	159	153	158	158	186	158	158	157	158	142	140	157
2009-2010	123	116	139	136	155	124	117	126	159	139	115	135	138	97	79	124	127	124	129	123
2010-2011	99	119	142	130	108	111	107	120	128	138	105	129	119	93	122	107	109	121	125	122
2011-2012	158	136	145	153	148	156	134	128	151	176	101	143	127	123	108	138	157	144	141	141
2012-2013	90	79	137	141	141	102	79	122	140	105	81	120	118	58	107	80	149	124	124	122
2013-2014	143	122	129	141	121	125	122	122	142	133	111	133	121	122	121	119	132	112	112	120

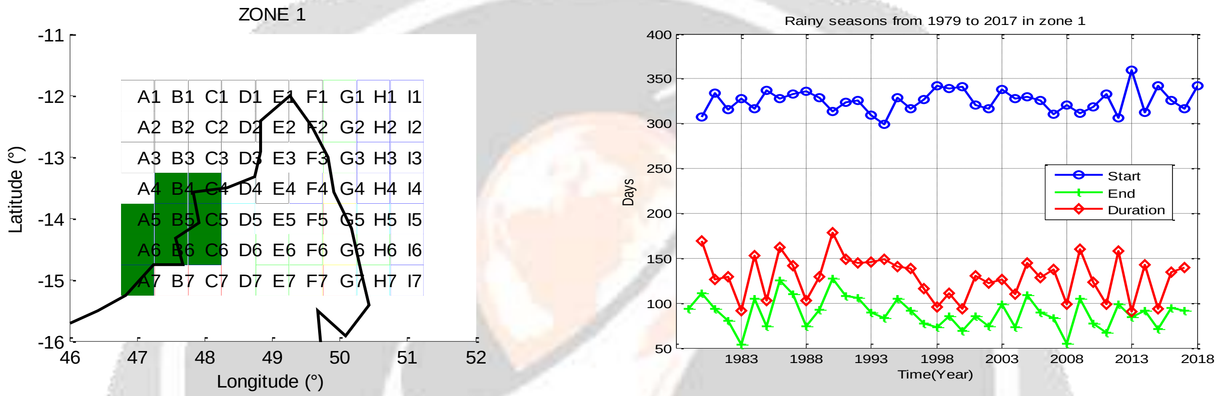
2014-2015	94	110	116	146	117	116	86	111	129	134	146	88	110	86	90	87	118	105	85	78
2015-2016	134	103	135	140	124	136	120	117	140	141	125	142	134	127	113	134	135	134	134	120
2016-2017	140	127	104	131	130	132	90	126	128	127	154	126	124	125	91	91	100	94	103	102

From these tables, we obtain the curves of the beginnings of the rains, the ends of the rains and the durations of the rainy seasons for each zone.

For all the figures of the date result of the rainy season, we have the number of the year on the abscissa going from 1979 to 2017 and the number of the day of a year on the ordinate going from 0 to 365 days. In these figures, we have three curves. The curve in blue is the start dates of the rainy season. The curve in green is that of the end of the season. And the curve in red is the difference between these last two curves or duration of the rainy season. In general, the length of each rainy season is variable. There are long rainy seasons, there are short ones.

Finally, on the figures of evolutions of the amount of precipitation during the rainy seasons, we have a green line which corresponds to the global annual average of precipitation during the season from 1979 to 2017 Characteristics of the rainy season in zone 1 from 1979 to 2017

In Figure 9(a), Zone 1 is represented by the color green. In Figure 9 (b), the blue, green and red signal curve represents respectively the variation of the start, end and duration of the rainy season in zone 1 from 1979 to 2017. The start date of the season rainfall fluctuates between 299th day (i.e. October 25) and 360th (i.e. December 25) of the year. And The end of the rainy season varies between 54th (February 23) and 84th (May 26) days of the year. On average, the rainy season in zone 1 begins approximately on November 20 and ends on March 28. Similarly, interpretations of the rainy season for all other zones are summarized in Table 9.



(a) **(b)**

Chart- 3: Variation of the rainy season from 1979 to 2017 in zone 1

For zone 1, the average precipitation is 3100 mm, represented in green color in Figure 10. We observe a downward trend in the duration of the rainy seasons. This shortening is strong with reductions of 16 days in 39 years. On the other hand, this phenomenon is contradictory in relation to the cumulative precipitation during the season. When we did the linear regression line on the annual precipitation during the rainy season, we find a positive slope trend of 22.256, i.e. the amount of precipitation during the rainy season was increased of 858 mm during the period from 1979 to 2017. Also, similarly, the interpretations concerning the trend of duration and the cumulative precipitation during the season for all the other zones are summarized in Table

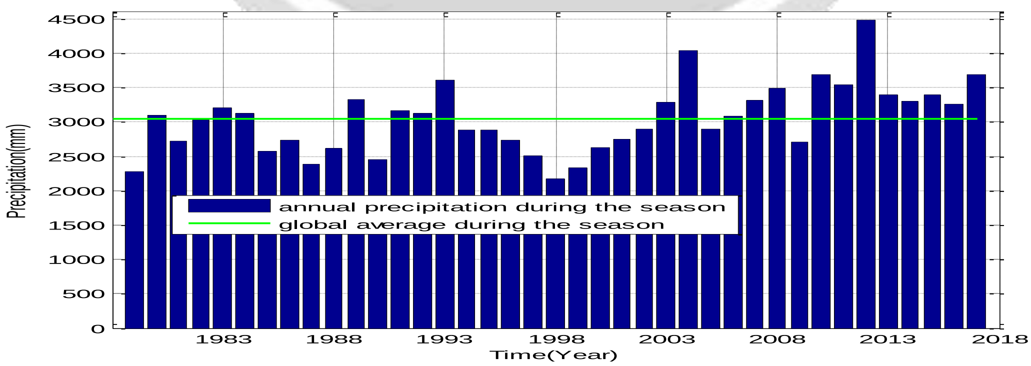


Chart- 4: Evolution of the amount of precipitation during the rainy seasons from 1979 to 2017 in zone 1

Table 4 : Extreme characteristic of the rainy season of each Zone from 1979 to 2017

START			END			DURATION		
Early	**Late**	**Medium**	**Early**	**Late**	**Medium**	**Early**	**Late**	**Medium**

Zone 1	25-oct.	25-déc.	20-nov.	23-févr.	6-mai	28-mars	90 jours	178 jours	129 jours
Zone 2	28-oct.	31-déc.	2-déc.	26-févr.	7-mai	1-avr.	79 jours	170 jours	120 jours
Zone 3	14-nov.	30-déc.	2-déc.	19-mars	17-mai	15-avr.	91 jours	158 jours	134 jours
Zone 4	26-oct.	30-déc.	8-déc.	7-avr.	1-juin	9-mai	101 jours	204 jours	152 jours
Zone 5	13-nov.	31-déc.	9-déc.	12-mars	23-mai	21-avr.	82 jours	174 jours	134 jours
Zone 6	21-oct.	26-déc.	20-nov.	28-févr.	20-avr.	25-mars	87 jours	176 jours	126 jours
Zone 7	28-oct.	31-déc.	3-déc.	27-févr.	12-mai	1-avr.	79 jours	170 jours	119 jours
Zone 8	27-oct.	31-déc.	5-déc.	9-mars	14-mai	10-avr.	79 jours	174 jours	126 jours
Zone 9	28-oct.	20-janv.	11-déc.	21-mars	2-juin	3-mai	91 jours	187 jours	144 jours
Zone 10	27-oct.	3-janv.	4-déc.	24-mars	31-mai	25-avr.	97 jours	193 jours	142 jours
Zone 11	16-oct.	14-déc.	17-nov.	24-févr.	19-avr.	18-mars	81 jours	179 jours	121 jours
Zone 12	26-oct.	2-janv.	2-déc.	20-mars	22-mai	18-avr.	88 jours	180 jours	137 jours
Zone 13	21-oct.	2-janv.	1-déc.	9-mars	13-mai	14-avr.	84 jours	186 jours	135 jours
Zone 14	1-nov.	31-déc.	30-nov.	24-févr.	28-avr.	22-mars	58 jours	163 jours	112 jours
Zone 15	7-nov.	31-déc.	6-déc.	24-févr.	27-avr.	26-mars	64 jours	158 jours	111 jours
Zone 16	29-oct.	30-déc.	2-déc.	27-févr.	2-mai	28-mars	80 jours	171 jours	117 jours
Zone 17	7-nov.	25-déc.	28-nov.	23-févr.	15-mai	29-mars	93 jours	158 jours	121 jours
Zone 18	15-nov.	29-déc.	5-déc.	10-mars	15-mai	3-avr.	86 jours	147 jours	119 jours
Zone 19	15-nov.	31-déc.	7-déc.	8-mars	13-mai	10-avr.	85 jours	164 jours	124 jours
Zone 20	28-oct.	2-janv.	2-déc.	12-mars	13-mai	11-avr.	78 jours	173 jours	130 jours

Table 5: Trend in duration and cumulative amount of precipitation during the rainy season over the period from 1979 to 2017

	Duration		Amount of precipitation	
	Slope of linear regression line (y=ax+b)	Variation during 39 years (days)	Slope of linear regression line (y=ax+b)	Variation during 39 years (mm)
Zone 1	-0,42	-16,38	22,256	867,984
Zone 2	-0,89	-34,71	21,634	843,726
Zone 3	-0,149	-5,811	4	156
Zone 4	-0,753	-29,367	-15,338	-598,182
Zone 5	-0,622	-24,258	5,19	202,41
Zone 6	-0,182	-7,098	50,874	1984,086
Zone 7	-0,889	-34,671	24,832	968,448
Zone 8	-1,048	-40,872	4,827	188,253
Zone 9	-0,332	-12,948	3,862	150,618
Zone 10	-0,584	-22,776	-7,372	-287,508
Zone 11	-0,369	-14,391	22,706	885,534
Zone 12	-0,743	-28,977	1,544	60,216
Zone 13	-0,897	-34,983	2,453	95,667
Zone 14	-0,525	-20,475	51,858	2022,462
Zone 15	-0,589	-22,971	33,6911	1313,9529
Zone 16	-0,706	-27,534	35,615	1388,985
Zone 17	0,158	6,162	30,698	1197,222
Zone 18	-0,007	-0,273	14,474	564,486
Zone 19	-0,547	-21,333	0,804	31,356
Zone 20	-0,91	-35,49	14,401	561,639

4. CONCLUSION

Three important steps have structured this work: the regionalization of the study area into different areas well determined by the Kohonen network and the detection of the start and end dates of the rainy seasons in each homogeneous area by the method of A.A.

Zoning results by Kohonen networks revealed twenty homogeneous regions according to the precipitation of our study area from 1979 to 2017.

The detection by the Anomalous accumulation showed that from 1979 until 2017, the earliest starting date was located in zone 11, and the latest in zone 9. In general, it can be said that the season of rains in the northern part of Madagascar begin on average at the beginning of December. About the date of the end of the season, the earliest was found in zone 1, and the latest in zone 9. The rainy season generally ends at the beginning of April. Regarding the length of the season, the shortest was found in Zone 14, and the longest in Zone 4. On average, the season in the northern part of the Grand Island lasts for 127 days, i.e. 3 months a little more. For the overall study area, we observe a downward trend in the duration of the rainy seasons.

The climatological analysis on the amount of rainfall during the rainy season concluded that the amount of precipitation has increased for most areas except area 4 and area 10. These are maritime parts east of our study area.

Knowledge of the characteristics of the rainy seasons makes it possible to know the agricultural regimes in this part of Madagascar.

As a perspective, we suggest making a forecast of the start date and the end date of the rainy season with the nonlinear method such as the artificial neural network in order to update the agricultural calendar.

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