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Impact of Spatio-Temporal Disruption of Climatic Parameters on Flight Safety at GOMA International Airport

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Résumé
Abstract.
Disturbances in climatic parameters; such as the spatio-temporal variability of operational data,air temperature,specific humidity,wind direction… are poorly understood throughout the time in DRC airport [RatnayakeU.Herath S. (2005)].
The acquisition of spatio-temporal data obtained by the LANDSAT space station between 1987 to 2018 of Goma International airport in DRC,corresponding to the period vulnerable to thermal extremes and serious aviation accidents and incidents at this airport, allow us to examine the impact of climate disruption and rely it to the flight safety [Kabasele,all,2017].
This study is necessary for the prevention of climatic risks likely to impact the safety of aircraft in extreme and abnormal fluctuations of climatic parameters conditions to cause risks in aeronautical operations [ENAC ALUMNI,2020].
Keywords: *climate disturbance, spatialization, flight safety, GOMA airport*

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I. Introduction

Expression disruption denotes any combination of meteorological phenomena causing weather degradation during the development of a depression, which can sometimes go as far as the genesis of storms. In temperate latitudes, this expression which one is commonly applied to the low pressure system structured by a warm front, a warm sector and a cold front (possibly with an occlusion); it can also designate the cloudy zone associated with such a system or, simply, with an isolated cold front.

Term variability of the climate makes it possible to assess its impact on aeronautical activities. Several studies over the past quarter of a century have addressed the issue of this variability of climatic parameters and atmospheric circulation [IPCC, 2001].

The need to obtain continuous climatic information in space is now strong, because many application areas can no longer be satisfied with only the point values provides by ground-based measurement stations.

Spatialization method of the spatio-temporal variables used is based on the correlation existing between them and topographical and environmental parameters. The possible applications of method can be extended to problems relating to permanent aeronautical and environmental risks, in particular lava and smoke from the volcano, the heat island or land use [Albert Kabaseleyy et al, 2017].

In mountain areas, such in Goma International Airport, the phenomenon is even more obvious, the topoclimatic component being strongly predominant in the definition of climate.All those factors impact drastically on flight conditions and affect the flight safety .

According to the [French dictionary Larousse,2010]; the term "perturbation" applies to atmospheric mechanics according to three different meanings:

Generally, we can call atmospheric disturbance any interruption of a state of equilibrium in a region of the atmosphere, of whatever nature this interruption may be;

In a much more precise sense, an atmospheric disturbance can refer to the meteorological conditions prevailing over an area where there are signs of developing wind circulation associated with a weak depression. In particular, a tropical disturbance (which is accompanied on the surface only by light winds) opposes a tropical depression (where the wind is already part of a well-characterized circulation and where its average speed can go up to 33 knots, i.e. 61 km / h), to a tropical storm (where the maximum of this average speed is between 34 and 63 knots, i.e. an interval of 62 to 117 km / h) and to a tropical cyclone (where this maximum is at least 64 knots, or 118 km / h);

Finally, in the most common sense which is the one assumed in the absence of other precision), the expression atmospheric disturbance denotes any association of meteorological phenomena causing weather

degradation during the evolution of 'a depression, which can sometimes go as far as the genesis of storms. In temperate latitudes, this expression is commonly applied to the low pressure system structured by a warm front, a warm sector and a cold front (possibly with an occlusion); it can also designate the cloudy zone associated with such a system or, simply, with an isolated cold front [GIEC,2001].
These disturbances are:storms,shears,lightning,reducedvisibility,cyclone and anti cyclone,reduction in rainfall,bareground,animal hazard in airports….

Airport operation can beeinfluenced by climatic parameters. Any flight must be carried out taking into account these parameters.

Let's first define the concepts of aerodrome and airport. An aerodrome is designed as a defined surface on land or on water (including, possibly, buildings, installations and equipment), intended to be used, in whole or in part, for the arrival, departure and movements of aircraft at the surface [ICAO, Annex 14, 2019].

An airport is any aerodrome on which the facilities necessary for the service are provided such as administrative facilities (office of the airport commander, customs services, etc.), commercial operating facilities (terminals for passengers or freight , police station, hotels, car park, fuel depot; etc.), maintenance facilities (aircraft hangar, workshop and garage, etc.), the technical operating facility (technical unit and lookout, service fire protection, meteorological service, power plant, etc.) [ICAO, Annex 14,idem].

II. Study Area And Method

2.1.1. Geographic location

The extended territory of Goma is part of the Great Lakes region and the southern part of the Great Rift Valley. It is a land of volcanoes, water and forests.). The lake contains CO2 and methane "trapped" in the deep waters, but which could be released with the risk of loss of life for the population.

The morphology of this airport determines very obvious climatic differences on a fine scale with average annual temperature between 21 and 29°C.

Goma International Airport (IATA code: GOM • ICAO code: FZNA) is the main airport in the city of Goma in the Democratic Republic of the Congo. It is located in the province of North Kivu on the edge of Lake Kivu, 14 kilometers south of the active stratovolcano Nyiragongo.

Strong topographical contrasts and tight between the lake to the south and Mount Nyragongo, which rises to about 1850 meters to the north.

In 2002, the northern third of the trail was covered in lava by the eruption ofvolcano, shortening the track from 3000 to about 2000m.

Relief: In the North NYIROGONGO volcano, in the North-East KARISIMBI and
MIKENO, east hill RUBAVU, south-west MONT GOMA, to
the west a chain of hills

2.1.2. Geolocation of Goma Airport

Geographical coordinates:
1 ° 40 '12' 'South, 29 ° 14' 15 '' East
Altitude: 1551 m (5089 ft) [RVA, AIP, 2017]

High altitude terrain, high temperatures or a tail wind increase the take-off length.

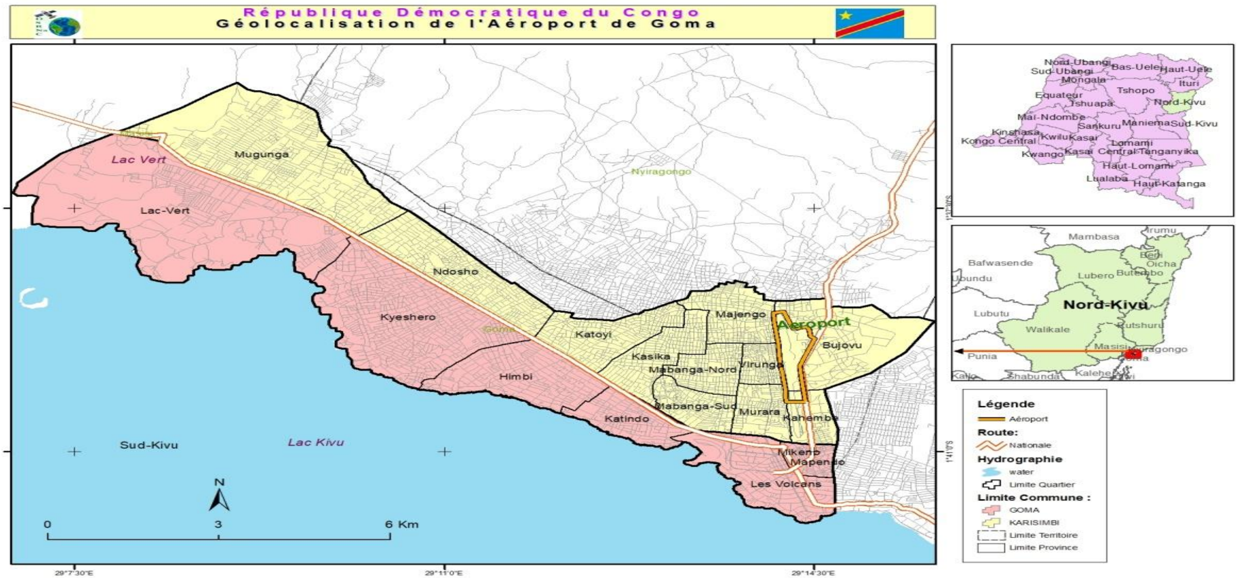


Figure 2.1, satellite image of geolocation of Goma airport,
Produced under ARCGIS by ORSNAC/UPN June 2020

2.2. Method

2.2.1.Data Source

The images selected for the study come from the TM sensor of the Landsat 5 satellite (see Table 2.2 in yellow). The latter receives data in seven distinct spectral bands. Bands 3 (red) and 4 (near IR) will be used for the calculation of the NDVI (Normalized Difference Vegetation Index)vegetation index developed . Thermal IR band 6 will be transformed into apparent temperature values in degrees Celsius (see section 2.5). It will thus be possible to make a thermal mapping of airports and compare it with the NDVI, *[NZUZI NZUZI André et al,September2020]*

Table 2.1. NASA sites consulted by the acquisition of satellite data

Satellite	Dated	Source	Utility
Landsat TM	03/05/1986	http://landsat.usgs.gov/	Delimitation of the DRC Oceanic Plateau DRC
Landsat TM	26/08/1998	http://landsat.usgs.gov/	Ocean delimitation, Heat Island Analysis
Landsat TM	22/08/1999	http://landsat.usgs.gov/	Heat Island Analysis
Landsat TM	08/04/2002	http://landsat.usgs.gov/	Heat Island Analysis
Landsat ETM	12/03/2004	http://landsat.usgs.gov/	Heat Island Analysis
Landsat ETM	27/06/2008	http://landsat.usgs.gov/	Heat Island Analysis
Landsat 8	03/06/2013	http://landsat.usgs.gov/	Heat Island Analysis
Ikonos	09/03/2006	Google Earth pro	Delimitation of the DRC Oceanic
Ikonos	19/01/2016	Google Earth pro	Delimitation of the DRC Oceanic
NOHA/MODIS	1912 to the present day	Daily Data ASCII Types	Precipitation, Flow, Air and Soil Temperatures, Evapotranspiration, etc.

Results: Production of Diachronic Airport Diagrams and Rasters.

Each image represents a snapshot taken on a specific day and time. Even though the capture time remains roughly the same for all images, i.e. around 3 p.m. GMT
(Greenwich Mean Time) or 4 p.m. local time, the sampled days are different and spread out during the seasons of the DRC. For this reason, data of climatic parameters were provided by remote sensing via Landsat 8 satellite translates these differences into its thermal infrared band the radiance emitted by the surface [Albert KABASELE YY, 2020].

2.2.3. Statistical method

We used SPSS 16.0 software designed to conduct a wide variety of statistical tests with speed. It is essential to check whether the data has been entered correctly into the computer under EXCELL in order to build a database.

SPSS 16.0 has various menus and each menu has submenus, so you have to choose them and know how to complete the dialogs.

In terms of data mining, we use:

- The Analysis menu, in which we find Reports, Descriptive statistics, Tabulate, correlation, regression, ...
- The sub-menus Reduction of dimensions, Factorial analysis which allows the analysis in principal components, hierarchical classification, ...

To access simple regression, we choose Analysis, and Linear regression. The table of means and standard deviations is obtained by opening the Correlation dialog box. This statistical processing led us to the Analysis of Variances.

We use the linear regression model (model B), a regression model of an explained variable on one or more explanations in which the function that connects the variables is linear. Model B gives us the angular coefficient and the constant.

The software was used for all the statistical analyzes, the significance level was set at 0.05 (5%).

2.2.4 Analytical method

2.2.4.1 Linear regression model: Determination of the regression lines

The angular coefficient and the coefficient of the line are determined by the relations:

(OLIVIER Martin, 2007)

$$b = \frac{\sum(x_i - \bar{x}).(y_i - \bar{y})}{\sum(x - \bar{x})^2} \quad (1)$$

And since the averages $\bar{y}$ et $\bar{x}$ are corresponding values, we have:

$$\bar{y} = a + b\,\bar{x} \quad (2)$$

so:(D'HAINAUT Louis, 1978 et OLIVIER Martin, 2007)

a= $\bar{y}$ – b$\bar{x}$ (3)

We predict y from x, we have $\bar{y}$= a + bx (equation representing the least squares line).

With $a = \bar{y} - b\,\bar{x}$, the equation of the regression line takes the form: (D'HAINAUT Louis, 1978, op cit)

$$y^* = \bar{y} - b\bar{x} + bx = \bar{y} + b(x - \bar{x}) \quad (4)$$

The parametera of the regression line indicates how much on average the value y varies as the value x increases by one. The parameter b corresponds to the theoretical value of y when the value of x = 0 . The linear regression model is often estimated using the least squares method, although there are other methods to estimate this model.

Thus, to estimate the parametersa and b, we can also use the least squares method which does not require any additional assumption on the distribution of the random error term.

When a regression equation is used to estimate a variable y from those of one or more independent variables, x , the estimate (modeled value) y does not usually achieve complete accuracy. Geometrically speaking, the data points do not fall exactly on the straight line, plane, or hyperplane specified by the regression equation.

The difference (y-$\bar{y}$) on the predicted values are called "residuals"

A residual is then the difference between the real value of the dependent value and its predicted value using the regression equation (KABASELE Albert, y y, 2020)

2.2.5.Predictionequation of principal variables

Regression coefficient and constant values are given in column B of the tables. Otherstatistical data listed are standard errors of the regression coefficient and the significancelevel.

Wegivebelow the predictionequationsevenif the significancelevelisgreaterthan 5% the regressionequationswillkeeptheirpredictive value because the onlysignificance of the prediction coefficient iszero [BAHAYA BARHAHAMUKENYI et, all; August 2020].

III. Results And Discussion

3.1.Physico-climatic airport indications

Goma has a humid tropical climate close to the equatorial climate .whose variations are summurized in table 3.1.below .these results are obtained under SPSS, ORSNAC, July 2020.

Table 3.1 Data for climate physicovariables per year at Goma airport from 1987 to 2018.

	N	Minimum	Maximum	Mean	Std. Deviation
gomaAero_Patm	32	830,9000	877,0963	851,356963	18,1959668
gomaAero_TempAir	32	17,200	21,7000	20,430938	3,4252952
gomaAero_TempAerologie	32	12,4291	32,7707	26,400906	4,5589695
gomaAero_Temp10_40Cm	32	16,70	22,2700	20,121563	3,4077825
gomaAero_Wd	32	36,5350	325,2917	168,742786	82,3685710
gomaAero_Wv	32	,0900	2,5700	1,647187	,4185400
gomaAero_PPmm	32	11,0200	133,0600	97,217500	31,9579676
gomaAero_RayNet	32	15565,08	203503,25	186849,678	32208,8576
gomaAero_HS	32	,0105	,0135	,011610	,0007964
Valid N (listwise)	32				

Source, Results under SPSS, ORSNAC lab, July 2020

Table 3.1.of statistic description under SPSS.thistable gives physico-climatic data of GOMA International Airport,it provided minimal and maximal values and standard deviations of climatic variables for the period between 1987 to 2018.

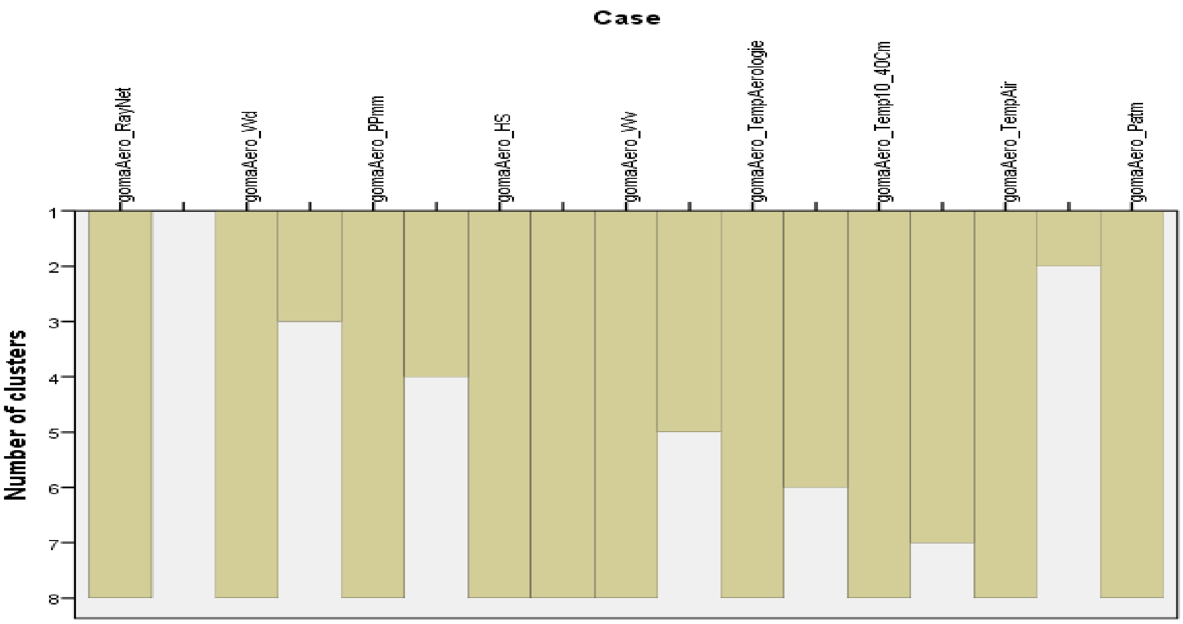


Figure 3.1. linear correlation cluster of difference physico-climatic parameters from 1987 to 2018.

This dendrogram shows that the specific humidity and the wind speed are very close and the Net radiation deviates from the other variables. Atmospheric pressure and air temperature are correlated 25% on the scale of 1/8 ,ect ...

Reconciliation analysis of the various physical parameters of the airport. For example, we can see that the temperature of the air as well as the ground are closer [KABASELE Yenga-Yenga, (2011.]

Such us simular analysis are done climatic data by the dendrogram below.

Figure 3.2.: Cluster of FZNA climate variables from 1987 to 2018.

Analysis of the principal component lead to the following 3D space projection :

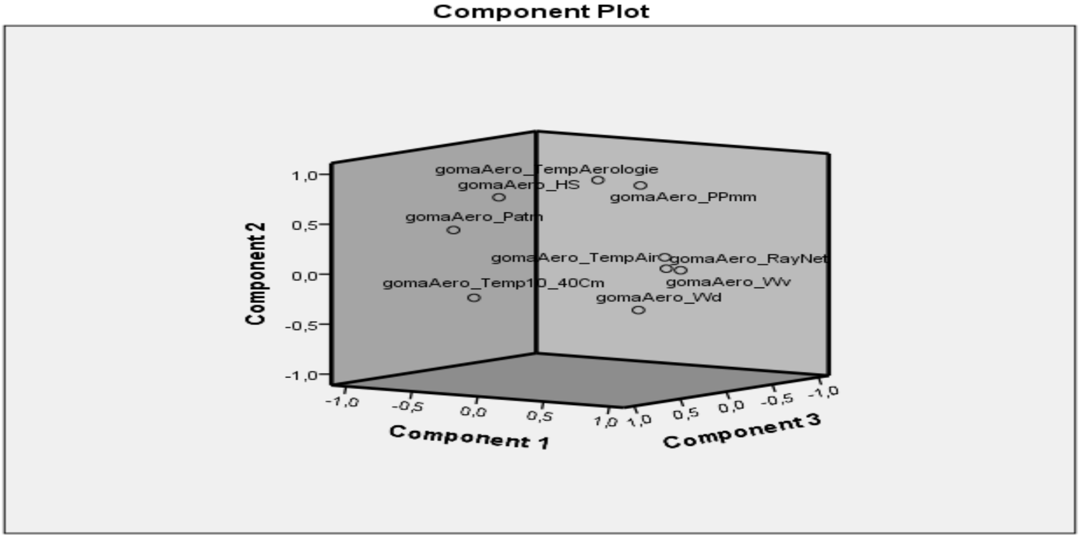


Figure 3.2 Aerospace diagram of climatic normals of Goma airport.

Data explaining more than others are located in the plane of the first and the second components ,such us the wind direction (direction and speed), air temperature, Net radiation…. Others Climatic data can be explained by the 2 nd and 3 rd principal axes , such as subsoil temperature, atmospheric pressure and soil temperature.

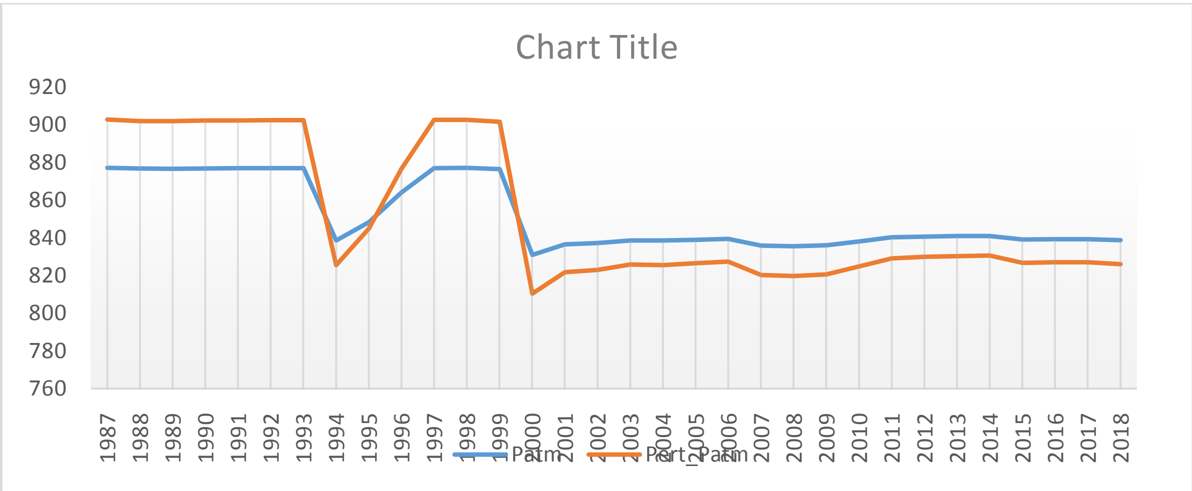


Figure 3.3. Change in atmospheric pressure at GOMA airport from 1987 to 2018.

Atmospheric pressure curve figure shows that since the year 2000, the airport has fallen into a high pressure zone that varies around an average of 840Hpa.

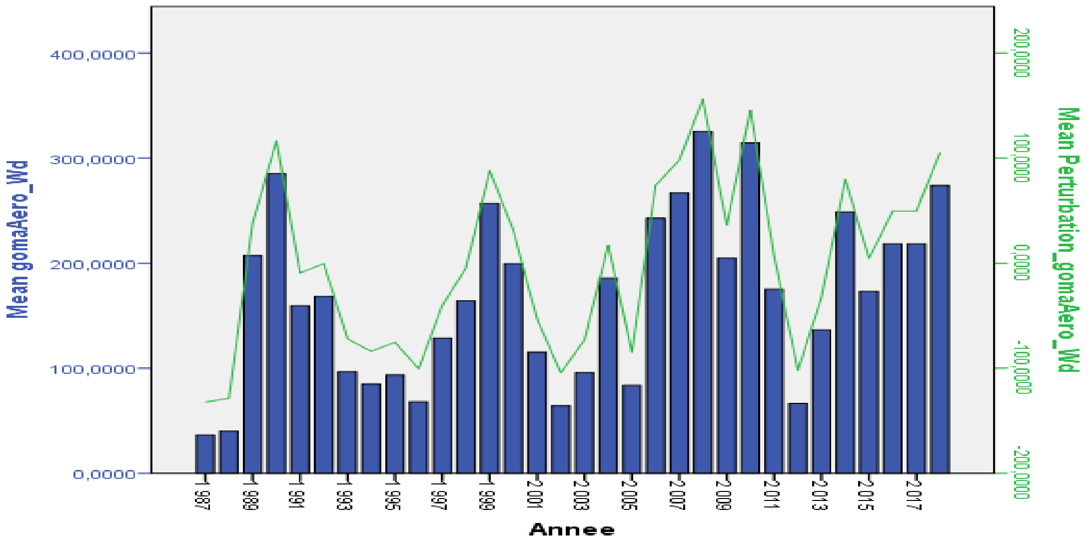


Figure 3.4. Index disturbance of the wind direction at FZNA

Wind direction curve shows large fluctuations that deserve special attention because it affects the takeoffs and landings of planes.

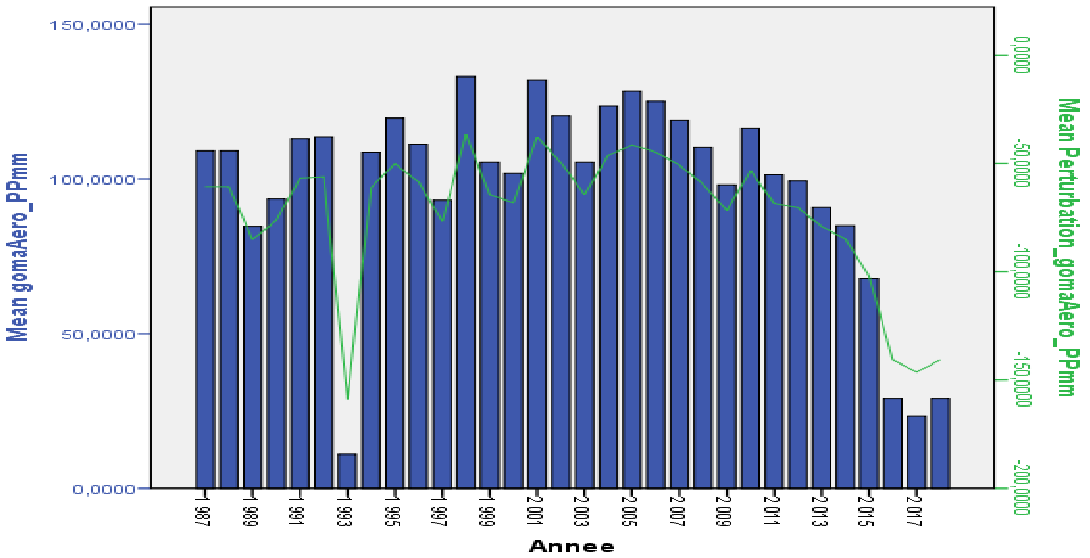


Figure 3.5. graphs of the FZNA rainfall disturbance indices from 1987 to 2018.

This figure illustrates two periods for the rainfall at Goma airport: the first goes from 1978 to 2009 characterized by low disturbances and from 2010 we see a drop in rainfall due to an exacerbation of very high ground temperatures; there is reason to say that there is local climate warming.

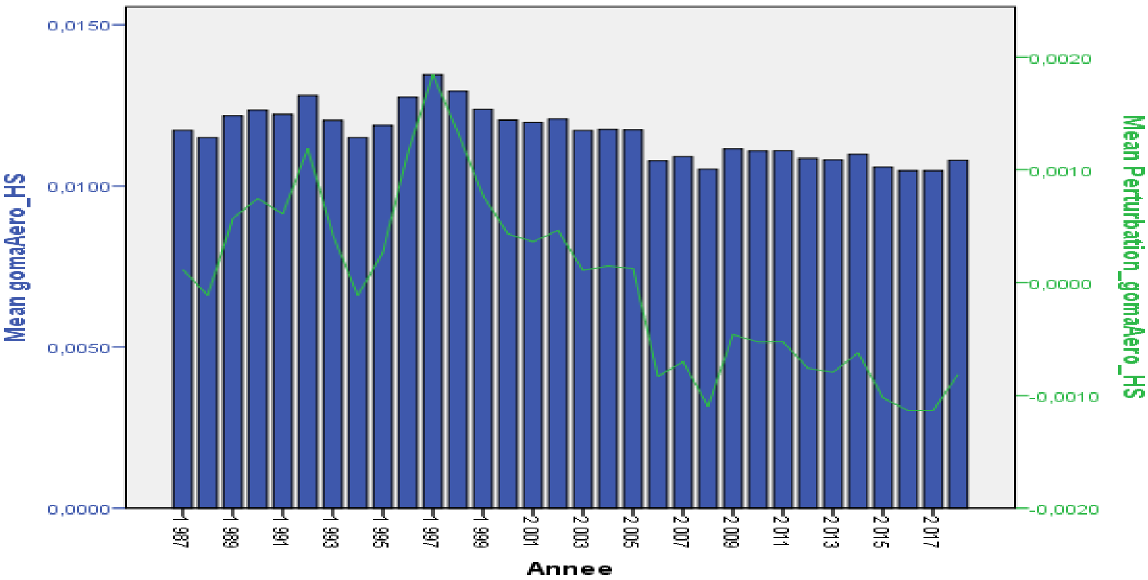
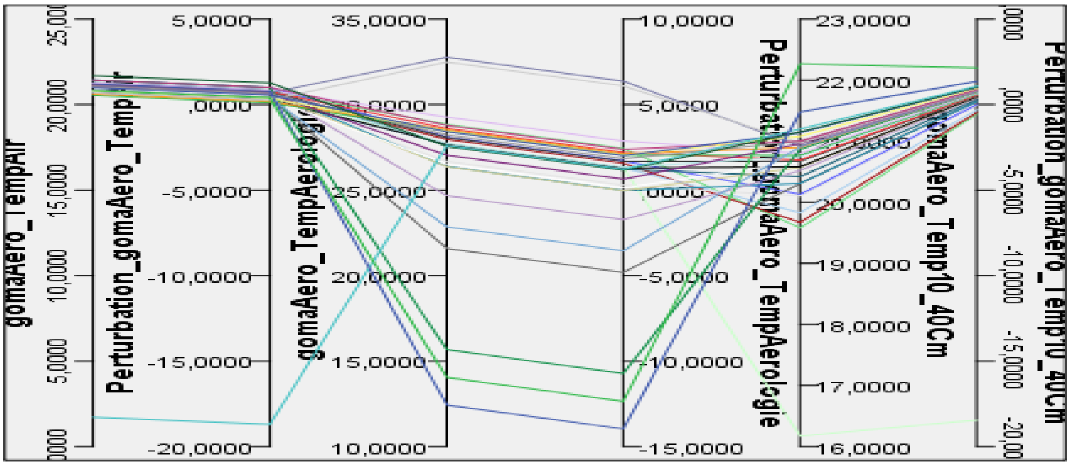


Figure 3.6 specify humidity at Goma international airoport from 1987 to 2018.

We note that a significant drop in specific humidity from 1997 until now.
figure3.7 curve of wind velocity et wind direction



Wind speed is stable throughout the period of the study but its direction is very disturbed with values going up to ± 100 ° C compared to the normal. Particular attention must be paid to this parameter very capital for the determination of the runway in use.

3.2.Principal component analysis

Correlation coefficient are generated by SPSS software
The correlation between two numerical variables amounts to seeking, in summary, the connection which exists between them.

Table 3.2.Air temperature correlationcoefficient at Goma airport

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12,203	7,990		1,527	,140
	gomaAero_Patm	-,022	,011	-,116	-1,948	,063
	gomaAero_TempAerologie	-,034	,058	-,045	-,592	,559
	gomaAero_Wd	-,001	,002	-,020	-,527	,603
	gomaAero_Wv	,355	,463	,043	,768	,450

	gomaAero_PPmm	,010	,010	,096	1,047	,305
	gomaAero_RayNet	9,679E-005	,000	,910	14,908	,000
	gomaAero_HS	706,699	254,508	,164	2,777	,010
a. Dependent Variable: gomaAero_TempAir						

Table 3.2.above shows that:
- the air temperature in Goma is in perfectcorrelationwith the net radiance at 100%.
- The correlationbetweenspecifichumidity and atmospheric pressure is 70%. All other variables have aweakcorrelationwith air temperature.

Precdictionequation for air temperature:

$$T° \text{ Air} = 12,203 - 0,022 \text{ Patm} + 9,679^{E}\text{-}005 \text{ RayNet} + 706,699 \text{ Hs} \quad (7)$$

Table 3.3. Rainfall correlationcoefficient with the otherclimatic variables

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-40,329	22,930		-1,759	,089
	gomaAero_Temp-sol	5,210	,856	,743	6,084	,000
2	(Constant)	-147,215	20,768		-7,089	,000
	gomaAero_Temp-sol	5,416	,530	,773	10,220	,000
	gomaAero_TempAir	4,966	,705	,532	7,040	,000
a. Dependent Variable: gomaAero_PPmm						

Table 3.3.above shows that:- The rainfall at Goma airportis in perfectcorrelationwith the groundtemperature, the temperature of the basement and the air temperatureisaround 100%.

Prediction Equation of rainfall:

PPmm –Aéro_Goma= 5,210T°sol -40,329 (6.a)

PPmm –Aéro_Goma= 5,416T°sol + 4,966T°Air -40,329 (6.b)

Table 3.4 Correlation coefficient of specifichumidity at Goma airport

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-,014	,005		-2,919	,007
	gomaAero_Patm	3,042E-005	,000	,695	5,293	,000
2	(Constant)	-,015	,004		-3,485	,002
	gomaAero_Patm	3,045E-005	,000	,696	5,972	,000
	gomaAero_PPmm	8,762E-006	,000	,352	3,018	,005
a. Dependent Variable: gomaAero_HS						

The table above shows a perfectcorrelation of specifichumiditywithrainfall and atmospheric pressure.

Predictionequation forspecifichumidity:

Hs_Aéro-Goma = 3,042E-005 gomaAero_Patm -0,014 (8.a)

Hs_Aéro-Goma = 3,045E-005 Patm + 8,762E-006 gomaAero_PPmm – 0,015. (8.b)

Table 3.5.Goma airportatmospheric pressure correlation

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	667,031	34,906		19,109	,000
	gomaAero_HS	15875,806	2999,601	,695	5,293	,000
2	(Constant)	721,345	34,797		20,730	,000
	gomaAero_HS	13561,521	2713,570	,594	4,998	,000
	gomaAero_Wv	-16,661	5,164	-,383	-3,227	,003
a. Dependent Variable: gomaAero_Patm						

Table 3.6.above shows a perfectcorrelation of the atmospheric pressure of Goma airportwithspecifichumidity and wind speed (Wv)

Prediction Equation of presssureatmospheric:

Patm_Aéro-Goma = 667,031 + 15875,806 Hs (5.a)

P atm_Aéro_Goma = 721,345 + 13561,521 Hs – 16,661 Wv (5.b)

3.2 Flight safety at Goma Airport

The analysis of statistics of aviation accidents and incidents allows to have a picture of the safety of air transport in order to take appropriate measures to prevent the same facts from happening again.

Table 3.6. Accidents and incidents aviation accidents at GOMA Airport from 1990 to 2018

REGISTRATION.	DATED	EVENT TYPE	PROBABLE CAUSES	WOUNDED	KILLED	DAMAGE
9Q-CVG	02/01/1990	Premature landing	Technical factor	0	0	Destroyed plane
9Q-CLV	06/27/1998	Runway excursion	Human factor	0	0	Important
9Q-CBO	09/08/2005	Forced landing	Technical factor	0	0	A / C downgraded
ZS-JXW	06/09/2005	Failed take-off	Human factor	0	0	A / C destroyed
9Q-CAW		Runway excursion	Environmental factor	0	0	A / C destroyed
5Y-BNN	02/15/2007	Disappearance	Environmental factor	0	0	-
9Q-CVM	06/26/2007	Crash	Material factor	0	0	Decommissioned front axle
4L-SAS	09/07/2007	Runway excursion	Environmental factor	0	3	
ST-HSR	11/15/2007	Engine stop	Material Factor	0	0	Damaged rotor
9Q-CHN	04/15/2008	Interrupted take-off, fire, overrun and runway excursion	Material factor and human factor	0	58	A / C calcined
9Q-CMG	05/26/2008	Overrun on forced landing	High speed human factor	0	0	
9Q-CIB	05/12/2009	Engine failure n ° 1	Detachment of an engine	0	0	
9Q-CAB	19/11/2009	Engine failure	Material factor and human factor	16	0	Nose destroyed over a length of 14m
9Q-CAB	01/19/2010	Overpass	Human factor	0	0	Significant damage
9Q-CBD	03/04/2013	Crash (landing in a built-up area)	Material	three	seven	A / C destroyed
9Q-CSL	06/21/2016	Landing gear not extended		zero	zero	

Source .BPEA 2020

The figure below illustrates the proportion of Aviation Accidents and Incidents at Goma Airport according to the factors that caused the said events.

The graph below show the pourcentage factors events for incident and accident at Goma airport from 1990 to 2018.

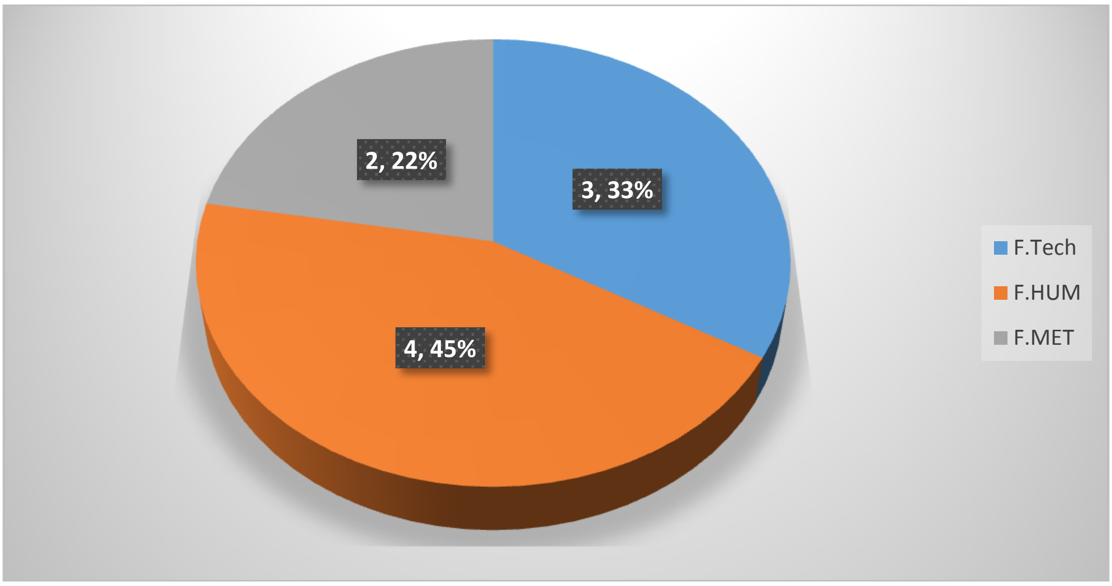


Figure3.8 Distribution of aviation accidents according to their causes

F. Tech: technical factor
F. Hum :Human factor
F.Met :meteorologycal factor.

We find that out of 17 event cases, the meteorological factor represents 22%, the technical factor represents 33%, the human factor 45%.

From Table 1 and fig 1(graph), it showstwo main classes of data:
Net radiation which deviates from other physical parameters which are really very close or correlated.
Strong disturbances compared to normal. we see two periods:
The period of high atmospheric pressure which goes from 1987 to 2000 (820 to 910 Hpa) and a period of low atmospheric pressure and stable which passed in 2000 (830 to 810 Hpa).

Variation indices for soil, air and subsoil T° at GOMA airport from 1987 to 2018.
The family of annual temperature curves represents very varied cycles:
The soil temperature decreases slightly from the year 2015 with a difference of 4.5 ° C with an average of 26 ° C. while the subsoil remains a little stable around the average of 20 ° C varying between 16 and 22 ° C
At the figure 2.6. wind direction index curves show strong disturbances which are far from stable. This has an impact on the take-off safety of planes on the airport platform

A Goma airport, specific humidity indices from 1987 to 2018
The air humidity experienced a significant drop from 1997 onwards. This drop impacts the air density which becomes very slight with consequences on the lift of the planes at takeoff. The planes will have more need a long distance from the climatic normal.
The heterogeneity of the relief has created a great variety of climates. In general, there is a strong correlation between altitude and average temperature. Below 1,000 m, this temperature is around 23 ° C. At 1,500 m, some 19 ° C is recorded and at 2,000 m, around 15 ° C. The average rainfall varies between 1000 and 2000 mm.
The lowest monthly precipitation is recorded between January and February and between July and August. More specifically in Goma, annual precipitation fluctuates around 1250 mm per year.

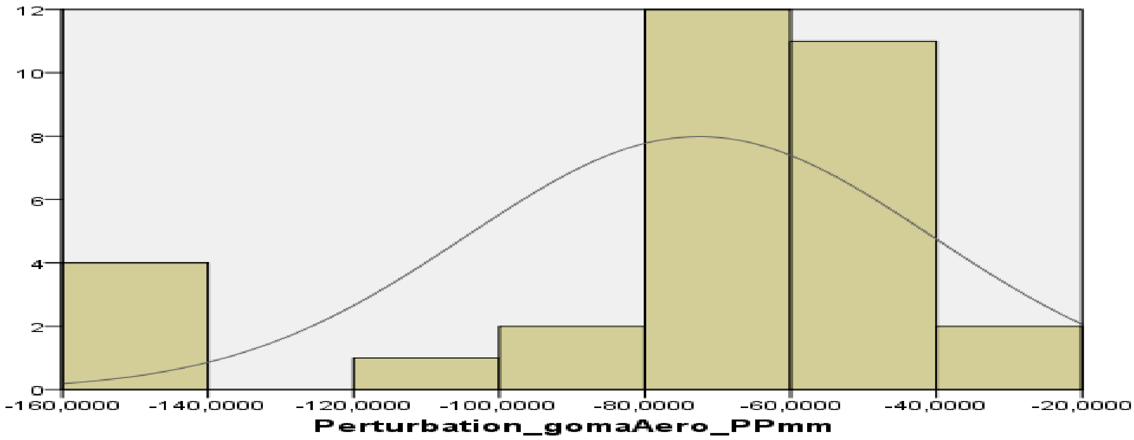


Figure 3.9. Comparison of the normal curve and the histogram of variation in disturbance of the rainfall of FZNA from 1987 to 2018, at Goma airport.

This rainfall figure shows that our data almost follow the Laplace-Gauss normal law. This asymmetry in rainfall influences atmospheric circulation near the airport. This influences the landing or take-off conditions of planes at Goma International Airport in DR Congo

Four seasons characterize the climate of Goma: 2 wet seasons and 2 dry seasons. The first wet season is between mid-August and mid-January and the second is from mid-February to mid-July. As for the two dry seasons, they are very short. The first is observed between mid-January and mid-February and the second between mid-July and mid-August.

The annual average temperature is 20 ° C while the minimum and maximum vary between 14 and 26 ° C respectively.

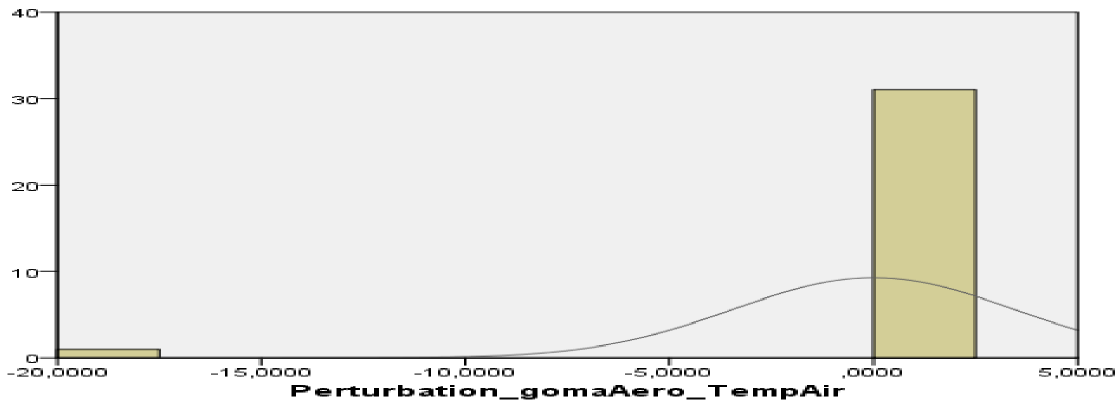


Figure 3.10. Comparative study of the normal curve and the histogram of variation in disturbance of the air temperature of FZNA from 1987 to 2018.

As the temperature variation histogram is not even close to the normal curve, this shows variability in the wind flow around Goma airport. These variations must be known by the pilots to increase the safety of the flying machines at this airport.

Thus, for jet planes, our study shows above 25 ° C, planes will reduce their takeoff weight by reducing the offered load found by subtracting the useful limitation from the operational weight.

Figure 2.8 of the graph of the specific humidity indices showed a drop in the specific humidity on the airport platform. This drop impacts the density of the air, which becomes very light, and have consequences on the lift of planes on take-off (see equation 1.7); planes will need a long distance more than normal climatic because the air becomes very light and its density decreases. This is shown in the figure below.

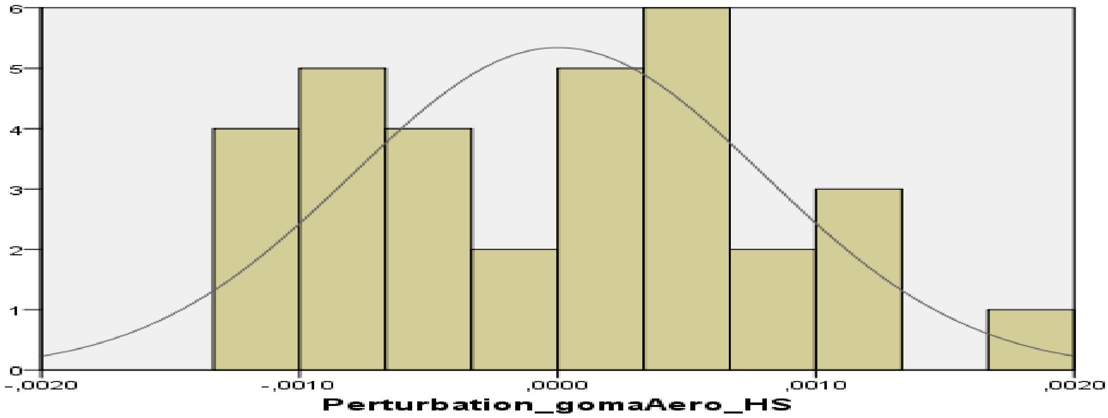


Figure 3.11 Comparative study of the normal curve and the histogram of variation in Hs perturbation of FZNA from 1987 to 2018.

The figure above illustrates the trend towards the normal distribution followed by the specific humidity data of Goma airport. Thus the air does not circulate the same way in all seasons. and this atmospheric circulation has varied from 1987 until 2018

The period of high atmospheric pressure which goes from 1987 to 2000 (820 to 910 Hpa) characterized by strong disturbances varying from 0 to 25 Hpa which put the airport in an anticyclone zone often associated with dry weather and high ground pressure and a period of low atmospheric pressure and stable which passed in 2000 (830 to 810 Hpa) to date. This puts the airport in a cyclonic situation characterized by weak winds with strong disturbances on the observed rainfall this time at the airport which drops very drastically, see figure 2.7.

Mapping of heatislands at Goma International Airport

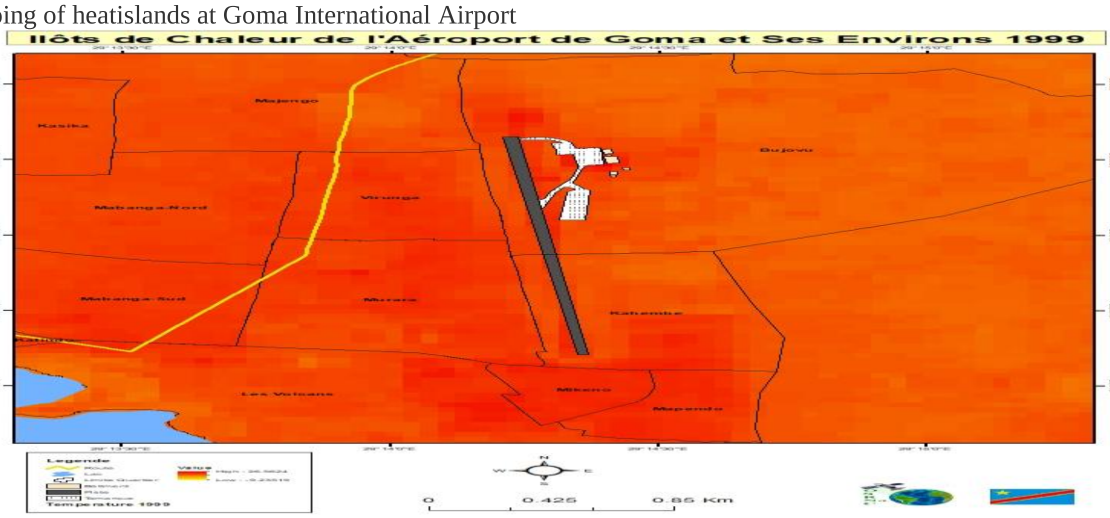


Figure 3.12.a.picture of heat island at goma airport in 1999

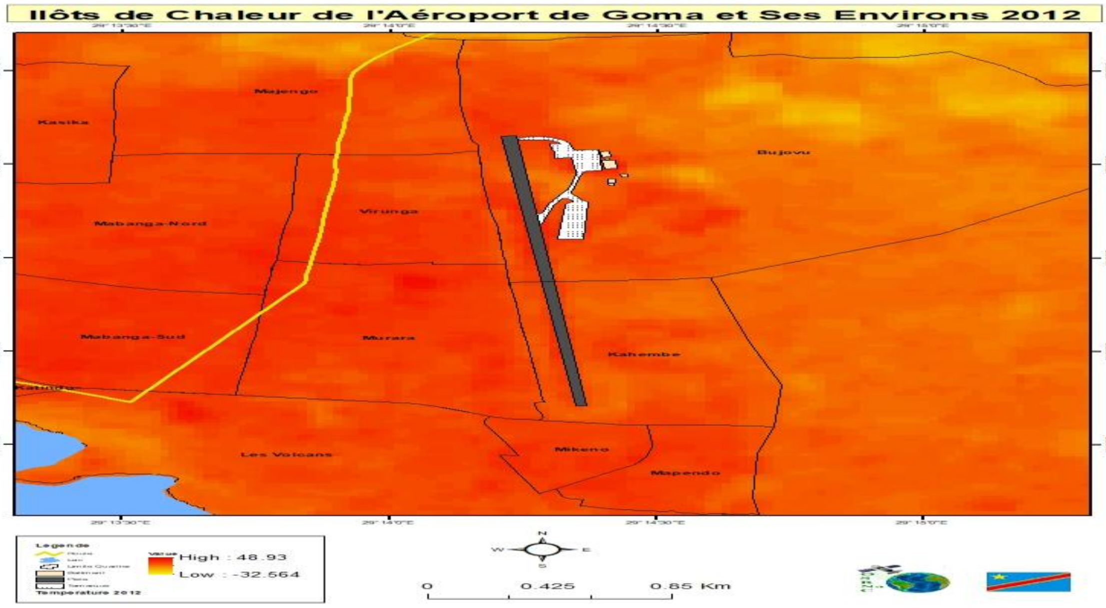


Figure 3.12.b. Surface temperature map of July 4, 1999 derived from thermal infrared bands of MODIS and Landsat satellites (NASA)

Author's result / LANDSAT under IDRISI 15.0 / NZUZI, OSRnac UPN Kinshasa 2020

NDVIoccupation floor of Goma International Airport

Goma International Airport

This Image shows Goma International Airport, a high resolution satellite image taken in 2019

***Figure 3.13.** planview of Goma International Airport*

The figure belowillustrates the process of NDVI analyzes of high resolution satellite images of Goma Airport, with a spatial resolution of 40cm.

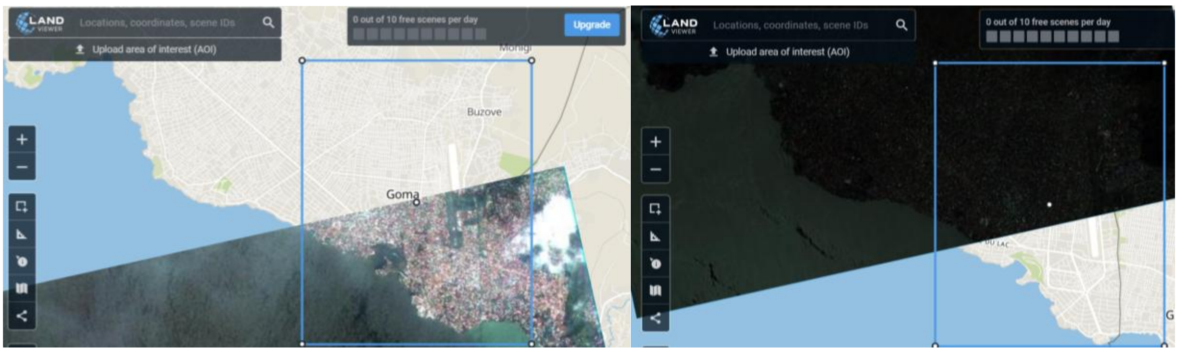


***Figure 3.14.** LAND VIEWER interface, high resolution image of Goma International Airport*

Source: author'sresult / LANDSAT under IDRISI 15, OSRnac UPN Kinshasa June 2020

Herewecanseethat the NDVI varies on averagefrom -0.1 to 0.2 thisindicates a lowpresence of large vegetationsuch as large treesaround Goma Airport. The negative value of NDVI indicates the presence of water whichis in this case the water of Lake Kivu justbeside the airport; NDVI values rangingfrom 0 to 0.1 indicatesoilwithoutvegetationcover or urban constructions as well as values rangingfrom 0.1 to 0.2 indicate the presence of grasses and grassysavannas.

Figure 3.15*.Annual variation of NDVI at Goma International Airport*
Source: Author'sresultunder IDRISI 15.0 / NZUZI, OSRnac UPN Kinshasa June 2020

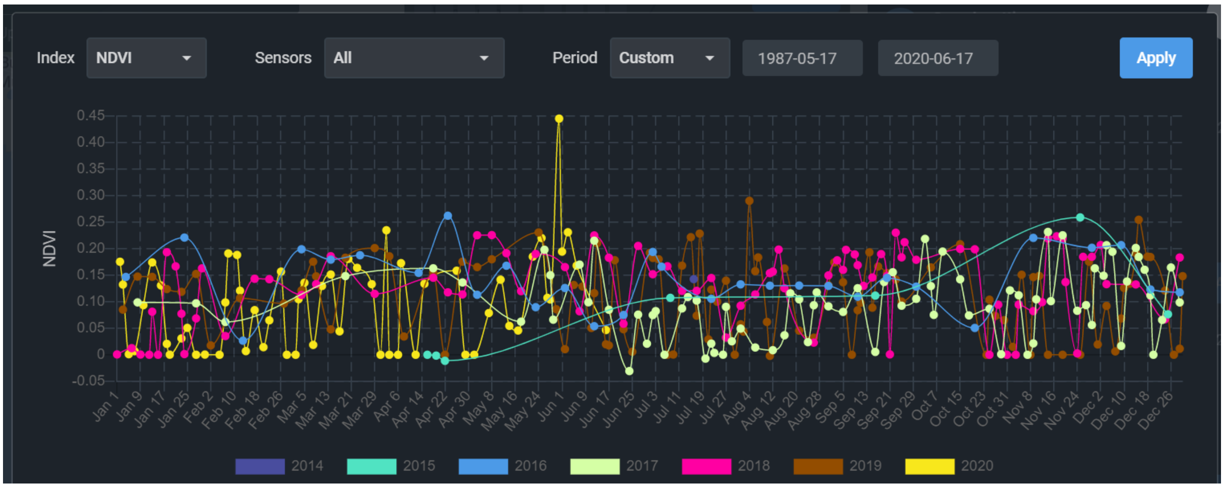


Figure 3.16. Daily variation of NDVI at Goma International Airport
Source: author's result under IDRISI 15.0 / NZUZI, OSRnac UPN Kinshasa June 2020

IV. Conclusion

The analysis of the spatio-temporal distribution of climatic parameters in this airport was carried out by considering data from LANDSAT stations for the period 1987-2018. The study of thermometric values shows very strong vertical gradients during all the seasons, because of the position with an average allowed to quantify by almost 4 ° C degrees the increase in the average temperature and a very drop in relative humidity. hence, operating restrictions in the event of an increase in air temperature above 27 ° C are envisaged, especially for jet-engine airplanes to cope with this situation, between, the reduction of take-off operating weight, adoption of satellite-based approach (STAR: Standard Terminal Arrival Route) and departure (SID: Standards Instruments Departures) procedures.

Estimation of surface temperatures from satellite imagery allowed us to determine the spatial variability of the airport heat island at two levels of spatial resolution for several dates during the heat wave. Taking into account the heat island at two scales, that of the canyon (30 m) and that of the district (1 km) is important for a characterization of the variability of the heat island phenomenon. Inverse relationship between surface temperatures and vegetation has been demonstrated with a resolution here of 30 and 1000 meters. The footprint of buildings as well as other facilities have a relatively strong relationship with night-time surface temperatures, which are gradually increasing.

We must also take into consideration the air pollution and the CO_2 released by planes, the presence of anarchic constructions in the vicinity of the airport, the presence of the volcano and Lake Kivu which also influence the climate changes of this airport. .

Adaptation measures, early warning and prediction equations were proposed in our study could provide a solution first to mitigate the impact of this temporary spatial variation of climatic variables and also to respond to the security problems that Summarizes in the training in new techniques of practical air navigation assistance provided by space remote sensing, by regulations and practices well adapted to the environment of GOMA airport.

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