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Tesis

Evaluation of the Behavior of Climatic Elements in the Mantaro Valley from 2000 to 2020, Department of Junín

Fiorella Melissa Sandoval Apolinario
Lilian Fiorella Mucha Huaire
Iralmy Yipsy Platero Morejon

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Autores:
1. FIORELLA MELISSA SANDOVAL APOLINARIO – EAP. Ingeniería Ambiental
2. LILIAN FIORELLA MUCHA HUAIRE – EAP. Ingeniería Ambiental

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Evaluation of the Behavior of Climatic Elements in the Mantaro Valley from 2000 to 2020, Department of Junín.

F M Sandoval[1], L F Mucha[1], I Y Platero [1]

1 Continental University, Huancayo, Perú
E-mail: 76039040@continental.edu.pe
72405045@continental.edu.pe
iplatero@continental.edu.pe

Abstract. In recent years, climate change has doubled its impact worldwide due to different anthropogenic activities, altering the climatic variability of atmospheric elements and meteorological phenomena that play a relevant role in establishing life on the planet. Thus, the behaviour of climatic elements was evaluated and analysed between the period 2000-2020 in the provinces of Chupaca, Huancayo and Concepción del Valle del Mantaro, by means of the synoptic climatology method using MATLAB software to process hydrometeorological data (TX, TI, RR and RH) provided by SENAMHI. The behaviour of these variables resulted in an increase from -0.5°C to 6°C of TI, TX increased the value of the year 2000-2020 with a +6°C and the amplitude of the values of the distribution of the whisker box, regarding RR from the year 2011-2020 the value of 500 mm decreased to 200 mm in the station "F" while the value of RH decreased and was maintained in the station "C, B, A" because there was no significant increase in temperature to heat the air. Thus, the analysed data evidences and reinforces the variation of the climate system in the values of TX, TI, RR and RH.

1. Introduction

The climatology of a land surface consists of the study of the behavior of the climate and its variations in a given area over a period of time, for this reason meteorological parameters such as humidity, temperature, precipitation and others are used [1].

The World Meteorological Organization (WMO) report on the state of the climate in Latin America and the Caribbean observed variations and anomalies of climatic elements in South America during the last few years, with Peru being one of the warmest countries with records higher than the mean annual temperature values, with ranges of 0.61°C - 0.79°C between 2015 and 2020, surpassing the 1980-2010 period. Likewise, in 2020, from January to March, a deficit of rainfall and extreme rainfall accumulated in the central zone of the Andes in the month of February [2]. Similarly, the Geophysical Institute of Peru (IGP) has conducted several studies on climate change in 2012, proposing objectives for disaster risk management in the event of drought, frost and heavy rains for better adaptation of the population of the Mantaro Valley [3], and studies of the Mantaro River basin [4] established rainfall and temperature forecasts that impact agriculture [5], These diagnoses made it possible to identify areas vulnerable to climate impact and future scenarios [6, 7]. In another sense, the precipitation and temperature trends analyzed from 2010 to 2015 made it possible to compare the perception of the Achipampa and Quichuay communities [8, 9], for the potential use of agricultural land and livestock in a production area located in the Mantaro Valley, which includes the provinces of Jauja, Concepción, Huancayo and Chupaca [10]. Therefore, it is necessary to carry out updated studies to foresee measures to adapt to climate change in the Mantaro Valley due to anthropogenic activity, such as deforestation, the use of herbicides and pesticides that generate polluting gases in the atmosphere, among other effects.

Accordingly, the research evaluated the behavior of the climatic elements of the Mantaro Valley, determined and analyzed the behavior of temperature, humidity and precipitation in the period 2000 to 2020.

2. Materials and Methods

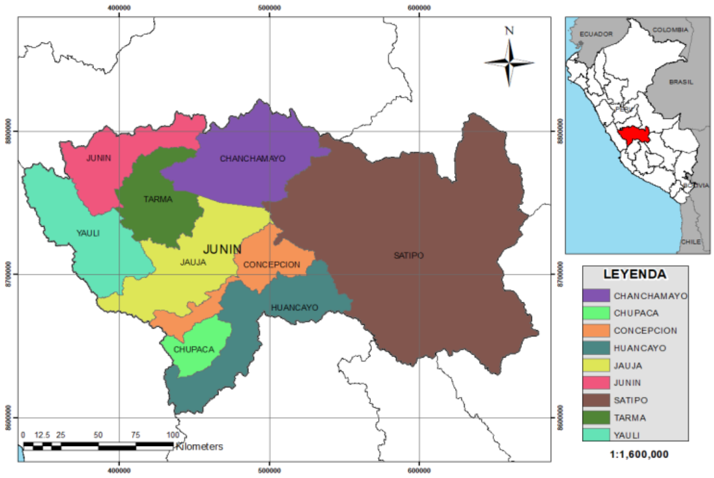
The evaluation of meteorological elements in terms of their behavior during the period from 2000 to 2020, considered the collection of hydrometeorological data from the web portal of the National Service of Meteorology and Hydrology (SENAMHI) who operate, control and organize more than 900 meteorological and hydrological stations (National Network) in accordance with the technical norms standardized by the World Meteorological Organization (WMO) [13]. The methodology for processing meteorological data to analyze their behavior is presented below.

2. 1 Description of the study area

The selected study area corresponds to the Mantaro Valley with an extension of approximately 70 km, located in the department of Junín in the central zone of the Peruvian region (see figure 1), with a mean latitude of 3200 masl [14], part of its extension is highlands (20 821 km2 - 46%) and jungle (23 376 km2 - 54%), it has a temperate and dry climate. And it is politically made up of the provinces of Concepción, Huancayo and Chupaca. The Valley's climate is variable and unstable due to its dependence on altitude, and most of its population is dedicated to agriculture and grazing because its surface is suitable for productive use [15].

Jauja and Huancayo present a life zone of tropical low montane dry forest with an altitude between 2000 and 3000 meters above sea level, temperature between 12 ° C and 17 ° C. In the province of Concepción in the high Andean part its life zone is pluvial moor subalpine tropical with an altitude between 4000 to 4500 meters above sea level and a temperature of 3 ° C to 5 ° C. [16]

Figure 1. Provinces of the department of Junín - UTM



2.2 Data Collection

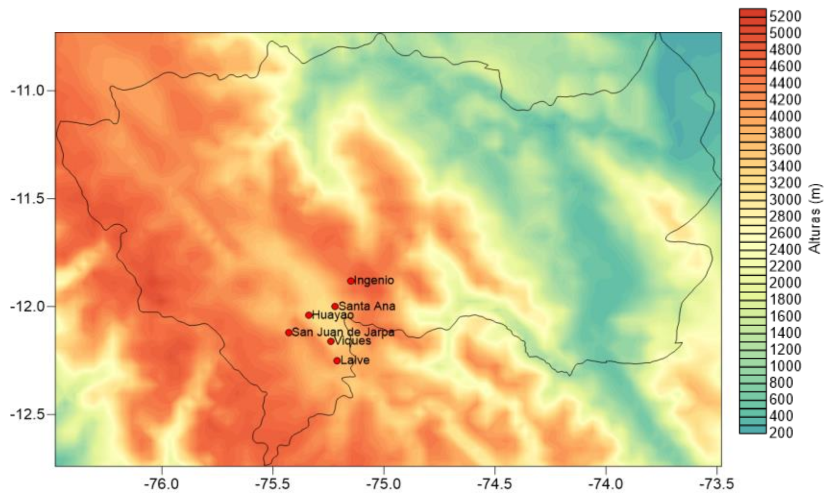
The daily meteorological data for maximum temperature °C (TX), minimum temperature °C (TI), precipitation mm (RR) and relative humidity % (RH) for the continuous period from 2000 to 2020 were collected from the 6 conventional weather stations located in the Mantaro Valley, using data collection forms provided by SENAMHI (see Table 1).

Table 1. Location of the 6 conventional meteorological stations in the Mantaro Valley

Province	*Conventional Weather Station*	*Denomination*	*Altitude (m.s.n.m)*	*Length*	*Latitude*
Concepción	*Ingenio*	*A*	*3390*	*76°17'16''*	*11°52'51''*
Huancayo	*Santa Ana*	*B*	*3293*	*75°15'15''*	*12°0'15''*
	Viques	*E*	*3186*	*75°14'17''*	*12°09'47''*
	Huayao	*C*	*3360*	*75°20'17''*	*12°2'18''*
Chupaca	*San Juan de Jarpa*	*D*	*3660*	*75|25'54.4''*	*12°7'28.3''*
	Laive	*F*	*3860*	*75°20'17''*	*12°2'18''*

The 6 meteorological stations are located between 3000 - 4000 m of vertical distances to the point on the earth's surface, as shown in Figure 2.

Figure 2. Heights of weather stations in meters.



The climatic element such as temperature is transmitted with the hot air by conduction and turbulence usually, precipitation occurs when the air masses are cooled by condensation or freezing action generating water droplets to reach sufficient size and intensity that is expressed in (mm) per unit of time and finally the humidity of the earth's surface is part of the precipitation due to the hydrological cycle that subdivides into relative humidity (water vapor contained in the atmosphere in %) and absolute (amount of water vapor contained in air volume in g/m3). The measurement of these elements is performed with instruments, such as the mercury or alcohol dilation thermometer for temperature, precipitation with the pluviometer or pluviographs and Relative Humidity with the psychrometer or hydrograph [1, 11].

2.3 Data Processing

The 6 meteorological stations belonging to SENAMHI were named to record the measurement of meteorological elements such as temperature, precipitation and relative humidity (see Table 1).

Subsequently, the data collected from the SENAMHI web portal were processed in the numerical computing system "MATLAB", to design a controller that graphs the inputs and outputs, previously applied the programming language. The software has the following structure for processing: data input, algorithm and data output. Based on this, the data was obtained in Excel (data collection sheet) and proceeded to readjust the days not recorded with the average after and before the data, this absence of data is explained by the lack of the monitor and the maintenance of the equipment for measurement. Subsequently, the data were interpolated and the standard deviation was obtained for the annual and monthly averages of TI, TX, RR and HR, using the fuzzy controller will be observed in Simulink and Matlab.

3. Results

The result was sketched in the analysis of the climatic elements of TX, TI, RR and RH with respect to the distribution of each variable over 20 years by the box-whisker plot.

3.1 Maximum Temperature (TX)

The climatic behavior of the maximum temperature (TX) was determined annually, divided by the province of Chupaca (see Figure 3, 4, 6), Huancayo (see Figure 7, 8) and Concepción (see Figure 9).

Chupaca Province

Figure 3. Whisker Box (TX) Huayao Station

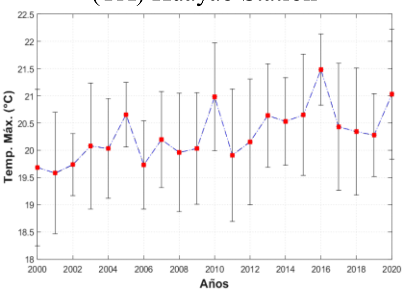


Figure 4. Whisker Box (TX) San Juan de Jarpa Station

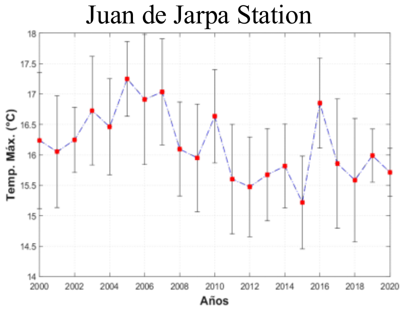
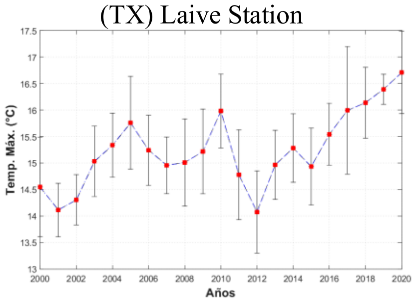


Figure 5. Whisker Box (TX) Laive Station



At the Huayao station (see Figure 3), it was observed that the maximum temperature was 21.5°C in 2016 and its lowest value was 19.6°C. While at the Laive station (see Figure 4) the maximum temperature is above 16.5°C in 2020 and a lower value of 14°C in 2012. Likewise, at the San Juan de Jarpa station (see figure 5) its maximum temperature exceeded 17°C in the year 2005 and its lowest temperature of 15°C in the year 2015. We can also say that the Laive station can record temperatures in a range of 13°C to 17°C, in contrast with the San Juan de Jarpa station which has a range of 14.5°C to 18°C.

Between the years 2000 to 2005 both stations (see figure 6, 7) reached higher temperatures of 19.5°C up to lower values of 21.5°C, and between the years 2006 to 2011 they have the same climatic behaviour referred to the interval of 20°C +1°C, in the year 2016 the Viques station was increasing each consecutive year its maximum temperature up to 21.7°C but the Santa Ana station only increased in the year 2013 and 2016 the values of 20.5°C and 21.5°C respectively.

Huancayo Province | **Concepción Province**

Figure 6. Whisker Box (TX) Santa Ana Station

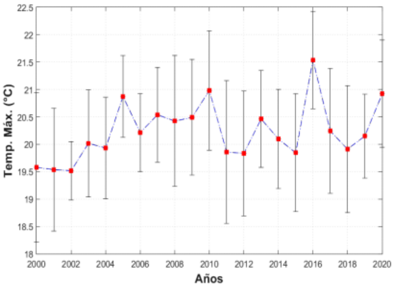


Figure 7. Whisker Box (TX) Viques Station

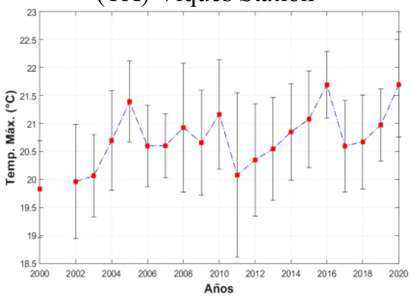
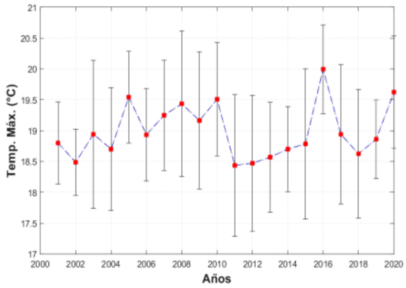


Figure 8. Whisker Box (TX) Ingenio Station



And the year 2017 and 2018 decreased the temperature to 20°C (see figure 6) and 20.5°C (see figure 7), showing that the Viques station tends to increase its temperature with an annual average of 20.75°C in the 20 years, contrasting with the Santa Ana station that tends to have interannual variations from 2010-2016. As can be seen in figure 8, the Ingenio station shows a significant temperature value of 20°C in 2016, however, the temperature behaviour recorded during the 20 years is in a range of 17.2°C to 20.5°C. So we can say that there is not so much variation as its temperature is of constant trend.

3.2 Mínimum Temperatura (TI)

For the analysis of the behaviour of the annual accumulated minimum temperature (TI), it was divided as follows: Chupaca province (see figure 9, 10 and 11), Huancayo (see figure 12 and 13) and Concepción (see figure 14).

Chupaca Province

Figure 9. Whisker Box (TI) Huayao Station

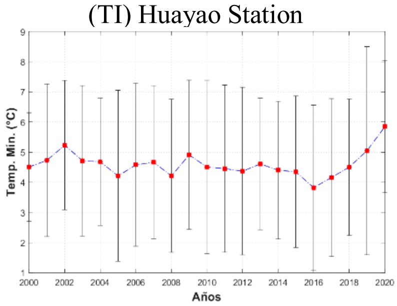


Figure 10. Whisker Box (TI) San Juan de Jarpa Station

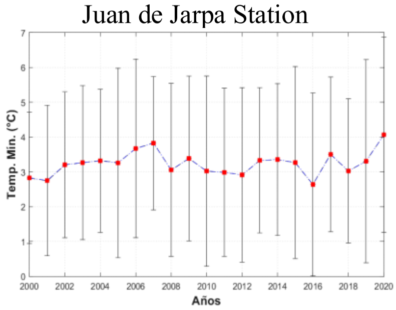
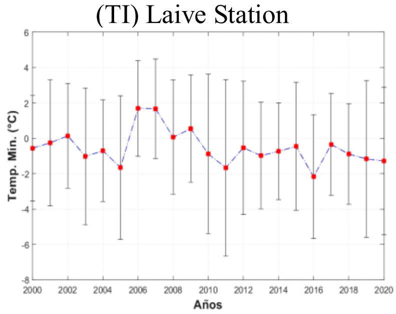


Figure 11. Whisker Box (TI) Laive Station



In the province of Chupaca, the Huayao and San Juan de Jarpa stations have annual averages between 4.5°C (see figure 9) and 3.3°C (see figure 10) of minimum temperature, but from 2016 to 2020 the minimum temperature increases at the Huayao station. But the Laive station does not present continuous annual averages, there is a variation from -2°C to 1.9°C (see figure 11), and the amplitude of the whiskers is shorter than Huayao and San Juan de Jarpa.

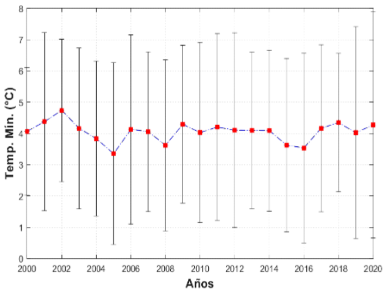
The climatic behaviour in terms of minimum temperature in the province of Huancayo in the Mantaro Valley has maximum ranges of 0.5-7.5°C in the Santa Ana station, and the Viques station does not have very wide ranges of 2-8.8°C, but it is shown that the continuous annual average is 4°C (see figure 12) and 5.5°C (see figure 13) given that there are no anomalies between the 20-year period. However, in the province of Concepción there is an anomaly in the year 2001 (see figure 14) due to the very short ranges of the whisker, then between 2006-2020 there is a continuous average behaviour of 4.25°C.

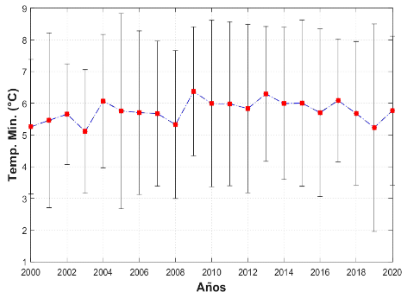
Huancayo Province | **Concepción Province**

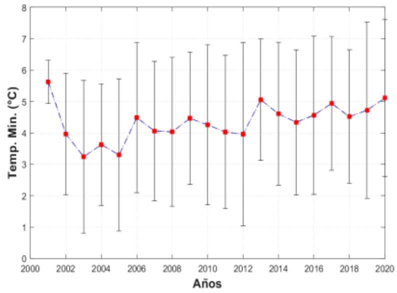
Figure 12. Whisker Box (TI) Santa Ana Station

Figure 13. Whisker Box (TI) Viques Station

Figure 14. Whisker Box (TI) Ingenio Station







3.3 Precipitation (RR)

The analysis of the climatic behaviour with respect to precipitation between the 3 provinces of the Mantaro Valley was analysed with the box-whisker plot to visualise the distribution of the measurements of the RR variable over the last 20 years.

Chupaca Province

Figure 15. Whisker Box (RR) Huayao Station

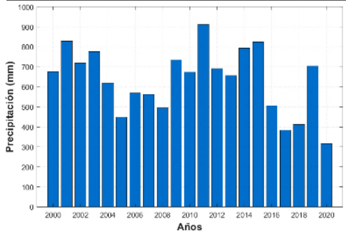


Figure 16. Whisker Box (RR) San Juan de Jarpa Station

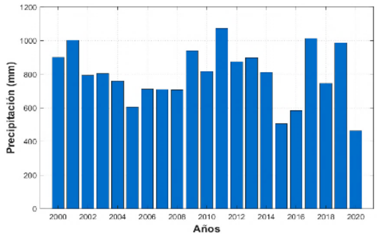
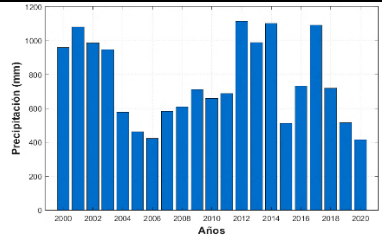


Figure 17. Whisker Box (RR) Laive Station



Huancayo Province

Figure 18. Whisker Box (RR) Santa Ana Station

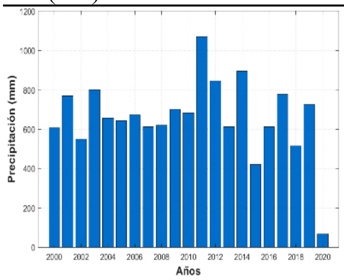
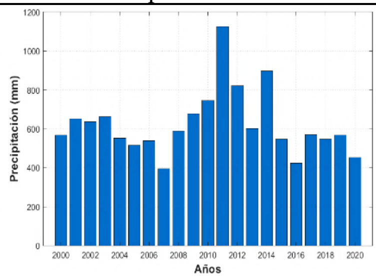
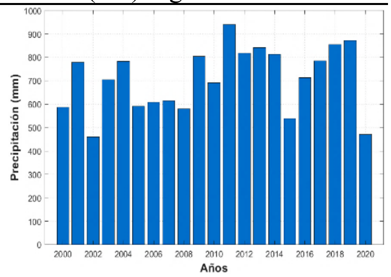


Figure 19. Whisker Box (RR) Viques Station



Concepción Province

Figure 20. Whisker Box (TX) Ingenio Station



In comparison, the three stations Huayao and San Juan de Jarpa (see figure 15,16) show higher precipitation in 2011, on the contrary in the Laive station (see figure 17) its highest precipitation value was in the year 2001,2012, 2014 and 2015. However, in 2020 its values coincide with low rainfall with a value of 400 mm.

In the figure 18 and 19 it is observed that both stations presented higher precipitation in 2011 and 2014, in addition, in the years 2000 to 2010 they reached a precipitation of 800 mm. However, in the Viques station the year 2005 varied significantly to a lower rainfall with a value below 400 mm. In the Ingenio station (see figure 20) it is observed that in the year 2010 until 2019 the rainfall is high, the most representative being the year 2010, which exceeded 900 mm. On the contrary, low rainfall figures in the years 2002 and 2020 below the value of 500 mm.

3.4 Relative Humidity (RH)

Annual averages were analysed by daily relative humidity (%) processing.

In the 3 stations (see figure 21, 22, 23) the humidity varies significantly from the year 2000 to 2012 in a range of 65% to 85%, however in the San Juan de Jarpa station the humidity usually rises up to a 90% in 2015 and at Laive station it rises to 94% in 2018. On the other hand, figure 25 shows that the RH distribution is gradually increasing from 74 to 78% over 20 years, in contrast to the Ingenio station (see figure 26) where the values are decreasing from 80-71%, while at the Santa Ana station they are maintained. As for the range of the whiskers, the Ingenio station (see figure 27) has short intervals in the years 2004 to 2010.

Chupaca Province

Figure 21. Whisker Box (RH) Huayao Station

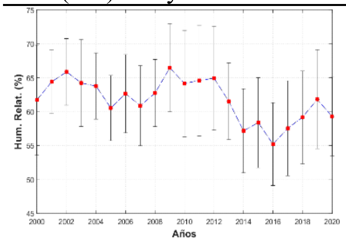


Figure 22. Whisker Box (RH) San Juan de Jarpa Station

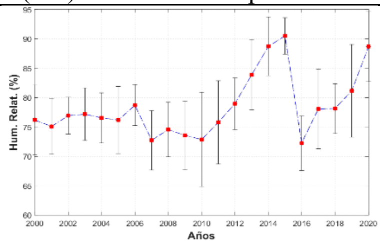
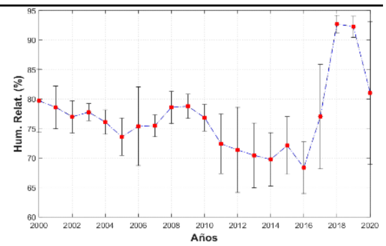


Figure 23. Whisker Box (RH) Laive Station



Huancayo Province

Figure 24. Whisker Box (RH) Santa Ana Station

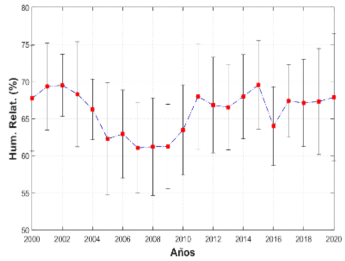
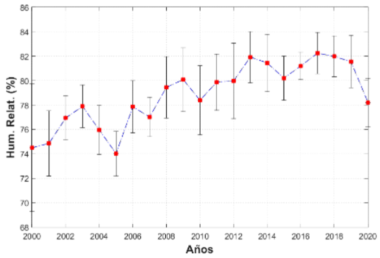
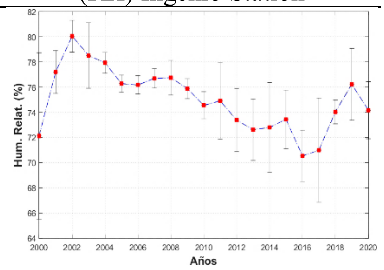


Figure 25. Whisker Box (RH) Viques Station



Concepción Province

Figure 26. Whisker Box (RH) Ingenio Station



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4. Discussion of results

The discussion of the research results will be carried out with a thesis of the 2020 "Behaviour of meteorological variables in the period 2010 to 2020 in the Mantaro Valley" of the Continental University, because it is adjusted to the research but with a shorter time of analysis of the climatic elements. For this reason, it is distributed as follows.

The results of the six weather stations have considered significant trends in the years 2015 and 2016. In 2015 (see figure 27), station D indeed presented high values in humidity percentage of 90%, in the same way in station C and F decreases to an average value of 60% relative humidity. However, for 2016, stations A and D decrease in a range of 60 to 70% (see figure 28).

This change may be due to the atmosphere being saturated, presence of clouds and not reaching a temperature for the evaporation process to be normal. The value from 2010 to 2020 of the only studied station "C" for the Mantaro Valley of the 2020 research work is -0.8 °C, but for the 2016 study it contemplates a value of 9°C for "C", being a response of the heat exchange with the atmosphere, under the altitude that determines the isotherms (see figure 30). The value from 2010 to 2020 of the only studied station "C" for the Mantaro Valley of the 2020 research work is -0.8 °C (see figure 31), but for the 2016 study it contemplates a value of 9°C for "C", being a response of the heat exchange with the atmosphere, under the altitude that determines the isotherms.

According to the stations in the Mantaro Valley, it is in August when rainfall decreases with values well below 500 mm, this is due to the altitude of the Mantaro Valley and its mountainous orography. On the other hand, the month of August is part of the winter season but there is an absence of rainfall and an increase in winds, which explains why the air flow moves the cloud masses in a different direction.

Figure 27. Relative Humidity % (RH) 2015 in the Mantaro Valley

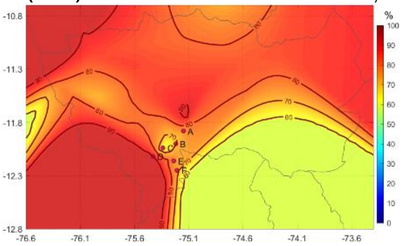


Figure 28. Relative Humidity % (RH) 2016 in the Mantaro Valley

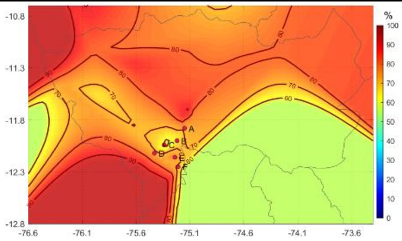


Figure 29. Max temperature °C (TX) 2016 in the Mantaro Valley

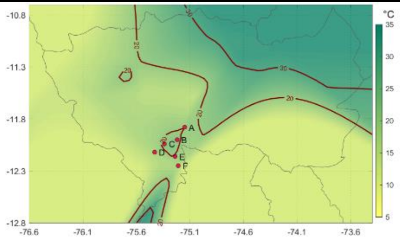


Figure 30. Min °C (TI) temperature 2016 in the Mantaro Valley

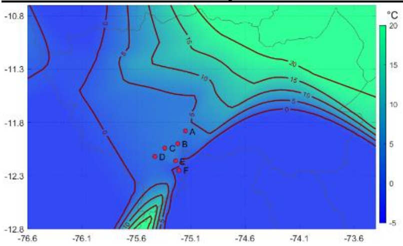


Figure 31. Min °C (TI) temperature 2020 in the Mantaro Valley

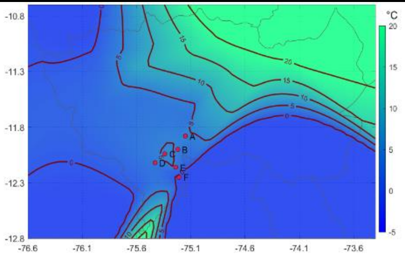
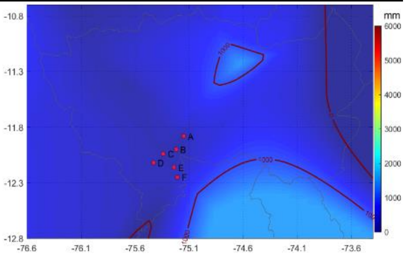


Figure 32. Precipitation mm (RR) Agost in the Mantaro Valley



5. Conclution

The behaviour of the variables analysed resulted in an increase of -0.5°C to 6°C of TI, TX increased the value of the year 2000-2020 with a +6°C and the amplitude of the values of the distribution of the whisker box, regarding RR from the year 2011-2020 the value of 500 mm decreased to 200 mm in the station "F" while the value of RH decreased and was maintained in the station "C-B-A" because there was no significant increase in temperature to heat the air. In this way, the analysed data evidences and reinforces the variation of the climatic system in the values of TX, TI, RR and RH until 2020 in the Mantaro Valley of the department of Junín.

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