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STUDY OF VARIATION OF DAILY TEMPERATURES IN THE CITY OF NATAL

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Abstract. *The behavior of the temperatures during a year in Natal was analyzed. For this we constructed a software that displays the temperature value at each moment in the city. The program was developed in Delphi using interpolated polynomial function of third degree. The equations were obtained in Excel and data were collected at the Instituto Nacional de Pesquisas Espaciais (INPE). Armed with this program you can build tables and charts to analyze the temperatures for certain periods of time. With the data provided by this software is possible to say which are the hours of highest and lowest temperatures in the city, as the months have indexes with the highest and lowest temperatures. Two days were chosen randomly to check the validity of the program. In both, the temperatures provided by the software were very similar to those of real data. The test of validity of the program also analyzed the temperature in several months, with small differences between predicted and real.*

Keywords: *Temperatures, Software, Natal.*

1. INTRODUCTION

Thermal radiation is generated when heat from the movement of charged particles within atoms is converted to electromagnetic radiation. The emitted wave frequency of the thermal radiation is a probability distribution depending only on temperature, and for a black body is given by Planck's law of radiation. Wien's law gives the most likely frequency of the emitted radiation, and the Stefan-Boltzmann law gives the heat intensity.

The large amount of solar energy incident on Earth's surface is the likely solution to the global energy demand. The United Nations has promoted several environmental conferences in order to decrease the amount of pollutants in the atmosphere, land surface and seas. It is estimated that our planet receives $1KWm^{-2}$ of radiation. Brazil receives about $1.13 \times 10^{10}GWh$ (Melo, 2008).

In relation to Rio Grande do Norte, the average daily global radiation is among 0.5 to 0.7 KWm^{-2} (Souza Filho, 2008). Solar radiation is an immeasurable energy source, there is a huge potential for use by harvesting and conversion to other forms of energy such as thermal energy, chemical or electrical. The energy obtained by the photovoltaic process is widely used in places distant from the power grid. This type of conservation of energy is more reliable and economical than other processes to occur in a decentralized and dependent only on the energy from the Sun (Lion Filho, 2007).

Scientific predictions say the planet's average temperature will increase between 1.4 and 5.8 degrees celsius by the end of the century (Epstein, 2010). The ocean warming will cause an increase in water level and consequent flooding of certain coastal areas.

Given this context, the need for experimental and theoretical studies can monitor the temperature in Natal.

2. METHODOLOGY

From the data collected from the site of the Instituto Nacional de Pesquisas Espaciais (INPE, 2010), was selected ten days of each month, following the arithmetic progression of three days. In each of these days, obtained a value of temperature versus days for a particular time. Thus, the data were arranged in Tab. 1:

Table 1. Data analyzed in January 2009

Day	Minute	Temperature
3	300	27,6467
6	300	27,6637
9	300	27,1717
12	300	26,1033
15	300	26,703
18	300	26,5675
21	300	26,432
24	300	26,60885
27	300	26,7857

This procedure was repeated for 8 hours to 11 hours, 14 hours and 17 hours, considering that the highest temperatures occur during this period, as well as exposure to ultraviolet radiation.

2.1 Data Analysis

After this data collection, were built five charts in Excel: 5 hours, 8 hours, 11 hours, 14 hours and 17 hours.

The functions were obtained for a polynomial of third degree. The reason for this choice is that this kind of function has greater freedom to vary depending on the dependent variable.

From these graphs were obtained equations for 5 hours Eq.(1), 8 hours Eq.(2), 11 hours Eq.(3), 14 hours Eq.(4), 17 hours Eq.(5).

$$T(t) = 0.0004t^3 + 0.0038t^2 - 0.1858t + 28.332 + f(t), \qquad 4.5 < t \leq 6.5 \tag{1}$$

$$T(t) = 0.0003t^3 - 0.0148t^2 + 0.1834t + 28.032 + f(t), \qquad 6.5 < t \leq 9.5 \tag{2}$$

$$T(t) = 0,0008t^3 - 0.0331t^2 + 0.403t + 27.513 + f(t), \qquad 9.5 < t \leq 12.5 \tag{3}$$

$$T(t) = 0.0014t^3 - 0.0541t^2 + 0.5231t + 26.775 + f(t), \qquad 12.5 < t \leq 15.5 \tag{4}$$

$$T(t) = 0.0002t^3 - 0.0047t^2 + 0.0486t + 27.055 + f(t), \qquad 15.5 < t \leq 18.5 \tag{5}$$

Each of these functions were modified because the addition of an experimental correction factor, so that the results were the closest to the real. This factor is a function of the first degree with a slope that was determined experimentally.

The introduction of the correction factor is necessary because the functions previously achieved only describe temperatues in relation the hours during which temperatures were collected. Other times of the day should also provide the values of temperatures. The correction factor modifies the functions that describe the temperature at 5 o'clock to describe the temperatures until 6:30. The equations that describe the temperatures at 8 hours are modified to provide values from 6:30 until 9:30. The same happens with the equations that represent the temperature at 11 hours, 14 hours and 17 hours.

These factors are presented in Eq. 6.

$$f(t) = \alpha(t - \beta) \tag{6}$$

The constants α and β are shown in Tab. 2.

Table 2. Constants

Hours	α	β
4.5 < t ≤ 6.5	0.65	5
6.5 < t ≤ 9.5	0.55	8
9.5 < t ≤ 11	0.2	11
11 < t ≤ 12.5	-0.2	11
12.5 < t ≤ 15.5	-0.55	14
15.5 < t ≤ 18.5	-0.65	17

The same procedure was repeated to the rest of the months 2009.

2.2 Software development

After determining the degree of the polynomial that will describe the temperatures, it was necessary to use a programming language to compile this information.

If the user wishes to obtain the temperature to an accuracy of minutes, it becomes necessary to convert the value of time. For example: To find the temperature value at 11 hours and 20 minutes. This should be informed in time value: 11.3.

The functions obtained were translated to Delphi, with the goal of creating a program to return the value of temperature to the desired moment.

Figure 1 shows the software developed:

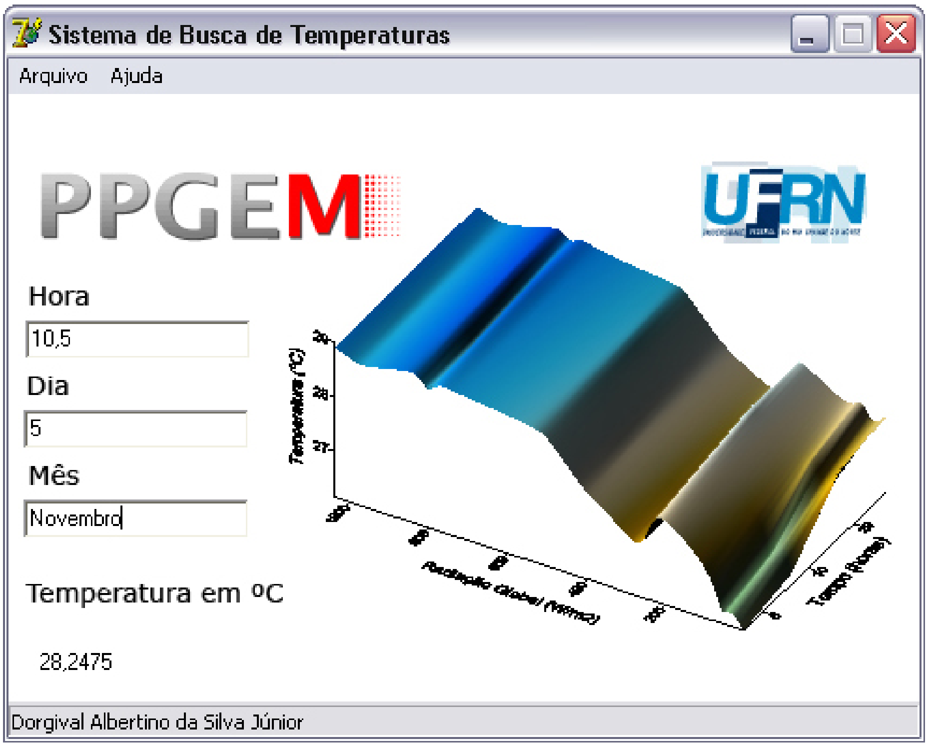

Figure 1. Software

3. RESULTS

There were two types of analysis. The first in a single day, the second was made over the months. Days and times were chosen randomly.

3.1 First analysis

In the first case, were randomly assigned two days of the year: Nov. 5 and Jan. 6.

The overlap of the graphs, fig. 2 shows that in some points there was an error estimation, a maximum of 0.5 C, ie 1.73%. With better approximations to the rest of the time.

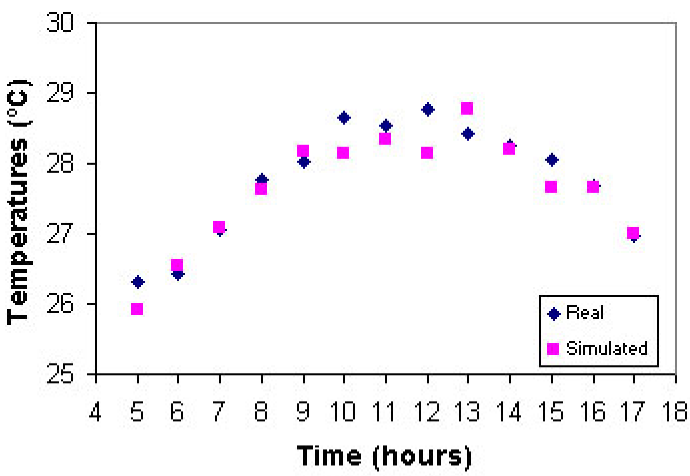

Figure 2. Daytime temperatures Nov. 5, 2009

In Figure 3, the maximum temperature occurred, according to the actual data at 10 hours. However, the simulated data showed the maximum temperature at 9 am for that day. Both graphs show a downward trend in temperature until 17 o'clock. The overlap indicates a maximum error of about 2.41%.

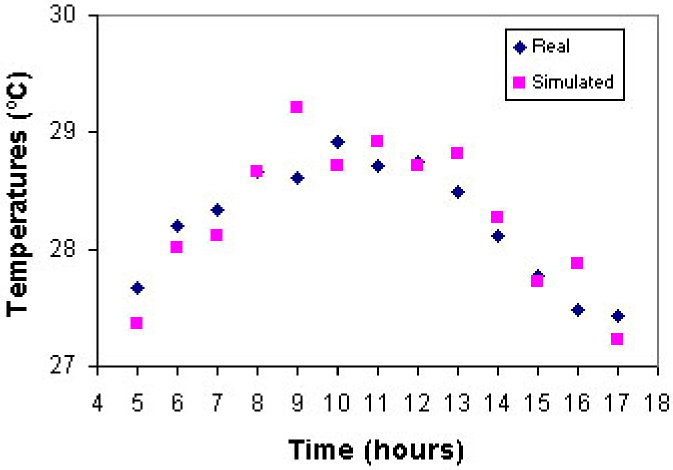

Figure 3. Daytime temperatures Jan. 6, 2009

3.2 Second analysis

Figure 4 indicates that there was a sudden drop of temperature in the month of May, with temperature increase in July to levels in April. The maximum error occurred in June and was 3.45%.

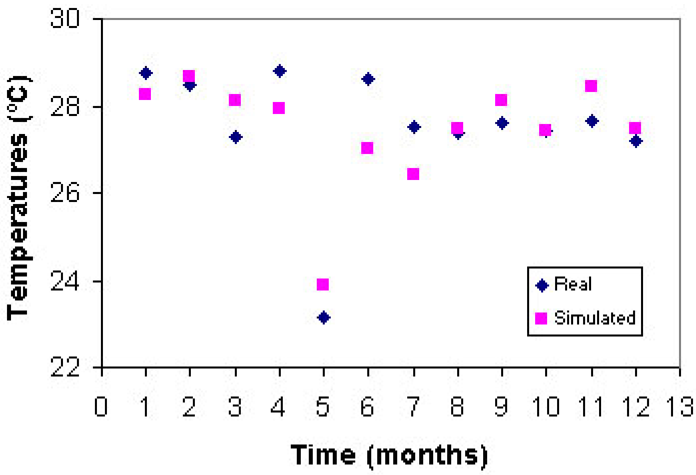

Figure 4. Graph of real and simulated temperatures of the third day of each month at 10 hours.

This last graph, Fig.5, also shows that temperatures in the month of May were the lowest during the year. There was an increase in temperature from January to March, falling by May, with subsequent increase until June and remain stable until October, and from that moment increases until the end of the year. The analysis has an error of 6.9%.

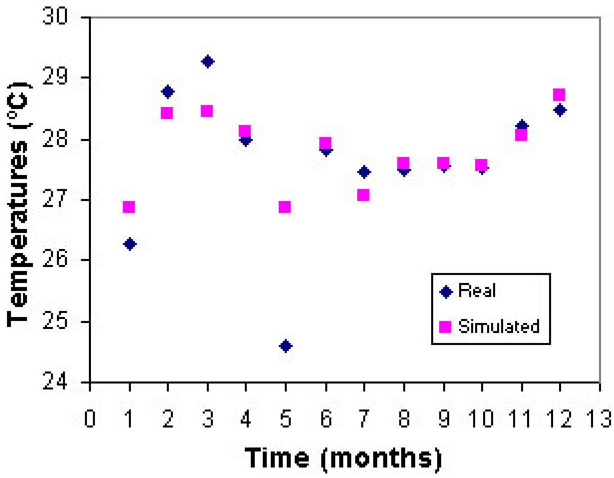

Figure 5. Graph of real and simulated temperatures of the twenty-first day of each month at 14 hours.

4. CONCLUSIONS

The highest temperatures occurred around 11 hours and 30 minutes. At that time, the rates of ultraviolet radiation are extreme. This because of the dependence of thermal radiation with temperature, the higher the temperature the greater the radiation. The highest temperatures were in the end and beginning of 2009.

Unable to build a program with a function of the sixth grade due to Runge's phenomenon, which gives values very different from real ones. So it was appropriate to choose a function of the third degree, for it shows inflection points sufficient to satisfactorily describe the temperature.

In the capital of Rio Grande do Norte, due to high temperatures throughout the year presented by the previous graphs, it is necessary that the concern with the thermal comfort is thought from the beginning of the project to build houses and industries, with a correct location of ventilation openings.

5. ACKNOWLEDGEMENTS

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