RESEARCH SEED IN SPACE SCIENCES

SICESP

REPORT OF THE RESEARCH PROJECT

"CLOUDS AND TEMPERATURE VARIATION MODEL OF THE ATLANTIC DEPARTMENT"

AUTHOR

ERQUINIO ALBERTO TABORDA MARTINEZ

COAUTORS

Camilo Mercado Socarras

Daniela Corpas Piñuela

Daniel

Jesús Eduardo Taborda

Johan Alberto Taborda

Luis Padilla Castro.

Selena De Lima

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**1. INTRODUCTION**

Astronomy is the science that aims to study the Universe, its evolution, characteristics and origin, to carry out this study has been divided into various specialties such as planetary Astrophysics, which studies the conditions of the planets and discovers new in other systems Extrasolar, stellar Astrophysics is responsible for studying the stars, their structure and evolution, among other specialties that feed research in this field of science. The present work develops a study of the variation of the temperature in the last 10 years, data that are extracted from the data base of the CERES-SCOOL project of the NASA that tries to look for answers to the presence of natural phenomena related to the clouds and The terrestrial radiant energy system, which has detected variations in the earth's surface, such as the increase of 0.55 ° C, in the year 2011. These effects are frequently associated with human behaviors that deteriorate the natural resources affecting the ecological balance, if Has hypothesized in these investigations that temperature fluctuations of the oceans may lead to very strong climatic changes such as: The phenomenon of the Child and the Girl that originate in the Pacific Ocean.

Although this is a reality that touches all the inhabitants, it is necessary that the young students investigate the subject, take ownership of the situation and try to propose solutions from their capabilities through this work that through a statistical analysis from its base Data that began in 2006 and is still in force to date, will record information concerning the coverage and types of clouds, temperature, relative humidity, characteristics that determine the climate in the region and thus create a mathematical model that allows us to predict the In order to be prepared for a possible attack of nature, we will use tables of frequencies and graphs that allow us to know the relation of factors that determine climate change, it is expected to find a relation between the variation of the temperature during a period of time and To contrast this data with other investigations carried out by authors specialized in the subject.

**2. STATE OF ART**

The El Niño phenomenon occurs when the trade winds weaken and from Indonesia and Australia the warm Pacific waters reach South America and displace the cold waters of the Humboldt current.

The La Niña phenomenon occurs when the trade winds intensify and the coldest deep waters of the equatorial Pacific remain on the surface and the sea surface temperature decreases.

Source: (http://www.comunidadandina.org/public/Atlas\_13\_El\_Nino\_y\_La\_Nina.pdf).

These concepts of the Child and Child phenomena correspond to climatic situations that affect mainly the North of Colombia. In Colombia the impacts of La Niña are more clearly evidenced, due to the ostensible increase of disasters due to hydrometeorological phenomena, especially floods and landslides.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Millions of current dollars |  |
|  | Country | 1982 – 1983 | 1997 - 1998 |
|  |  |  |  |
|  | Bolivia | 1 372 | 527 |
|  |  |  |  |
|  | Colombia | Nd | 564 |
|  |  |  |  |
|  | Ecuador | 1 051 | 2 882 |
|  |  |  |  |
|  | Perú | 3 283 | 3 500 |
|  |  |  |  |
|  | Total | 5 706 | 7 473 |
|  |  |  |  |

Table 1: Losses by countries that are affected by the Child and Child phenomena (source: CAF 2000)

We can observe how countries in the Andean area are affected economically in this period of years, without taking into account the data that from 1998 to date are related. These economic effects hit the productive sectors of the country and is evidenced by losses of land and species that later require heavy investment and time to recover, to take into account an example, since the floods of 2010, there are still areas in the South Atlantic Where they continue to be affected by housing and agro-industrial production land that this region is plunged into poverty.

**PROBLEM QUESTION**

¿How does the temperature in the Department of the Atlantic vary due to the climatic change generated by the effects of the phenomena of the NIÑO and the NIÑA?

**2.1 IMPACTS OF THE CHILD'S PHENOMENON IN COLOMBIA**

The El Niño phenomenon manifests directly on the Colombian Pacific coast with increases in sea surface temperature and increases in mean sea level. The changes in rainfall and evaporation, related to the El Niño phenomena hitherto recorded, have resulted in alterations in the natural processes that make up the hydrological cycle and have affected the dynamics and distribution in space And in time, of the water supply in the different regions of the country, both in terms of quantity and quality. Due to the considerable decrease in some areas and due to excessive rainfall in others, the normal availability of water that is retained by vegetation has been affected, which evaporates from different surfaces, which is infiltrated to feed the subsoil and Underground storage and, consequently, the flows of the different streams and bodies of water that supply the demand in the Colombian territory. In fact, the decline of this water supply in terms of rainfall has significantly affected traditional agriculture. The deficit in water yields has reached in many regions of the national territory percentages greater than 30%, where this resource is usually scarce. This has mainly affected the supply of drinking water, hydroelectric generation, irrigation systems for agriculture and navigation, among others. These considerable reductions have generated greater competition for the water supply for the different uses. The volume of cargo transported has been seriously affected by the El Niño phenomenon, especially in the Magdalena River which crosses much of the area directly impacted by it. As the levels and flows that determine the conditions of navigability are affected with some delay with respect to the pluviometric alterations, the decrease in navigation is maintained for some time in addition to the completion of the El Niño phenomenon. In some El Niño events, the hydropower sector has been affected, due to the reduction in the supply of electricity that caused the blackouts and a severe rationing for more than a year.

The El Niño phenomenon, due to the changes in rainfall and the supply of water resources, has negative socioeconomic impacts that can be dramatic for some regions and economic sectors.

In the case of significant reductions in precipitation over considerable periods, such as those caused by El Niño, the analyzes confirm trends in decreases in agricultural productivity, especially in the years in which the phenomenon occurs. When the phenomenon covers periods of two consecutive calendar years, it has been found that the negative impact on agricultural yields is greater in the second year, where there is a downward pressure on the yields of the 17 main crops of the country, excluding the Coffee, an average of 5% attributable to each event. The impact is slightly higher in permanent crops (5.5%) than in transients (4.4%).

In the case of the country's main agricultural product, coffee, a recent study by CENICAFE concluded that the El Niño phenomenon has historically not affected coffee production in a significant way. Despite this, the same study warns that some low sectors of the coffee zones present important water deficiencies that make productive yields vulnerable in the presence of the phenomenon.

**2.2 IMPACTS OF THE PHENOMENON OF THE GIRL IN COLOMBIA**

The changes in the pluviometric pattern of Colombia caused by the La Niña phenomenon cause precipitation surpluses (between 20 and 40% of the normal values) that are recorded in a very localized form in the northeastern, central and southern areas of the Andean region And the northeastern Caribbean region. Very specific nuclei of severe surpluses (over 40%) are recorded in Guajira, northern Magdalena, Santander’s, Cundinamarca and a border area between Tolima and Valle.

**2.3 EFFECTS OF THE CHILD 2009 - 2010 IN COLOMBIA**

In Colombia, after an eruption of La Niña, a cold phase of ENOS, in 2007-2008, which left 120,000 people affected by downpours and floods, in 2009 El Niño has reduced the flow of rivers, caused a heat wave and encouraged Fires of vegetation.

The forest fires in Colombia reach even the Andean páramos, because they have a vegetation rich in pajonales that dry with the lack of water. Seven thousand forest fires, a 7 percent reduction in agricultural production, a 30 percent reduction in milk supply, some 500 000 hectares of dry pasture, some 300 rivers and dry ravines and a country on the verge of electric rationing Is the balance, in Colombia, of the consequences of El Niño

**2.4 ACTIONS TO PREVENT OR MITIGATE THE EFFECTS OF SUCH EVENTS IN COLOMBIA**

Adaptation plans have been developed to mitigate the impacts, in the hydroelectric generation sector, as a result of the experience acquired in previous events, an efficient strategy for the communication of climate information between IDEAM and the different socioeconomic sectors. The collaboration of academic and research institutions. Colombia maintains close interaction with international organizations, allowing it to improve its capacity to produce better climate predictions. (Source: EL NIÑO HYDROLOGICAL IMPACT ANALYSIS - COMPILATION, STUDIES AND RESEARCH GTHRH-rapporteur: Olga Umpiérrez)

**3. METHODOLOGY**

To perform a statistical study of the atmospheric conditions (type of cloud present, humidity, temperature, barometric pressure) present in the department of the Atlantic, using the database of the CERES-SCOOL project of NASA, to carry out these activities the base is used Of data attached on the NASA website in Excel format, then proceed to filter the immense information contained in this file and by means of a table of frequencies, histograms and other statistical graphs determine the measures of central tendency that allow to find matches Or discrepancies with the events occurred in previous years and to be able to correlate this information and thus create a first statistical report of the situation in Atlantico department.

To construct a mathematical model that describes the state of the time in the last 8 years in the department of the Atlantic from atmospheric observations registered in the database of the NASA, this model can be established according to the statistic thrown in the previous stage And with the help of differential equations.

The researchers obtained the overflight schedules of the satellite through a spreadsheet determine at what time exactly the satellite overhangs the region and thus can make the observation on land at the same time that the satellite does the same, after establishing The schedule is observed and reported clouds with a margin of 15 minutes from the satellite, at the end we proceed to compare and classify the agreement between the observations from the ground and the satellite, using the web page: http: // science- Edu.larc.nasa.gov/SCOOL/index-sp.php, importing this information into an Excel format for further analysis. We also take the data obtained from the Globe Observer program at https://www.globe.gov

These observations are recorded by students in the morning, initially during eight years of constant work where the data are recorded with the aid of a cloud observation chart, format that shows which are the clouds present in a day, its Coverage, temperature and relative humidity

As the purpose is to analyze a large amount of matching data, this is the option that has been taken. To download these files, Once the file is obtained on the computer, Excel is used (or similar application) the file is opened from the program.

Members: Teachers. Students: Research nursery consisting of students aged between 8 and 18 years.



When making these indications it is possible to obtain the tables of observations ready for their statistical analysis, as it appears in the summary of observations in the following table of data:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **TRMM** | **Terra** | **Aqua** | **Both Terra and Aqua** |
| **1998** | [39 rows; 12 kb](http://scool.larc.nasa.gov/matches/SCOOL_TRMMCorrespondence1998.xls) |  |  |  |
| **1999** | [129 rows; 32 kb](http://scool.larc.nasa.gov/matches/SCOOL_TRMMCorrespondence1999.xls) |  |  |  |
| **2000** | [87 rows; 20 kb](http://scool.larc.nasa.gov/matches/SCOOL_TRMMCorrespondence2000.xls) | [1266 rowsi; 276 kb](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2000.xls) |  |  |
| **2001** | [40 rows; 12 kb](http://scool.larc.nasa.gov/matches/SCOOL_TRMMCorrespondence2001.xls) | [2835 rows; 616 kb](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2001.xls) |  |  |
| **2002** |  | [3511 rows; 760 kb](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2002.xls) | [525 rows; 120 kb](http://scool.larc.nasa.gov/matches/SCOOL_AquaCorrespondence2002.xls) |  |
| **2003** |  | [3190 rows; 684 kb](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2003.xls) | [1569 rows; 344 kb](http://scool.larc.nasa.gov/matches/SCOOL_AquaCorrespondence2003.xls) |  |
| **2004** |  | [3814 rows; 828 kb](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2004.xls) | [1887 rows; 416 kb](http://scool.larc.nasa.gov/matches/SCOOL_AquaCorrespondence2004.xls) |  |
| **2005** |  | [4873 rows; 1.1 MB](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2005.xls) | [1982 rows; 440 kb](http://scool.larc.nasa.gov/matches/SCOOL_AquaCorrespondence2005.xls) |  |
| **2006** |  | [4479 rows; 992 kb](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2006.xls) | [2376 rows; 532 kb](http://scool.larc.nasa.gov/matches/SCOOL_AquaCorrespondence2006.xls) |  |
| **2007** |  | [3619 rows; 808 kb](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2007.xls) | [2210 rows; 500 kb](http://scool.larc.nasa.gov/matches/SCOOL_AquaCorrespondence2007.xls) |  |
| **2008** |  | [2736 rows; 620 kb](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2008.xls) | [2102 rows; 476 kb](http://scool.larc.nasa.gov/matches/SCOOL_AquaCorrespondence2008.xls) |  |
| **2009** |  | [2225 rows; 608 kb](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2009.xls) | [1823 rows; 520 kb](http://scool.larc.nasa.gov/matches/SCOOL_AquaCorrespondence2009.xls) |  |
| **2010** |  | [Actualizado a diario](http://scool.larc.nasa.gov/matches/SCOOL_TerraCorrespondence2010.xls) | [Actualizado a diario](http://scool.larc.nasa.gov/matches/SCOOL_AquaCorrespondence2010.xls) |  |

Table No. 2 data of cloud observations in Excel format.

CERES-SCOOL database.

Http //: scool.larc.nasa.gov

**4. RESULTS**

Analysis: The amount of cloud cover is determined by estimating the percentage of clouds covering the sky, this scale is determined as follows:

1. Clear: means a coverage of 0 to 5% of clouds present in the sky.

2. Partly cloudy with a 50 percent chance of snow showers.

3. Mostly cloudy with a 50 percent chance of snow showers.

4. Completely cloudy: 95 to 100% clouds in the sky.

When recording the observations of the years 2006-2011 in the morning, it is concluded that the sky is partly cloudy or a sky covered from 5 to 50%, with 27.76% of observations recorded in six years of continuous work, This information indicates that there is not a very high cloud value which is related to moderate rainfall.

Analysis:

The troposphere is the lower part of the atmosphere (from 0 to about 12 kilometers), where the climate and life develop. It contains three quarters of the mass of the atmosphere and about 99 percent of the atmospheric water; Its depth varies with the latitude and the season of the year. Solar energy does not warm this layer sensitively, so its heating is due to the radiation coming from the earth's surface. Its temperature, therefore, decreases with the height (approximately 6.5 degrees centigrade per kilometer), which gives rise to a thermal structure that causes vertical (convective) movements of air currents that favor the atmospheric mixture, transport the water and can extend Until the beginning of the stratosphere.

Our climate, in the final analysis, is the result of a constantly adjusted balance between water, atmosphere, solar and terrestrial energy. The water cycle is central to this equilibrium and represents the largest movement of a chemical on the surface of the Earth. Its basic mechanisms are well known, especially those carried out in oceans and continents; However, there are still many details that are still a subject of much research in the water vapor phase and clouds. The main processes involved in the movement of water between the different reservoirs are evaporation, condensation, transport, precipitation, runoff (water runoff from the land surface), infiltration and transpiration.

Within this conglomerate of processes in the water movement we study the precipitations and their relation with the type of cloud present in a determined time, this graph relates the greater number of observations related to the type of cloud that predominates more in the city of Barranquilla Between the years 2006-2011 during the morning hours, the results show that cumulus with 29.79% and stratocumulus with 28.45% lead the percentage of clouds that have more presence in this period of years.

When doing a more detailed study of these types of clouds present we have that The cluster is a white cloudy mass. The younger ones are associated with good weather. The large ones are seen with a flat base and very bulky surface. They have a pure white on the side illuminated by the sun, but on the sides and base are dark gray. Under certain conditions, these individual masses grow inordinately forming the cumulonimbus, which is the typical storm cloud that causes many rains, strong winds and large electric shocks.

Analysis:

Half of the solar energy received annually on the Earth's surface is used to evaporate water from the continents and oceans. Evaporation occurs when molecules in a liquid acquire sufficient kinetic energy to escape from the liquid phase and pass into the gaseous phase, overcoming surface tension and cohesion on the surface of liquid water. The rupture of hydrogen bonds that hold water molecules together in the liquid phase requires energy, so the process is performed more rapidly the higher the temperature. At low temperatures evaporation is slower. Basically it is the same process for perspiration, only that it happens on the surface of the soil and in organisms.

When the vapor that enters the atmosphere reaches the point of saturation of the air (that is, when it contains all the water vapor that it is possible to contain at that temperature), the excess molecules condense to form drops or ice crystals. Evaporation and condensation are continuous processes that generate and redistribute heat, transporting it and transforming all the time between vapor, liquid and ice crystals, depending on the temperature and pressure of the air.

The higher the air temperature, the more steam you can contain. Hence the concept of relative humidity serves to indicate, in percentage, the amount of water vapor that contains a portion of air, in relation to which it can contain given its temperature. A relative humidity of 100 percent indicates that that portion of air can not contain more steam. If the temperature of the air drops, the amount of vapor that it can contain decreases and all excess will condense. If the temperature of the saturated air increases, it will increase its capacity to contain water vapor and will decrease the relative humidity.

For these reasons the temperature is an important indicator for the climate in Barranquilla, when recording the observations in the morning hours, we obtain that the temperature range that prevails in the period of six years is the one corresponding to (22,6 a 26.3) ºC, whose average we will take into account to develop the mathematical model will be 24ºC. These observations were recorded in the morning in correspondence to the Terra satellite of the CERES-SCOOL program.

The results are equal in the percentages obtained in the range corresponding to (26.3 to 30.1) ºC with the range (30.1 to 33.8) ºC. With 16.8% respectively. This shows the variability in the temperature of the city in this period of years.

**5. CONCLUSIONS**

MATHEMATICAL MODEL FOR PREDICTIONS OF TEMPERATURE IN THE CITY OF BARRANQUILLA IN MORNING HOURS.

INITIAL MODEL GUIDELINES

Using this simple model you can see how the temperature of Barranquilla in the morning, can change if the amount of net energy input changes. The model is based on 2 assumptions:

The average incoming radiation is 364 Joules per square meter per second = 364 JM -2S-1.

The ratio of outgoing radiation depends only on the temperature of Barranquilla, and is given by the Law of Stefan-Boltzmann.

Reason for salient radiation = σT4 = 5.67 x 10 -8 JS-1 M -2K -4

 Problem Question

1. What can alter the reason that energy reaches Earth?

HEATING

The change in Earth's temperature depends on the difference between the ratio at which the radiation above and the ratio coming out. It also depends on the heat capacity of the Earth (how easily the City of Barranquilla heats up).

The heat capacity of the Earth is = 4 x 10 8 JK-1M-2 requires 4 x 10 8 J to raise the temperature from 1M2 to 1 ° K.

The change in Earth Temperature in a year is given by:

Temperature change = (incoming radiation - outgoing radiation) x time / Heat capacity

And the temperature of the city of Barranquilla in the morning hours, after a period of time will be given by: New temperature = old temperature + temperature change

From here we can conclude that the differential equation for our model will be represented by:

Where:

DT / dt: change or change in temperature Cc: heat capacity t: time

Ri: incoming radiation

Rs: outgoing radiation

Therefore, the new temperature is calculated through the following equation:

Where: Tv: old temperature

Tn: new temperature

Performing the calculations in Excel to determine the variation or temperature changes in the morning hours of the 32-year period, we have

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | dT/dt | Tv K | TvºC | Tn K | TnºC |
| Años | Ri-Rs | Cc | t | (Ri-Rs)\*t/Cc |  | K-273,15 | Tv+(dT/dt) | K-273,15 |
| 1 | 0,31214288 | 40000000 | 31536000 | 0,24609345 | 297,15 | 24 | 297,396093 | 24,2460934 |
| 2 | 0,31214288 | 40000000 | 63072000 | 0,49218689 | 297,2 | 24,05 | 297,692187 | 24,5421869 |
| 4 | 0,31214288 | 40000000 | 126144000 | 0,98437378 | 297,25 | 24,1 | 298,234374 | 25,0843738 |
| 8 | 0,31214288 | 40000000 | 252288000 | 1,96874757 | 297,3 | 24,15 | 299,268748 | 26,1187476 |
| 16 | 0,31214288 | 40000000 | 504576000 | 3,93749514 | 297,35 | 24,2 | 301,287495 | 28,1374951 |
| 32 | 0,31214288 | 40000000 | 1009152000 | 7,87499027 | 297,4 | 24,25 | 305,27499 | 32,1249903 |

Table 3 results of the mathematical model for temperature variations in the Atlantic department in the morning.

Where:

Rs-Ri: It is the difference between the outgoing radiation and incoming radiation in the city of Barranquilla.

Cc: Heat capacity of the Earth.

T (sec): This is the elapsed time in seconds.

DT / dt: is the variation of temperature as a function of time

Tv K: Old temperature in degrees Kelvin.

T ° C: Old temperature in degrees centigrade.

Tn K: New temperature in degrees Kelvin.

Tn ºC: New temperature in degrees centigrade.

In this way, using the range that obtained the highest percentage of temperature in the morning hours, we can take as an average temperature the average of this range 24ºC and replace it in the equation to determine the new temperature for the first year will be:

Tn = 24.246 ° C

In this model we can observe in the fifth column the proportional increase of the temperature variation over 32 years, which influences according to our formula to predict the next temperature in morning hours for the same period of time, this information is Evidence in column 9 when doing the calculations.

Increases in the surface temperature of the department of Atlántico are evidenced in morning hours every 2 years starting from 2006 up to 32 years later.

**6. FUTURE WORK**

In order to continue with future studies, the establishment of a second mathematical model is established, allowing the variability of the surface temperature of the department of Atlantico to be known in the afternoon, for which it is necessary to establish observation hours in the afternoon in Together with the AQUA (NASA) satellite and in this way to be able to create a similar table of values ​​that can evidence these changes of temperature over a period of years equal to this study.

The reports obtained in this work will serve as a basis for comparing the variations at different times of the day and thus have more complete this analysis.

**7. REFERENCES**

• Science for non-scientists: what Einstein did not know about climate change Yair Alexander Porras Contreras, Ivonne Inés Angarita Gálvez, Memories of the 1st National Congress of Research in Biology Teaching.VI National Research Meeting on Teaching Biology and Education Environmental. ISSN 2027-1034. P. p. 103-115.

• Acevedo, J.A. (1996). Technology in CTS relationships. An approach to the topic. Teaching Science, 14 (1), pp. 35-44.

• Acosta, A. and Martínez, E. (Comp.) 2008. Good living. A way for development. Quito: Abya-Yala.

• ANDRADE-C. M.G. 1998. Use of Butterflies as Bioindicators of the Type of Habitat and its Biodiversity in Colombia. Rev. Acad. Colomb. Science. 22 (84): 407-421

• Caamaño, A. (ed.) (1995). Education science-technology-society. (Monographic). Alambique, 3.

• Cardona, A. 2009. Institutional Mapping. Actors related to the approach to climate change in Colombia. Project Integration of climate change risks and opportunities into national development processes and United Nations country programming. UNDP: Bogotá.

• Caride, J. A. and Meira, P. A. 2001. Environmental education and human development. Ariel.

• Dent, P and Dalton, G. 2010. Climate Change and Professional Surveying Programs of Study. International Journal of Sustainability in Higher Education. Vol. 11 No. 3, 2010 pp. 274-291.

• Fals Borda, O. Reflections on participatory research. CENAPRO. Mexico, 1981.

• García-Canclini, N. 1990. Hybrid Cultures. Strategies for entering and leaving modernity. Ed. Grijalbo, México.

• Analysis of hydrological impacts of "El Niño" - compilation, studies and research. GTHRH-rapporteur: Olga Umpiérrez NOAA (2009).

**8. ANNEXES**

TABLE CLOUD COVERAGE

|  |  |  |
| --- | --- | --- |
| Cobertura de nubes 2006-2011 | fi | % |
| claro | 447 | 24,06 |
| Parcialmente nublado | 531 | 27,76 |
| Mayormente nublado | 468 | 24,98 |
| Completamente Nublado | 427 | 23,18 |
| Total días registrados | 1873 | 99,98 |

TABLE TYPE OF CLOUDS

|  |  |  |
| --- | --- | --- |
| Tipo de nube | Frecuencia | % |
| cumulonimbos | 259 | 11,9 |
| cúmulos | 648 | 29,79 |
| nimbostratos | 384 | 17,65 |
| estratocúmulos | 619 | 28,45 |
| Niebla | 128 | 5,88 |
| Estrato | 137 | 6,29 |
| Total observaciones | 2175 | 99,96 |

TABLE SURFACE TEMPERATURE (TOM MORNING)

|  |  |  |
| --- | --- | --- |
| Temperatura | F | % |
| (15.192-18.92) | 275 | 15 |
| (18.92-22.648) | 318 | 17 |
| 22.648-26.376) | 386 | 21,29 |
| (26.376-30.104) | 299 | 16,8 |
| (30.104-33.832) | 304 | 16,8 |
| (33.832-37.56) | 231 | 13,01 |
| Total observaciones | 1813 | 99,9 |

Variation of the ambient temperature in the Department of the Atlantic in the period 2006-2038

Rat of change in temperature (dT / dt)

EXPERIMENTAL CONTRAST YEAR 2016