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Mesoscale weather simulations of Northern Perú (2015) using Brazilian Regional Atmospheric Modeling system (BRAMS)

Simulación meteorológica a nivel Mesoescala del norte de Perú (2015) usando Brazilian Regional Atmospheric Modelling System (BRAMS)

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Resumen

El calentamiento de las aguas del pacífico generan la llegada del fenómeno del El Niño; el Perú en los años 1997 y 1998 sufrió grandes pérdidas tanto material como víctimas humanas, en la actualidad con distíntas técnicas se predice la magnitud de los fenómenos naturales. Nuestro objetivo es estudiar los cambios en las variables meteorológicas como son; Temperatura, Campos de viento y Humedad relativa, en los meses de octubre a noviembre del 2015 y comparar con los años 1997 y 1998. Se utilizó el modelo BRAMS (Brazilian Regional Atmospheric Modelling System) el cual permite analizar diferentes variables metereológicas en distíntos períodos de tiempo; la variación de la temperatura en el norte del Perú oscila entre 18 a 29 grados centígrados, la humedad relativa entre 35 a 100 % para la costa, los campos de viento de 2.7 km/h a 9.9 km/h, las ciudades como Tumbes, Piura, Lambayeque y La Libertad presentan una disminución de 9, 5 y 6 grados centígrados en el mes de octubre a Noviembre, respectivamente. Por tanto, podemos concluir que las variables metereoógicas han disminuído para el mes de noviembre en el 2015 lo cual no ha ocurrido en los años del fenómeno del niño 1997 y 1998 cuyos valores se mantuvieron constantes.

Palabras clave. Simulación numérica, BRAMS, clima, fenómeno El Niño, modelamiento atmosférico.

Abstract

The warm of the tropical pacific ocean generate the El Niño phenomenon. The Perú between the years 1997 and 1998 took big materials losses and human victims because the presence of EL NIÑO. Now the scientists try to make a prediction of the magnitude of natural phenomenon using different methods of simulation. Our objective are study the changes in the weather variables such that: temperature, wind fields and relative humidity, from October to November in 2015 and compared with years 1997 and 1998. We used the BRAMS (Brazilian Regional Atmospheric Modelling System) model; with this model We could analyze the differences of temporal and spatial changes for the weather variables. The variation of temperature in northern Peru was around 18 and 29 degrees Celsius , relative humidity was around 35 and 100 % of the coast, the wind fields were 2.7 km/h to 9.9 km/h . The Temperature at regions of interest: Tumbes, Piura, Lambayeque and La Libertad presented a decrease in 9, 5 and 6 degrees celsius from octuber to November, respectively. In conclusion, the weather variables have presented a decrease in November 2015, these behavior did not occur in the years 1997 and 1998.

Keywords. Numerical Simulations, BRAMS, Weather, El Niño phenomenon, atmospheric modeling.

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1. Introducción. The warm water currents in the pacific ocean cause the El Niño phenomenon. The Perú is near from Ecuatorial line and that is a danger zone [1, 2, 3, 4, 5].

The temperature variation before October made us to postulate that intensity of El Niño for this year will be greater than the years 1997 and 1998, since at Perú between this years 1997 and 1998 took big materials losses and human victims because the presence of EL NIÑO phenomenon.

Actually, the meteorologists have taken more attention to predict the magnitude of the El Niño phenomenon for the impact of it on the all continents of the world. Now the scientists try to make a prediction of the magnitude of natural phenomenon using different methods of simulation.

Our objective are study the changes in the weather variables such that: temperature, wind fields and relative humidity, in the northern part of Peru comprising the geographical region of Tumbes, Piura, Lambayeque and La Libertad, at time interval from October 22 to November 10 in 2015 and the comparison is carried out with same profiles fields obtained from the years 1997 and 1998 at the same points of observation.

For the integration we used the numerical model BRAMS 5.2 (Brazilian Regional Atmospheric Modeling System) [10], in parallel version freely available on CPTEC-Brazil, which is a modified version of the former RAMS(Regional Atmospheric Modeling System) from the Colorado University, designed to simulate atmospheric circulations at many scales.

The weather change was governed by variation of different variables (Temperature, Relative humidity, wind fields and precipitation), with these we could make the prediction of their behavior [8].

The mathematical model which used RAMS for interpreted these variables are the fully compressible non-hydrostatic equations, which was proposed by Pielke et al.[16]. Although there is authors as [7, 14, 13] which proposed models with partial differential equations and interpreted of movements as incompressible and incompressible fluid.

The mathematical model was aproximated numerically with the method of Finite Differences [16] on a rectangular domains.

The RAMS is implemented with a multiple grid nesting scheme which allows that the mathematical to be integrated simultaneously on various computational nets of increasing spatial resolution, which enable to obtain solves at resolution of mesoscale.

With this software, we have made the prediction of weather variables; The BRAMS was used to study many weather changes around the world [11, 12, 10]. which comprises with several new functionalities and parameterizations specialized for the tropics and sub-tropics. RAMS is a multipurpose, numerical prediction model designed to simulate atmospheric circulations spanning from hemispheric scales down to large eddy simulations (LES) of the planetary boundary layer.

In this work, we study the weather changes, at variables propose in mesoscale levels from October 22 to November 10, and and make a comparison between the years 1997, 1998 and 2015, using the BRAMS numerical model. With this model we could analyze the differences of temporal and spatial changes for the weather variables.

2. Methods. The interest area was the coast of Northern Perú, at the Tumbes, Piura, Lambayeque and La Libertad regions; those regions were affected strongly by the last El Niño phenomenon of the years 1997 and 1998 [2, 3, 5]. The weather variables of interest were: temperature, relative humidity and wind fields, which give a basic description of the weather.

2.1. Area of integration . In order to perform the weather prediction, we need the global data; which is obtained from CPTEC/IMPE (Centro de Previsão de Tempo e Estudos climáticos- IMPE-Brazil). This data covered an geographic area from 120 W to 80 E and 40 N to 80 S degrees, where was placed a grid with a resolution of 120 Km [15]. We need to increase the resolution because the area of interest is small [9], for which the BRAMS provided the mechanism for increment progressive of the resolution [9], in this case it was used three nets with with a dependency on the following with ratios 1, 4 and 2, respectively. Obtained the following resolution of the first net 83 km, second net 20.7 km and the resolution of the third one 10.3 Km.

Each net center and the number of discretization nodes in nomenclature of BRAMS variables are shown in the Table 2.1.

TABLE 2.1
Center of the three nets (lat,long) and the number of discretization points.

	center		points	
N net	Lat S	Lon W	NPx	NPy
1	9.165	74.945	33	34
2	9.165	74.945	98	98
3	6.025	77.705	98	98

2.2. Parameter for the prediction. The interval time for the simulations of the weather variables was taken for 20 days, from October 22nd to November 10th, 2015. The step time is $\Delta t = 3$ hours, which is taken for maintain the stability of the numerical scheme. In order to put the benchmark of the application, some other parameters are considered as the standard for a tropical region, for example the vegetation type in the BRAMS is (NVGCON=6), which correspond to Evergreen broad leaf tree.

2.3. Characteristics of Computational system. The computational system is a Cluster with 3 server SPARC T5120 of 4 core each physically and virtually 32 processors of the a Sun Microsystems, with a Operative system of Open Solaris 10.

3. Results. The first net covered an area from LON 87.056 W to 62.832 W and LAT 21.323 S to 3.133 N; the second net covered from LON 83.742 W to 65.409 W and LAT 18.142 S to 0.1 S , and the last net covered from LON 82.302 W to 73.184 W and LAT 10.496 S to 1.475 S, with an elevation of 57.3 m (see Figure 3.1)

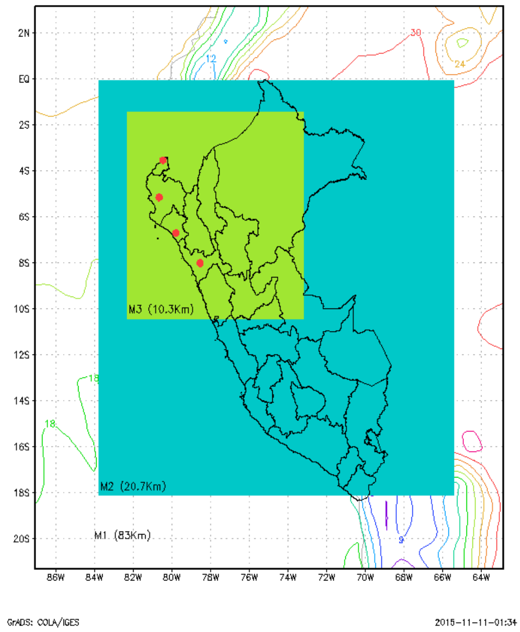

FIGURE 3.1. *Area of interest covered by three nets and the points of interest for series of time.*

The following figures were obtained using the grapher Grid Analysis and Display System (GrADS). The changes of the relative humidity are shown in Figure 3.2, where we found the variation at the coastal area was from 70 at north to 100% at La Libertad for the 2015, 11/10 at 15:26 Greenwich hours; the variation of wind fields is shown in Figure 3.3, where we see we observe the chaotic pattern of behavior in the mountains in contrast to the coastal zone.

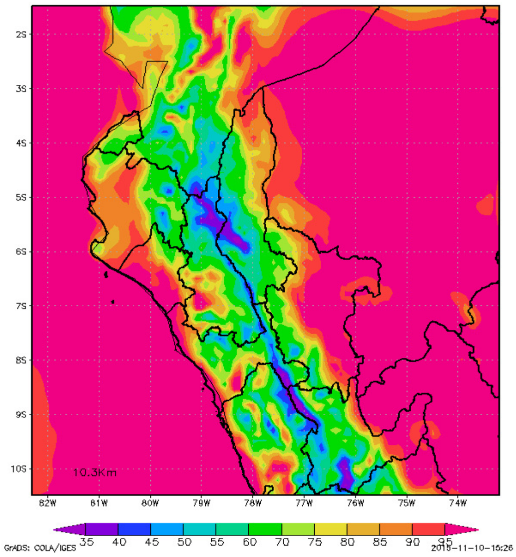

FIGURE 3.2. *Average variation for the third net in Perú.*

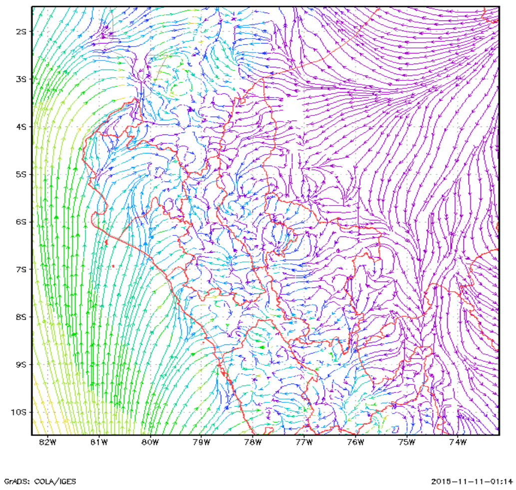

FIGURE 3.3. *Average variation for the wind fields in the third net of Perú.*

The Figures (3.4) and (3.5) show the forecast temperature range for these simulated days, these pattern of temperature averages are present in the three nets. We observed that there are general range of variation from 2 degrees Celsius in the mountains to 24 degrees Celsius on the north coast of Tumbes for this day.

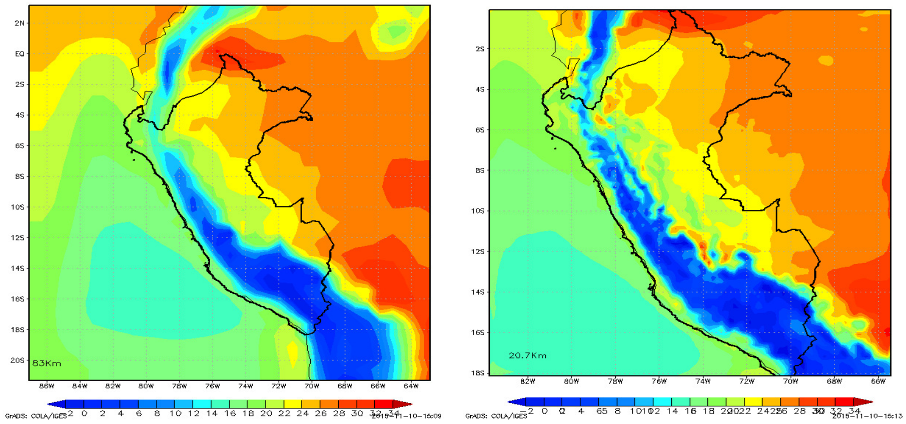

FIGURE 3.4. *average temperature for first and second net*

Moreover at the third net we observed that the average temperature is stable between 20 to 22 degrees apx. at the coastal zone, which reveals that they are normal days of autumn tropical.

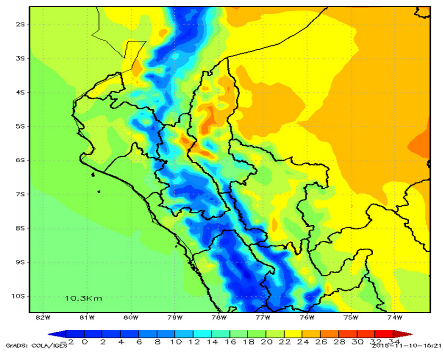

FIGURE 3.5. *Average temperature for the third net.*

To display the time series of temperature was necessary to choose a node located in a city for each state, for example for Tumbes we choose $(3.567S, 80.415W)$, for Piura $(5.185S, 80.65W)$, for Lambayeque $(6.73S, 79.78W)$ and La Libertad $(8.04S, 78.53W)$. Moreover we present the times series compared with three years involved, 1997, 1998 and 2015(predicted) in order to verify the tendency.

The time series of the temperature for the three years 1997 (blue),1998(green) and 2015(red) at states (Tumbes, Piura) at the same interval time October 22 to November 10 with step time 3 hrs, are shown in the Figure (3.6), while that the ones (Lambayeque and La Libertad) showed at the figure 3.7. We observe that the 2015 temperature at Tumbes, Lambayeque y la Libertad has a patron decrease compared with the other years, while that at Piura there is a some peaks in November of 2015. This proves that at least in this period of time no presence is evidence of El Niño phenomenon.

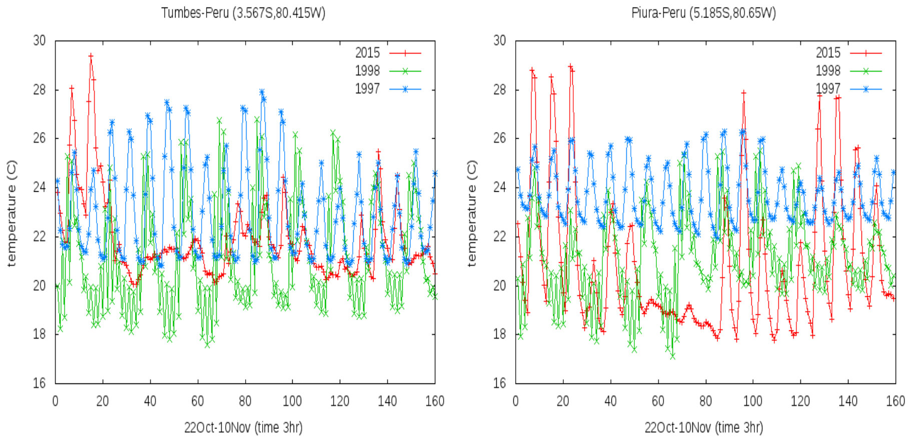

FIGURE 3.6. *Time series for the temperature in Tumbes and Piura.*

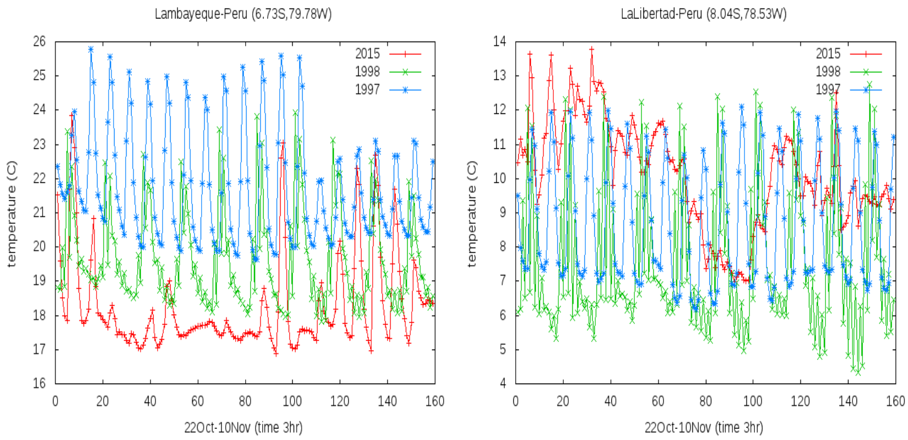

FIGURE 3.7. *Time series for the temperature in Lambayeque and La Libertad.*

The time series of the relative humidity show an increase in the period of interest (see Figures (3.8), and (3.9)) in the 2015. The Tables 3.1 and 3.2 show the average values for the temperature and relative humidity for the years 2015, 1997 and 1998.

TABLE 3.1
Average temperature variation.

	Temperature (C)		
	2015	1997	1998
Tumbes	21.89	22.93	21.15
Piura	20.78	23.69	21.13
Lambayeque	18.27	21.73	19.61
La Libertad	10.12	8.69	7.49

TABLE 3.2
Average relative humidity variation.

	Relative humidity (%)		
	2015	1997	1998
Tumbes	82.59	66.38	69.71
Piura	84.35	70.39	69.17
Lambayeque	95.08	81.74	80.70
La Libertad	62.49	74.63	77.75

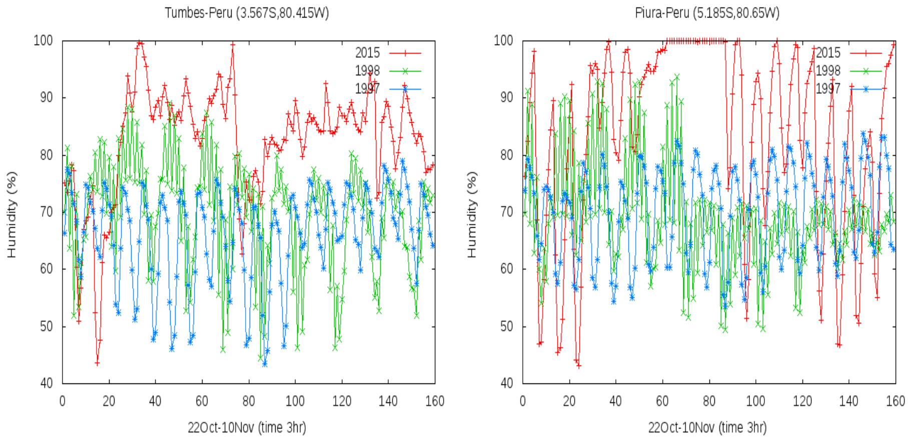

FIGURE 3.8. *Time series for the relative humidity in Tumbes and Piura.*

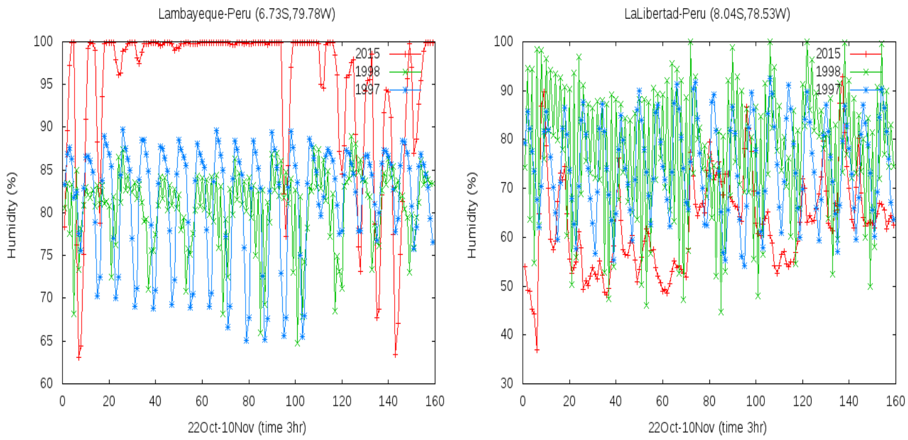

FIGURE 3.9. *Time series for the relative humidity in Lambayeque and La Libertad.*

4. Discussion. The global CPTEC data is update daily at 00:00 hrs and 12:00 hrs, with measure data in different weather stations, after the actualization of the global data is mathematics predictions.

In this work we have taken the October 27 th, 2015 as the last update of global data of CPTEC, after this. we was only predictions with the model used in BRAMS until November 10th.

The simulation showed a different pattern for the weather variables of the year 2015 compared with years 1997 and 1998, although the values of the temperature were in the same range for each regions (see Figures (3.4), and (3.5)).

5. Conclusion. The prediction with the BRAMS showed that weather for this year 2015 is not the same than the years 1997 and 1998; because the oscillations in those years was daily similar in October and November. In contrast for 2015 the daily deviations are smaller for November than October.

Which which tells us that there will be present in these days the oscillations that characterized the presence of El Niño in those years.

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