# CLIMATE INDEX: ANTARCTIC OSCILLATION (A.A.O), INDIAN OCEAN DIPOLE (I.O.D) AND THEIR INFLUENCE ON THE RAINFALL IN PART SOUTHWEST OF MADAGASCAR

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*This work contributes to the correlation study of climate indices (AAO and IOD) and rain in the south - western part of Madagascar. We used mathematical tools such methodology. We took a series of weather data from France, first rainfall data, data and climate indices from 1979 to 2000 (A.A.O) and 1971 to 2000 (I.O.D) in site NOAA other. We applied principal component analysis to determine zoning. Then we have used the F.F. T to determine the frequency: this gives us a result that the IOD is 20.23 08 months period and the period of 65.75 months AAO. At the end we applied the cross correlation method to know their impact on precipitation and we have got the values x = -181mois, y = 0.139 for the IOD and x = -6 months, y = -0, 1389 to the AAO And as these values are low (y = 0.139 (IOD) and y = -0, 1389 (AAO)) so our study shows that there is no correlation between climatic indices (IOD, AAO) and rain in our study area.*

## INTRODUCTION:

Rainfall is a decisive factor for the development of a country. The island of Madagascar is located in the southeast of Africa which it is separated by the Mozambique Channel. It is between longitudes 43 ° East and 51 ° East on one side, and latitudes 11 ° South and 26 ° South on the other side. As Madagascar is included in the tropics, it has two different seasons that could be subdivided into microclimate (climate varies considerably from region to region and from season to season): the rainy season or season humid austral summer (November to April); the dry season in austral winter (March to October). From the international point of view, we can see in the last decade, a major imbalance in climatology: if one suffers from flooding in some countries, others of drought. For Malagasy people, among all the elements of climate, no doubt the rain occupies a prominent place in everyday life, for it is the source of all fresh water available, and in some areas which farm for survives. Its excess or lack becomes a matter of life or death. To understand the current climate change and estimate its future development, it is essential to know its past evolution. Therefore, the study of climatology for rain more effective weather forecasting long and short term, is a key point of integrated development process. The precipitation may be disturbed by waves (climate indices). Our goal is to see the correlation between precipitation and climate indices AAO (Antarctic Oscillation) and IOD (Indian Ocean Dipole) in the south - western part of Madagascar specifically between longitudes 42.5° East and 46.5° East and between latitudes 21.5° North and 26.5 ° South. For this, we have divided this work into three parts: In the first part the Principal

Component Analysis (P.C.A) monitoring results obtained by this method, the second part is the Fourier Transformation (F.F.T) and the results and in the last part the results by applying the cross correlation.

## METHODOLOGY AND RESULTS:

### I) Principal Component Analysis (P.C.A)

**Purpose:** We used this method to determine the zoning

The principal component analysis: a set of methods to carry out linear transformations a large number of inter correlated variables so as to obtain a relatively small number of uncorrelated components. This approach facilitates analysis by grouping the data into smaller sets and allowing eliminating the problems of multi collinearity between variables.

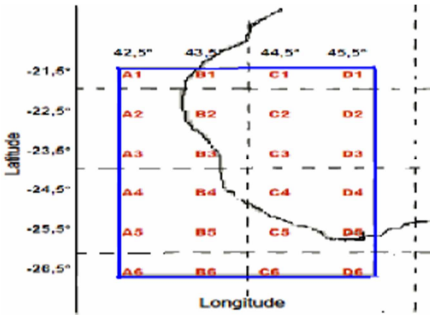



***Figure 1:*** *correspondence between individuals and their name*

We present below some results of the P.C.A conducted with the MATLAB software on these data.

### I.1) RESULT ON I.O.D

#### I.1.1) Choice of number of axes to remember

**Table 1:** Eigenvalues and variance of IOD

| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 | F12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Valeur propre | 5,474 | 3,244 | 1,657 | 0,852 | 0,549 | 0,187 | 0,034 | 0,001 | 0,000 | 0,000 | 0,000 | 0,000 |
| %variance | 45,620 | 27,036 | 13,807 | 7,103 | 4,578 | 1,557 | 0,286 | 0,010 | 0,001 | 0,001 | 0,001 | 0,000 |
| %cumulé | 45,620 | 72,656 | 86,463 | 93,566 | 98,144 | 99,701 | 99,987 | 99,997 | 99,998 | 99,999 | 100,000 | 100,000 |

The total inertia (100%) of the point cloud is distributed according to 12 values. It keeps only the factors whose inertia is greater than 100/12 = 8.3 %, this leads us to select the first three axes (greater than 8.3 %, see Table 1), which holds 86,463 % of the total inertia.

#### I.1.2) Variables on result

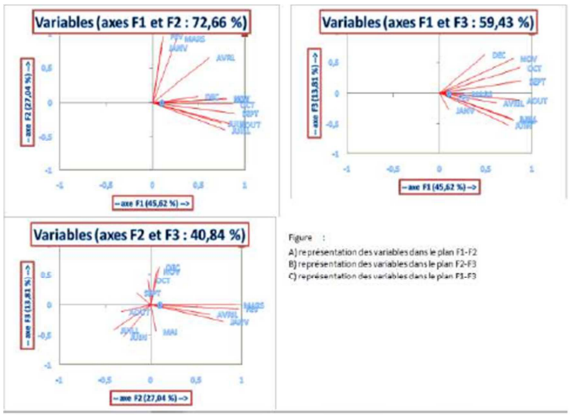



***Figure 2:*** *Variable Projection (I. O.D)*

#### I.1.3) Profit on individuals

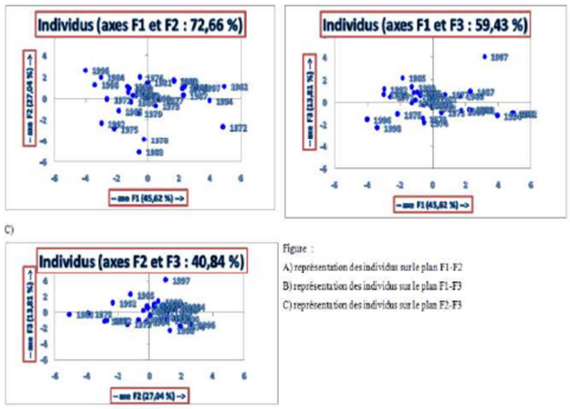



***Figure 3:*** *Projection of individuals (I.O.D)*

The climate index I.O.D is periodic. We see that it begins the months of March and

April is the maximum months of September and October and disappears the month of December; and having projected individuals (Year) on factorial F1- F2, F3 and F1- F2 -F3, we note that there was an appearance of climate IOD index during the years 1980-1982 and 1994-1997. This verifies that the IOD period is 1-4 years

## I.2) RESULT ON A.A.O

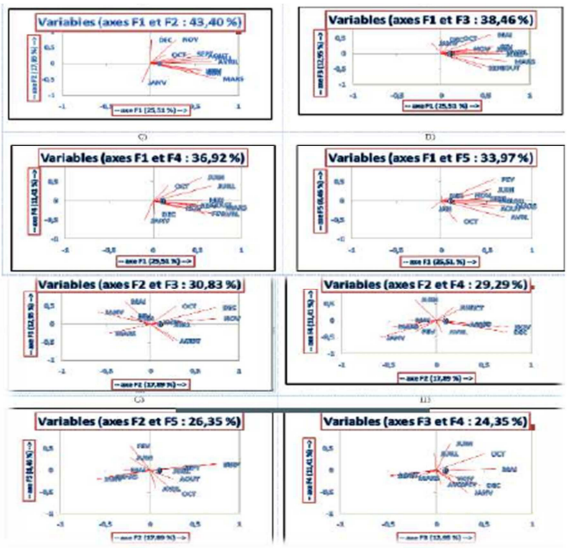
### I.2.1) Choice of number of axes to remember

**Table 2:** Eigenvalues and variances (A.A.O)

| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 | F12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Valeur propre | 3,062 | 2,146 | 1,553 | 1,369 | 1,015 | 0,793 | 0,705 | 0,409 | 0,386 | 0,285 | 0,186 | 0,09 |
| Variance % | 25,513 | 17,886 | 12,946 | 11,407 | 8,460 | 6,611 | 5,878 | 3,410 | 3,213 | 2,371 | 1,551 | 0,753 |
| Cumulé % | 25,513 | 43,399 | 56,345 | 67,752 | 76,212 | 82,823 | 88,701 | 92,111 | 95,324 | 97,695 | 99,247 | 100,00 |

The total inertia (100%) of the point cloud is distributed according to 12 values. It keeps only the factors whose inertia is greater than 100/12 = 8.3%, this leads us to select the first five axes (greater than 8.3 %, see tableu2), which holds 76.2 12 % of the total inertia.

### I.2.2) Variables on result



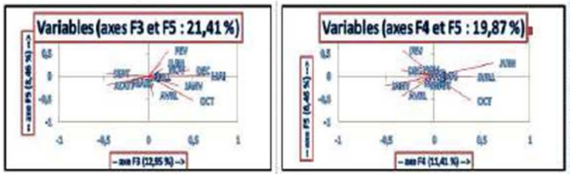




***Figure 4:*** *Variable Projection (A.A. O)*

### I.2.3) Profit on individuals

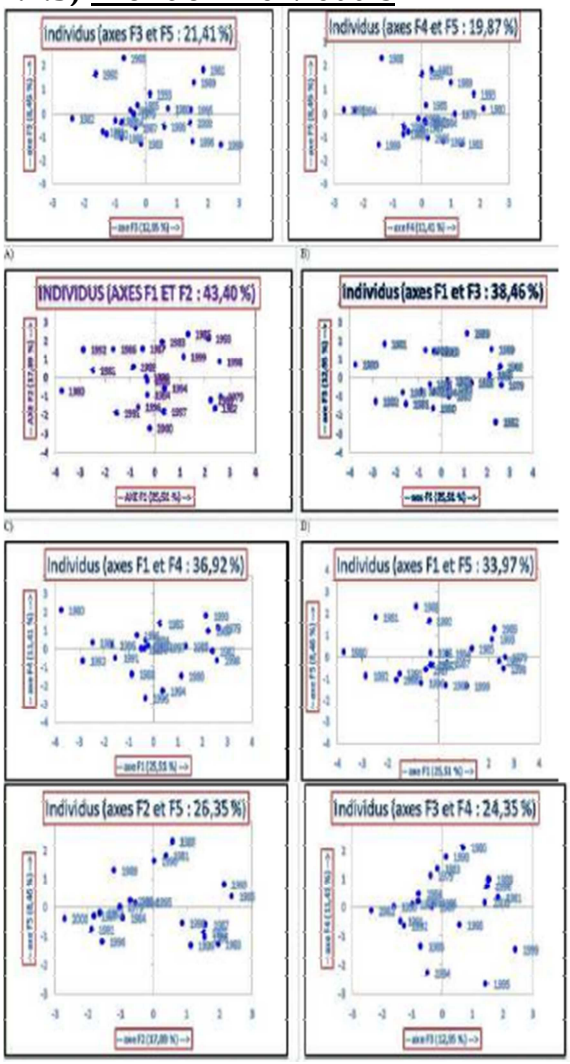



***Figure5:*** *Projection of individuals (A.A. O)*

The A.A.O is periodic climatic index (Figure 9). And the years we have seen the emergence of the A.A.O climate index are: 1980 - 1983 - 1988 - 1993 -1994-1995 - 1999. This shows us that the AAO period is 1-5 years.

## I.3) RESULT ON RAIN

### I.3.1) Choice of number of axes to remember

**Table 4:** Eigenvalues and variance of rain

| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 | F12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Valeur propre | 6,928 | 3,448 | 1,101 | 0,267 | 0,113 | 0,073 | 0,044 | 0,013 | 0,008 | 0,004 | 0,001 | 0,000 |
| % variance | 57,733 | 28,735 | 9,172 | 2,222 | 0,943 | 0,605 | 0,367 | 0,106 | 0,066 | 0,036 | 0,010 | 0,002 |
| % cumulé | 57,73 | 86,469 | 95,641 | 97,863 | 98,807 | 99,411 | 99,779 | 99,885 | 99,952 | 99,988 | 99,998 | 100,0 |

The total inertia (100%) of the point cloud is distributed according to 12 values. It keeps only the factors whose inertia is greater than 100/12 = 8.3 %, this leads us to select the first three axes, which retains 95 = 641 % of the total inertia.

### I.3.2) Results variables

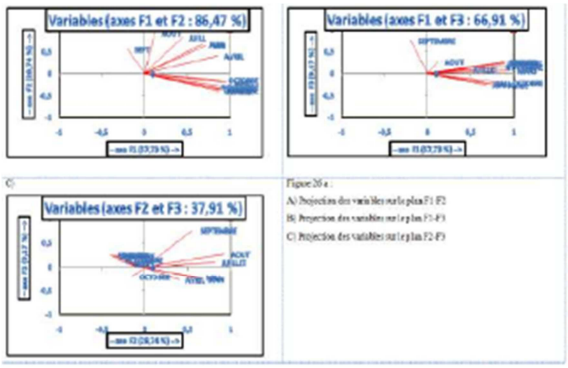



*Figure 6: Variable Projection (rain)*

### I.3.3) Results on individuals

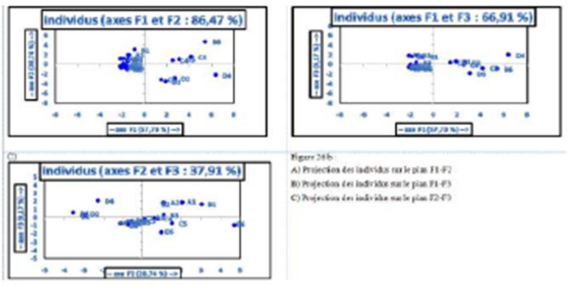



*Figure 7: Projection of individuals (rain)*

From Figure 6, we see that during the austral summer (November to April), there is a strong precipitation (rain) during the months of December, January and especially February; and rain decreases during the austral winter (March to October). Some places (individuals) as C1 (Antsoha) C4 (Ampanihy) -D4 (Ankililoaka) - D5 (Faux Cap) have high precipitation in relation to other, during the austral summer. In the latter, the rain is much more abundant in southern winters. We see that every month are correlated except September which is correlated to any month. This shows us that there is some places (individuals) who have more precipitation than normal in southern winter (winter rainfall) in our study area as: B1 (Lake Ihotry) -B2 (Andobotoka) -B3 (Tulear) (see Figure 7).

## II) Fast Fourier Transformation (F.F.T)

**Purpose:** We need this formula Transformed Fast Fourier to see the periodicity of our climate indices (I.O.D and A.A.O).

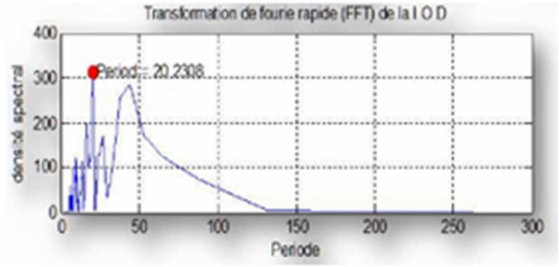



*Figure 8: Fast Fourier Transform (IOD)*

Figure 8 shows that the monthly period of climatic index IOD is 20.2308 months which corresponds to 1.68 years, frequency 0.049/months, and the spectral density of 315.9; we also found that there is no other peaks at low spectral density to the point 16.46; and finally developed to the point 26.3 43.83; which allows us to say that the phenomenon is repeated every 16; 26 or 43 months.

### II.2) Results on A.A.O

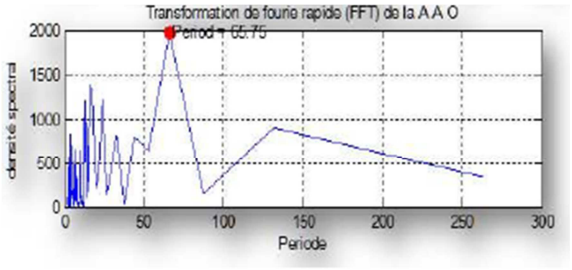



***Figure 9**: Fast Fourier Transform (A.A.O)*

It is clear that the monthly period the A.A.O climate index is 65.75 months (Figure 9) which corresponds to 5.479 years, frequency 0.015 months -1, and the spectral density of 1979, it was also found that there is no other peaks at low spectral density to the point 12.52; developed 16.44 23.91 and finally at the point; that allows us to say that the phenomenon is repeated every 12; 16 or 23 months.

## III) CROSS-CORRELATION

**Purpose:** We applied this methodology (the cross-correlation) to determine the correlation between climate indices (I.O.D and A.A.O) and rain in our study area.

### III.1) Cross-correlation of Rain and IOD

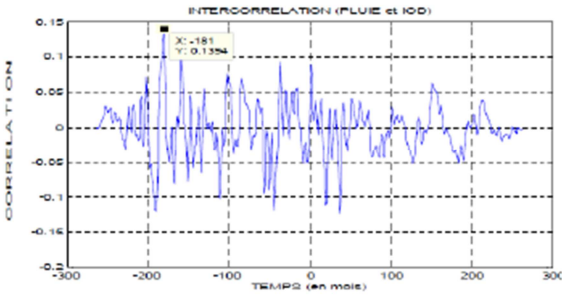



***Figure 10**: Cross-correlation rain and the I.O.D*

We see that the largest peak 10 is coordinated x= -181 months and y = 0.139 that is to say the -181mois shows us that the climate index IOD passes 181 months (~ 15 years) before there is a rush to turn but is not sure yet because the value 0.139 is very low so they have a low correlation, when simply IOD hardly influences the rain in our area of study.

### III.2) Cross- correlation of Rain and AAO

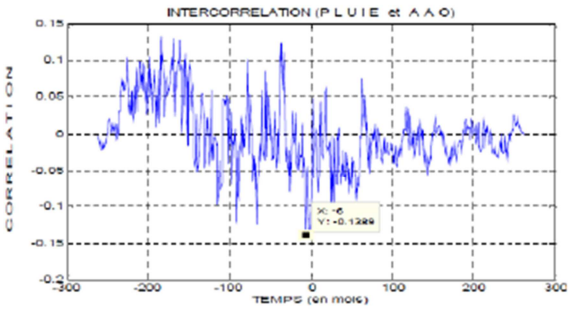



***Figure 11**:Cross-correlation rain and the AAO*

From this figure 11, the weather index A.A.O is ahead 6 months compared to the precipitation (the value x = -6 months) and the A.A.O has little influence on the latter because of the low value of correlation between the two (the value y = -0, 1389).

## DISCUSSION AND CONCLUSION

In this work, we analyzed the correlation between rain and the climatic indication I.O.D and A.A.O. We used the monthly average rainfall (1979 to 2000) and the IOD during the 30 years from 1971 to 2000; AAO during the 22 years from 1979 to 2000 in the Southwest region of Madagascar between longitudes 42.5° East and 46,5Est and between 21.5° South latitude and 26.5 ° South.

After the C.P.A for rain data, we had the following outcomes: places (individuals) as C1 (Antsoha) - C4 (Ampanihy) - D4 (Ankililoaka) - D5 (Faux-Cap) have high precipitation during the austral summer (November to April) especially the month of February. The month of September is correlated with any month and the formation of the F3 axis, this month

represent 51.57% of contribution which mean that, there is also a places (individuals) such as: B1 ( Lake Ihotry) - B2 (Andobotoka) - B3 (Tulear) that have more precipitation than normal during the austral winter (winter rain). The result of the Fast Fourier transform (FFT) confirms that climate index IOD period is ~ 20 months and that of the AAO is ~ 65 months. Finally, due to the low correlation values: = y - 0, 1389 (for AAO) and y = 0.139 (for IOD), after applying the method of cross correlation; climate indices (IOD and AAO) have no impact on the rain in our study area.

Normally we need to work on a series of data for 30 years but for the AAO data is not available unless from 1979 to 2000 alone.

## ACKNOWLEDGMENTS

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