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PRECIPITATION GENERATION FOR VARIOUS RETURN PERIODS USING RAIN4PE AND PISCOP V2.1 GRIDDED PRODUCTS IN THE SUPE RIVER BASIN

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SUMMARY

This paper examines the distribution of maximum precipitation of the Supe basin at the return periods of 10, 100, 1000, and 10,000 years using Weibull technique to estimate return time. They compare PISCOp v2.1 and RAIN4PE which are two gridded rain products to evaluate their predictability in terms of extreme precipitation occurrences. These gridded products are compared with the data of the Ambar rainfall station, which is located in the upper part of Supe basin. Findings indicate that the highest values of precipitation using PISCOp v2.1 and RAIN4PE are similar with the highest amount of precipitation at 57.12 mm/day (PISCOp v2.1) and 60.07 mm/day (RAIN4PE) at a 10,000-year return period. These findings were also confirmed by the spatial analysis in ArcGIS and Google Earth Engine, in which the products were verified by means of historical data. The research is valuable to the future hydrological planning as it offers credible terms of precipitation to manage flood risks and water resource planning. The statistical analysis such as the Weibull method and the spatial interpolations (Kriging) show that both gridded products are very helpful in forecasting the rainfall intensities in the area. Nevertheless, PISCOp v2.1 indicates lower precipitation minimum values than RAIN4PE. The results demonstrate the significance of proper forecasting of precipitation in disaster management and planning of infrastructure, especially flood management and river management.

Key words: *supe basin, return periods, PISCOp v2.1, RAIN4PE, maximum precipitation, weibull method, hydrological planning, flood risk management, spatial analysis.*

INTRODUCTION

Currently, due to the phenomenon of climate change, increases in rainfall were observed in various regions of the country, generating a threat to different communities globally. In the case of Peru, the coastal area generally does not experience heavy rainfall; however, since their rivers originate in the high Sierra, where rains are frequent and persistent, they are totally exposed to natural disasters such as floods, landslides (huaicos) and river overflows. It should be noted that, on certain occasions, communities that are rarely affected by these problems may underestimate their severity [1][2].

Figure 1. News of the landslide disaster in supe [1]

In 2017, Supe suffered landslides due to the El Niño phenomenon and despite the fact that there were precedents, the authorities and its own population did not take adequate preventive measures (Figure 1). Causing material damage in the area of sanitation, involving the pipeline that transports water for the population, altering the supply of the benefited sectors [1].

Likewise, INDECI reported that due to the rains suffered in that sector of Peru at the beginning of 2023, several streams were activated that generated landslides, which affected homes, crops, basic services and livelihoods. [2]

Therefore, it is sought to perform a comparative analysis of the distribution of maximum rainfall using the grilled products PISCOp v2.1 and RAIN4PE in the different return times of 10, 100, 1000 and 10000 years in the Supe basin. In this way, the study will be able to contribute to future hydrological studies in support of ideas for preventive measures through the construction of riparian defenses to protect sectors near the river and appease the negative impacts of natural disasters that often occur in Peru [12][3].

In addition, the behavior of the records obtained by the grilled products and with the Ambar rainfall station will be analyzed, which is located in the upper part of Supe near the Peruvian highlands where rains are most frequently present for verification and reliability in planning actions such as construction of hydraulic works.

The rising rate and severity of extreme precipitation as a consequence of the climate change present serious threats to the communities, especially in such areas as the Supe River basin in Peru. Although the regions along the coastline have low rainfall, the rivers that drain the high Sierra mountains are prone to sudden and heavy precipitation which tends to cause disastrous floods, landslides and damage of the infrastructure. Proper modeling of this extreme precipitation is essential in effective management of flood risks as well as to come up with resilient infrastructure. Nevertheless, conventional techniques are prone to not detecting the variability and the magnitude of rare events, and it is imperative to consider new instruments to obtain efficient predictions including high-resolution gridded precipitation products. This paper will fill that gap by utilizing superior approaches to predict extreme rainfall and present actionable information to enhance preparedness and response on improved strategies in hydrological planning.

Key contribution

- Use of Weibull technique in determining the return time of extreme precipitation in Supe basin.

- Comparison of PISCOp v2.1 and RAIN4PE gridded products with detail in relation to the reliability of precipitation prediction products.

- Application of spatial analysis software (ArcGIS, Google Earth Engine) to check and visualize the maximum rainfall intensity at 10, 100, 1000 and 10,000 years return periods.

- Recommendations on future studies in hydrology, flood management and development of infrastructure in the area.

The paper is organized in the following way: Section II describes the literature Review and Section III includes the theoretical framework, which includes the description of the area of the study and methods used. Section IV presents the methodology, including information on extraction and data analysis. The results are provided in section V with the calculation of the time of returns and the distribution of spatial rainfall and the findings and their implications are discussed. Lastly, the study concludes with Section VI, which gives a recommendation on the future research directions.

LITERATURE REVIEW

Various researchers have indicated the growing risk posed by heavy rains as a result of climatic change, especially in flood-limited areas. The study state that the use of statistical models, including the Weibull distribution, has been useful in the prediction of major events in river basins, which provides a basis to comprehend the periods of large rainfall occurrences [5] [14]. Likewise, another study also noted the usefulness of grid-based precipitation products such as PISCOp v2.1 in hydrological predictions as they allow improved spatial-temporal examination of rainfall intensities in Peru [6] [15]. Their results show that these products enhance flood prediction, and they also make climatic studies in the region more efficient.

RAIN4PE has demonstrated potential in the Supe basin to deliver high-resolution and precise precipitation data, and the article describes how it has been used to predict rainfall in various locations throughout Peru and Ecuador [8] [16]. This is in line with the aim of the present study that RAIN4PE and PISCOp v2.1 will be used to compare the return times of extreme precipitation events in the Supe basin [17][18]. With these high-tech gridded products, the analysis will help overcome the problem of very small data coverage, which tends to limit the flood risk evaluation in some locations [19].

In addition, Google Earth Engine (GEE) has become prominent due to the possibility of extracting massive environmental data, as emphasized, which allows making specific analyses of the patterns and trends of precipitation. The current research applies these approaches to confirm the extreme precipitation forecasts and add to the mitigation plan of disasters in the Supe River basin [7][20].

The literature indicates the growing importance of fine-gridded precipitation products such as PISCOp v2.1 and RAIN4PE to provide the proper forecast of precipitation in the flood prone areas. According to previous research, statistical models like the Weibull distribution are useful in estimating the period of extreme events. Expanding on these findings, the present study will enhance both the hydrological modeling and flood risk assessment in the Supe river basin through the enhanced preparedness and infrastructure planning with the help of these tools.

THEORETICAL FRAMEWORK

Project Location. The Supe hydrographic basin is located in the northeast of the Lima region, within the provinces of Barranca and Huara, it is located in zone 18 and has an approximate area of 1008 km2 with a slope of 0.016% on average, this area is included between the UTM coordinates of North 8794000m – 8806000m and East 202000m – 234000m, the main river, which is the Supe River, comprises a length of 92km that begins in the Agushcocha lagoon and ends in the Pacific Ocean (Figure 2).

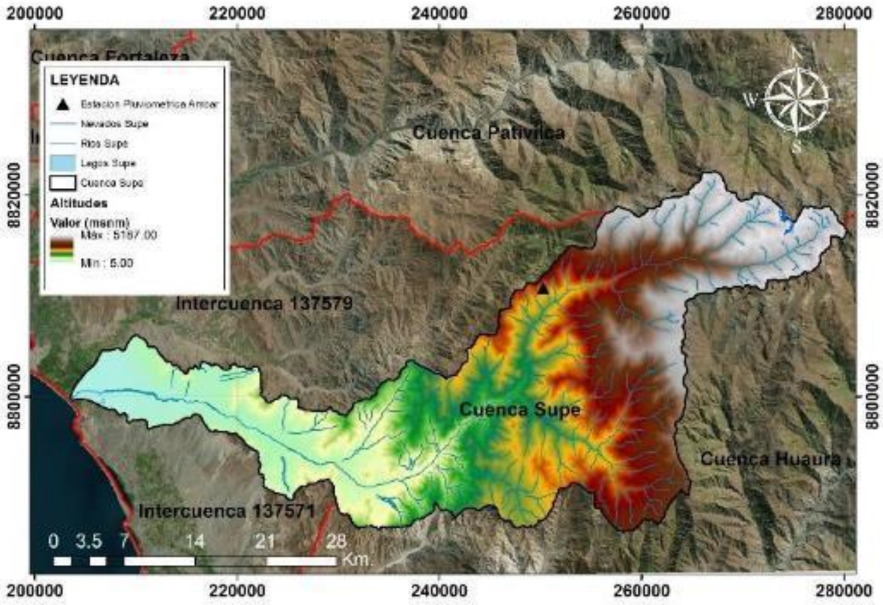


Figure 2. Map of altitudes of the Supe basin

It is a system that makes it easier to collect, organize, manage, analyze, and distribute geographic information around the world [3]. This system can be used by governments, universities, digital media and civil engineers, miners, surveyors, etc. Its use is mainly based on the formation of different maps with certain characteristics, such as topographic maps, slope maps, political maps and analyzing the behavior of rivers around their basin.

Google Earth Engine (GEE). It is a cloud-based geomatics platform that allows users to obtain detailed information on satellite images in which can get data on temperatures, greenhouse gas levels, wind speeds, precipitation levels with a time of more than 40 years [13][4]. The platform is free for students. Data on rainfall in the 1981–2015-year interval will be acquired to calculate return times with the Weibull method.

We're burning. The Weibull extreme value distribution method is a widely used tool for the study of the frequency of exceptional events. Weibull proposed this equation in order to analyze the magnitude of unpredictable events and their respective intervals of recurrence [5]. For the study of frequency periods, the following equation 1 will be used:

Where "n" is the number of years the study has of study and "m" it is the order of classification of the intensities.

In figure. 3 the map of the slopes is observed; this was possible to obtain thanks to the code provided by Mg. Sc. Ing. Abel Carmona that was executed in Google Earth Engine (GEE) with the following coding link: https://code.earthengine.google.com/0acd7ac25f5fda250f8932 6463cd28b7.

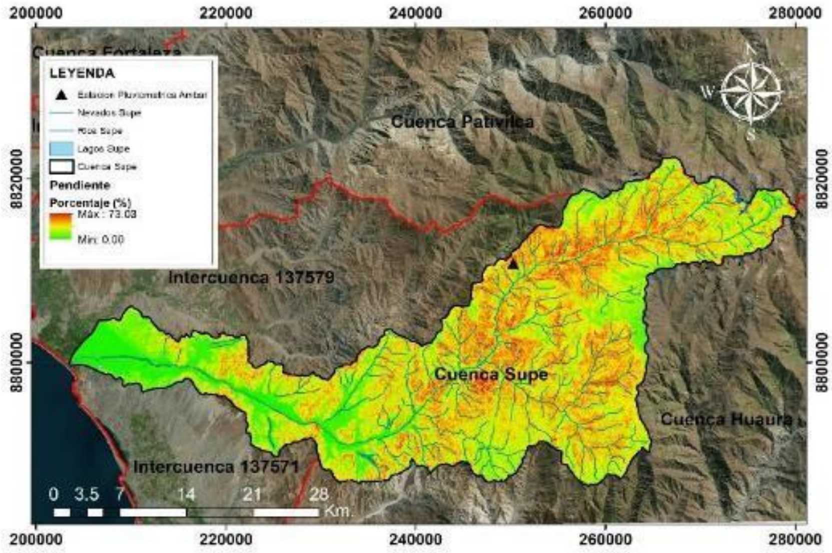


Figure 3. Slope map of the supe basin

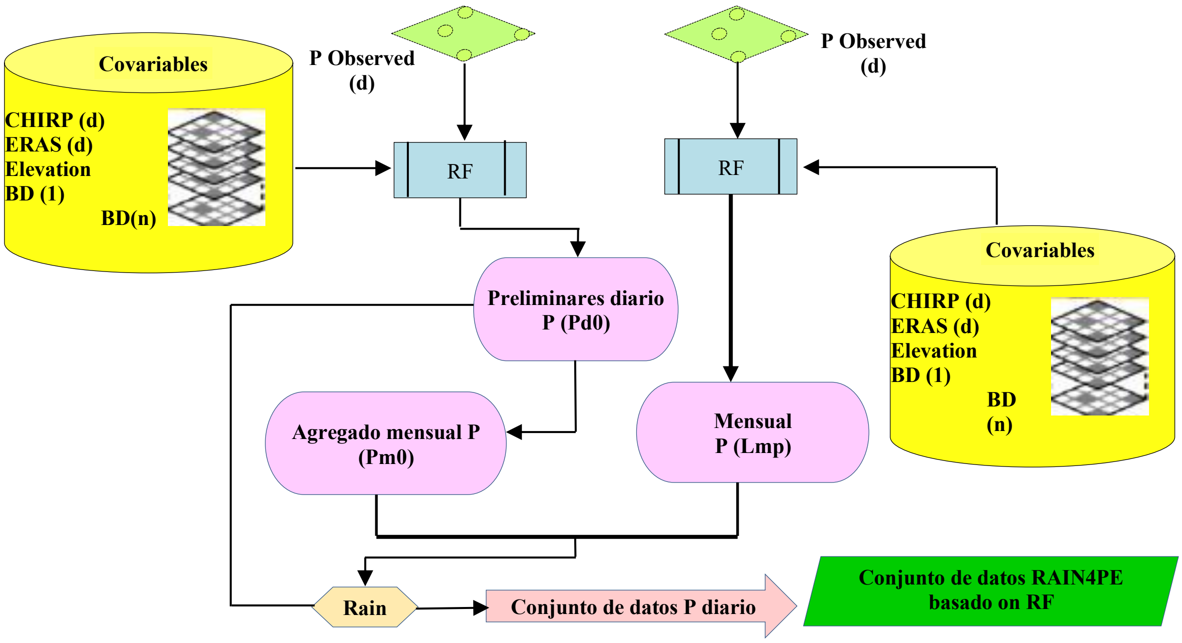
ArcGIS. PISCOp Grilled Product v2.1

This grilled product has a resolution of 10km x 10km obtaining rainfall data throughout Peru in the interval from 1981 to 2016. For the construction of PISCOp v2.1 it was necessary to use the CHIRPS project database as a covariate [6]. It will help to obtain daily rainfall records in each crew. Figure. 4 shows the schematic summary of the development of PISCOp v2.1 [7]

$$T = \frac{n+1}{m} \qquad (1)$$

Grilled Product RAIN4PE

It is a set of information on the daily rainfall that falls on Peru and Ecuador. It is obtained by combining information from CHIRP and ERA5 among others to acquire more accurate values using the random forest regression method [8]. An interesting fact is that reverse hydrology is applied because it begins to work with precipitation data from the basin of analysis, obtaining results that must then be calibrated in another viable source of record. Figure. 4 shows the diagram of the grilled product RAIN4PE.



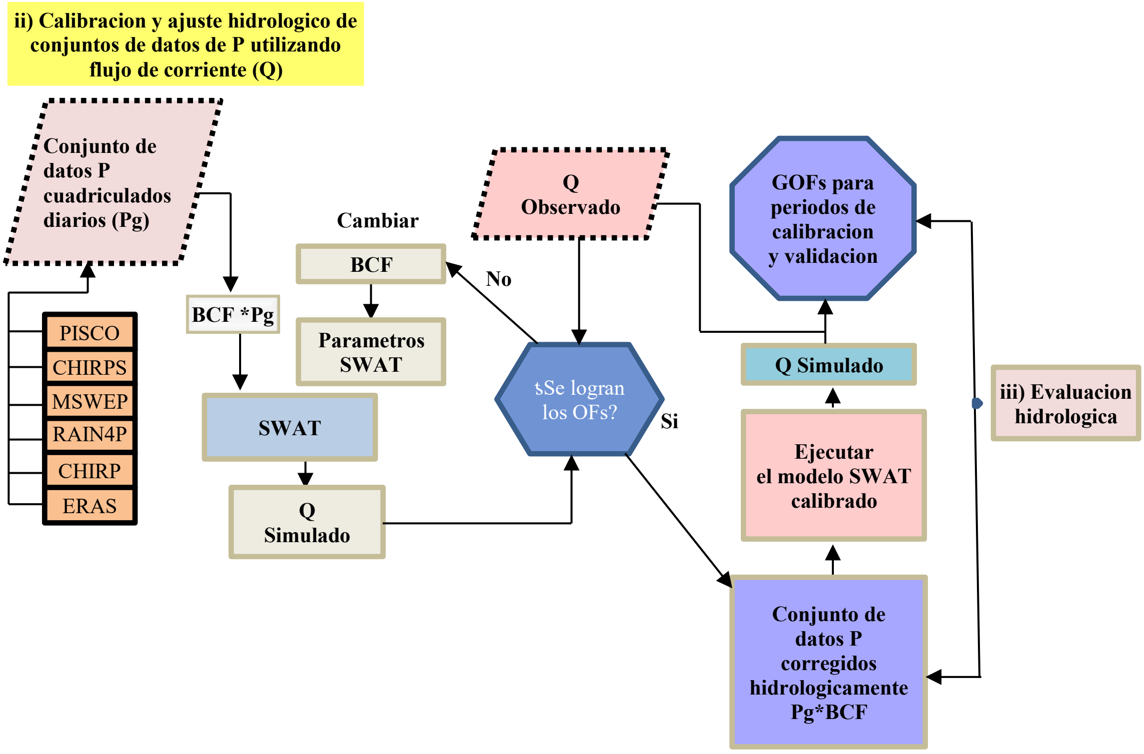


Figure 4. Schematic framework of the RAIN4PE product [7]

SENAMHI. It is the public body in charge of collecting and reporting on meteorological and hydrological data in Peru, as well as managing the stations throughout the country [9]. For this research, the study was able to collect precipitation data at the Ambar station located in the upper basin of the Supe River.

National Water Authority (ANA). It is the governing body and the highest technical-regulatory authority of the National Water Resources Management System, its mission is to administer, conserve and protect the water resources of the different basins, opting for sustainable development and a shared responsibility between the government and society, encouraging the culture of water that recognizes its economic value. social and environmental [10].

METHODOLOGY

In the present study, RAIN4PE gridding in Google Earth Engine was used as a source of rainfall in conjunction with PISCOp v2.1 gridding in ArcGIS software. Both methods with the same coordinates of the points are compared with the Ambar weather station that is located within the Supe basin.

Data Extraction with the Piscop V2.1 Method

Table 1 shows the selection of 38 geographic coordinate points generated for the study analysis of the Supe basin.

To carry out the process, the PISCOp v2.1 gridded product is first inserted into the ArcMap software where pixels of a size 10km x 10km containing rainfall data will be displayed. The study must convert those pixels into points and select those that intervene in and around the study basin for greater precision. These points are imported into another layer and the data is extracted from each one respectively to synthesize with in the Weibull method to obtain the return times of the basin for each coordinate to the ArcGIS program.

Table 1. Geographic coordinates extracted from ARCGIS software for PISCOP v2.1 and rain4pe data

No.	X	And
1	-77.15	-10.55
2	-77.45	-10.65
3	-77.35	-10.65
4	-77.25	-10.65
5	-77.15	-10.65
6	-77.05	-10.65
7	-76.95	-10.65
8	-77.75	-10.75
9	-77.65	-10.75
10	-77.55	-10.75
11	-77.45	-10.75
12	-77.35	-10.75
13	-77.25	-10.75
14	-77.15	-10.75
15	-77.05	-10.75
16	-76.95	-10.75
17	-77.75	-10.85
18	-77.65	-10.85
19	-77.55	-10.85
20	-77.45	-10.85
21	-77.35	-10.85
22	-77.25	-10.85
23	-77.15	-10.85
24	-77.05	-10.85
25	-76.95	-10.85
26	-77.65	-10.95
27	-77.55	-10.95
28	-77.45	-10.95
29	-77.35	-10.95
30	-77.25	-10.95
31	-77.15	-10.95
32	-77.05	-10.95
33	-77.65	-11.05
34	-77.55	-11.05
35	-77.45	-11.05
36	-77.35	-11.05
37	-77.25	-11.05
38	-77.15	-11.05

Data extraction with the RAIN4PE method

The grilled product RAIN4PE through the Google Earth Engine platform was used to extract rainfall data around the geographical coordinates of the points extracted in PISCOp v2.1. They are downloaded in a timely manner in a maximum range of 10 years per chart; therefore, 4-point Excel templates will be downloaded because it only contains data from 1981 to 2015.

Algorithm 1 GEE-Rain4PE Spatial Averaging and Visualization Algorithm

```
// 1. Enter Coordinates

var ROI = ee. Geometry.Point([-79.05, -7.05]);

var start_date = "1981-01-01"; var end_date = "2015-12-31";

// 2. Function to calculate the spatial average. var ppreducer = function(rain4pe) {
```

```
var params = {collection: ROI, reducer: ee. Reducer.mean(), scale: 5000};

var image_value = rain4pe.reduceRegions(params). first ().
get('mean');

var image_date = rain4pe.get ('system: time_start');

var ft = ee. Feature (null, {'system: time start': image_date, 'date': ee. Date(image_date).
format('Y-M-d'), 'value': image_value});

return ft;};

// 3. Create a time series chart.

var rain4pe_data = ee. Image Collection ("projects/satio/open- datasets/rainpe/daily")

var rain4pe_data = rain4pe_daily_data. filterDate (start_date, end_date)

. map(ppreducer); var graph1 = ui. Chart.feature. byFeature (

rain4pe_daily_data. filter Date ("1981-01-01",   "1991-01- 01"). map(ppreducer),

'System: time_start', 'value');

print (graph1.setChartType("ColumnChart")

. set Options ({vAxis: {title: 'PP (mm/dia)'}, hAxis: {title: 'fecha'}}));

var graph2 = ui. Chart.feature. byFeature (rain4pe_daily_data. filter Date ("1991-01-01","2001-01- 01").
map(ppreducer),

'System: time_start', 'value'

); print (graph2.setChartType("ColumnChart")

. set Options ({vAxis: {title: 'PP (mm/dia)'}, hAxis: {title: 'fecha'}}));

var graph3 = ui. Chart.feature. byFeature (rain4pe_daily_data. filterDate ("2001-01-01", "2011-01-

01"). map(ppreducer),'system: time_start', 'value'

); print (graph3.setChartType("ColumnChart")

. set Options ({vAxis: {title: 'PP (mm/dia)'}, hAxis: {title: 'fecha'}}));

var graph4 = ui. Chart.feature. byFeature (rain4pe_daily_data. filterDate ("2011-01-01", "2016-01-
01"). map(ppreducer),

'System: time_start',

'value'); print (graph4.setChartType("ColumnChart")

. set Options ({vAxis: {title: 'PP (mm/dia)'}, hAxis: {title: 'fecha'}}));

// 4. Show image by Rain4pe

vardaily rain= ee.
```

Image("users/ryali93/rainpe/daily/2010_01_25")

var palette = ['000096','0064ff', '00b4ff', '33db80', '9beb4a', 'ffeb00', 'ffb300', 'ff6400', 'eb1e00', 'af0000']; Map.addLayer(daily rain, {min:0, max:80, palette: palette}) Map.centerObject(ROI)

; Map.addLayer(ROI)

The algorithm 1 (using Google Earth Engine (GEE)) extracts and processes the daily rainfall RAIN4PE product with Supe River basin. It starts with the definition of the region of interest (ROI) in geographical coordinates and a certain period of time (1981-2015). Mean reducer is used to calculate the spatial average of rainfall to get a representative value of precipitation. The algorithm creates time series graphs of the various 10-year periods and plots the analyzed information on a map, where the color scale will reflect the level of precipitation. This information is then exported to ArcGIS where it is analyzed and compared.

The Code described is to obtain precipitation extraction for Peru and Ecuador. This coding is shared from here [11].

This platform gives its own data and graphs, but to compare with the other method, it must be represented on maps with the data exported to ArcGIS. This will be presented in the results to be described.

Data Extraction at the Water Observatory (ANA)

The "Ambar" rainfall station was found located in the upper part of the Supe basin. The data is downloaded through the ANA platform, which is available to all Peruvians. The station has coordinates -77.28, -10.75; therefore, seeing the proximity to point N° 13, it presents the coordinates

-77.25, -10.75, so it will be the one indicated to carry out the study with that station. The historical data is from 1980 to 2010, so the previous databases will be adjusted in relation to the Ambar station.

Obtaining Return Times

With data from PISCOp v2.1 and RAIN4PE the maximum annual precipitation (MAP) was found. Once this data is obtained, the frequency is calculated by the Weibull method to obtain the return time (Tr), which is the inverse of the frequency, and finally the Tr must be operated with respect to its logarithm based on

10. Now, to find the PMA of the future return times, a graph will be made where the study will position the Log data (Tr) in the abscissas and on the axis of the ordinates of the PMAs that were initially calculated. These calculations will allow to obtain a line graph with its respective equation 2, which is as follows:

$$y = m(x) + b \qquad (2)$$

Where the variable "m" is the slope and "b" the variable

independent. With these data, the equation replaces the variable "x" by the return time is to be known, and thus its PMA will be obtained for each point.

Finally, the collected LDCs are introduced to ArcMap and interpolated with the Kriging tool to have as a final product a raster with the LDCs of each year ready to be presented in the form of a map.

RESULTS

Calibration

With the databases of the grilled products and that of the Ambar rainfall station, a bar graph was made where the study can observe the rainfall per day. Figure. 5, figure. 6 and figure. 7 show the evidence of the intensity expressed in mm/day obtained from both the PISCOp v2.1 and RAIN4PE grids to be subsequently calibrated with the SENAMHI database, specifically at the Ambar station. Calibration is important because it allows a comparison of the data estimated by coding in software with the real data measured by the National Water Authority to check if there are similarities.

Spatial analysis in this case involves the ArcGIS where the data is extracted, mapped and interpolated (Kriging) to obtain the required precipitation data. The data on rainfall provided in the RAIN4PE gridded product is extracted and processed with the help of Google Earth Engine (GEE) that serves to calculate spatial averages and produce time series charts. Moreover, Excel is applied to the organization and export of data, and Matplotlib is applied to visualization of the results in graphs and charts.

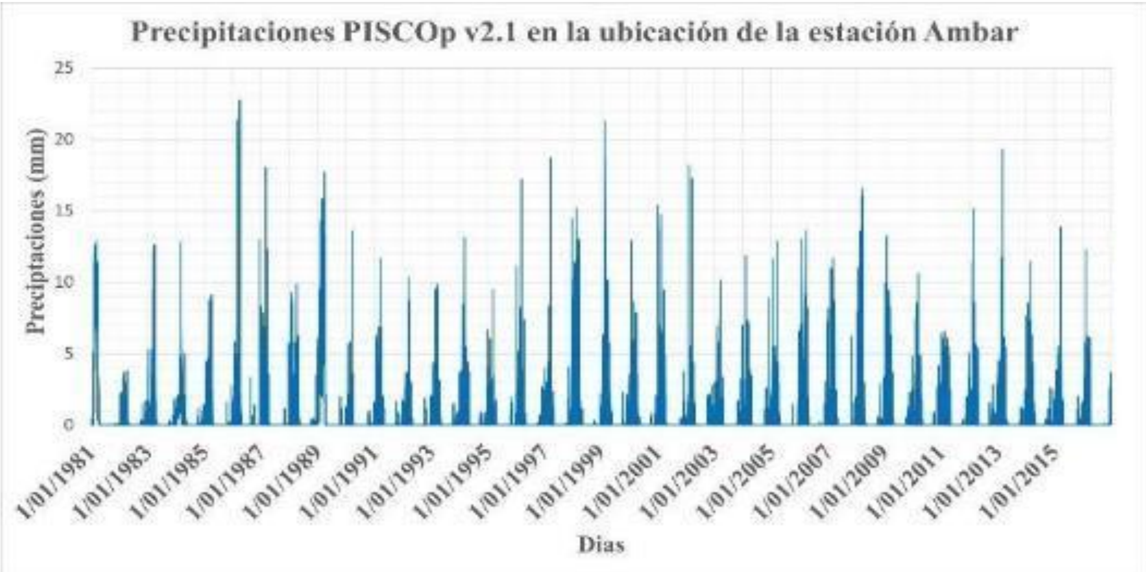


Figure 5. Intensity (mm/day) obtained from PISCOp v2.1

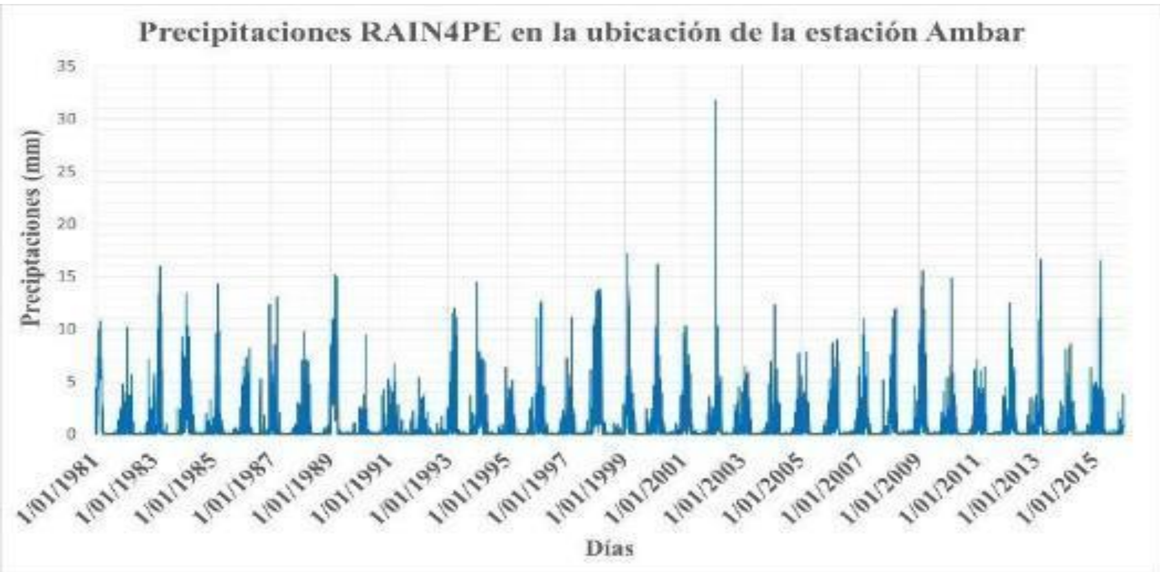


Figure 6. Intensity (mm/day) obtained from RAIN4PE

Figure 7. Intensity (mm/day) obtained from the amber station

From what can be seen in figure 7 is that in the time intervals of 1983-1986 and then 1992-1994 there is no record of data from the Ambar rainfall station; therefore, the study had to remove those data that showed zero and if the study continued to analyze it was going to come up with skyrocketing results out of reality compared to the data records obtained from the PISCOp v2.1 and RAIN4PE grilled products.

Return Times for PISCOp v2.1 and RAIN4PE

The Kriging tool in ArcGIS is used for the PISCOp v2.1 maps and RAIN4PE as shown in figure. 8, figure. 9, figure. 10, figure. 11, figure. 12, figure. 13, figure. 14 and figure. 15, and these are analyzed with a return time in the time intervals of 10, 100, 1000 and 10,000 years, respectively.

Figure. 8 shows the intensity of the return time of 10 years applying PISCOp v2.1, showing that the maximum value of precipitation is 20.59 mm/day, located in the highest part of the basin, and in the part near the Peruvian sea is precipitation with a minimum value of 0.26 mm/day.

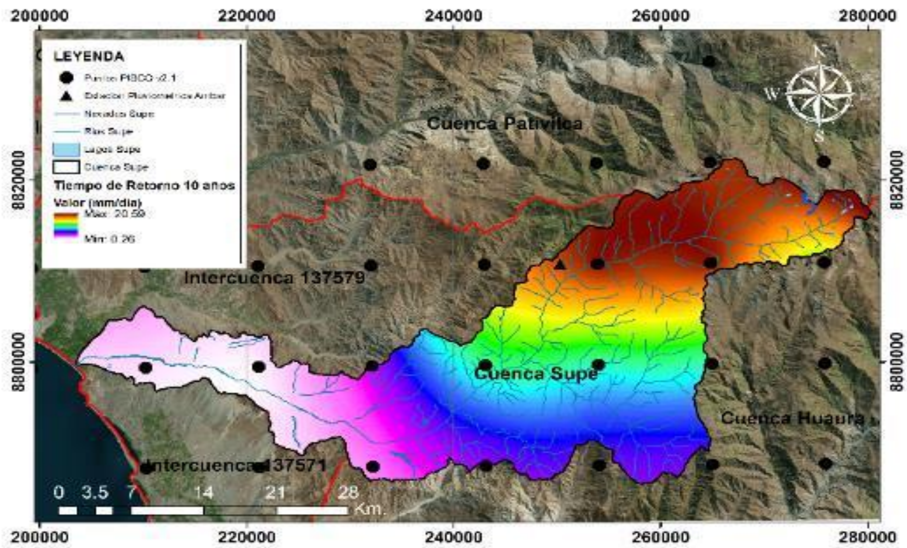


Figure 8. Intensity of the 10-year payback time – PISCOp v2.1

In Figure. 9, RAIN4PE is applied for the return time of 10 years, evidencing the maximum precipitation value of 19.40 mm/day located in the central part of the basin, more close to the Sierra; while, to the southwest it registers 2.60 mm/day.

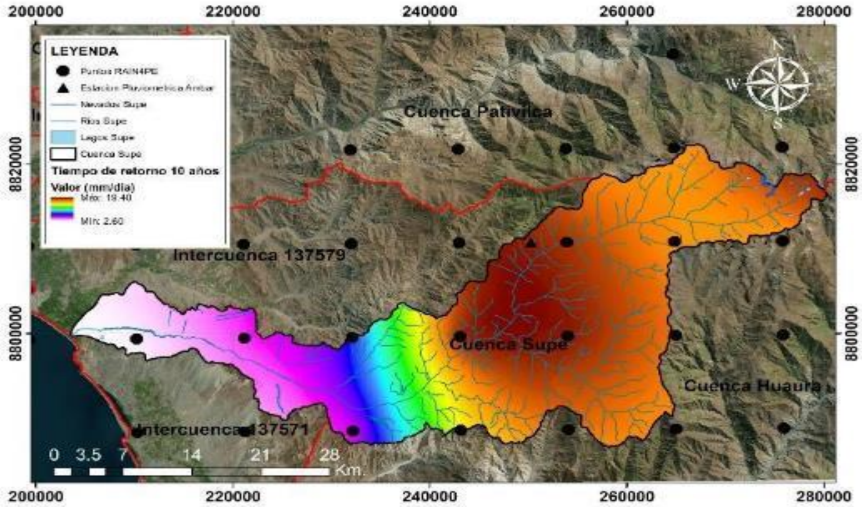


Figure 9. Intensity of the return time 10 years - RAIN4PE

Figures 8 and 9 show that the maximum rainfall values are very similar; however, PISCOp v2.1 is the one with the highest registered value. In the case of minimum rainfall, the opposite happens, although there is little variation, but RAIN4PE is the one that registers the highest value compared to PISCOp v2.1 whose value is very close to 0 mm/day. This may happen because in the areas closest to the Peruvian coast it does not rain more frequently and data on very low rainfall intensities are obtained.

In figure 10, the intensity of the return time of 100 years is shown using PISCOp v2.1 where the maximum value of precipitation is 32.77 mm/day located in the northeast of the basin and in the part near the Peruvian coast is the minimum rainfall yielding a value of 0.41 mm/day.

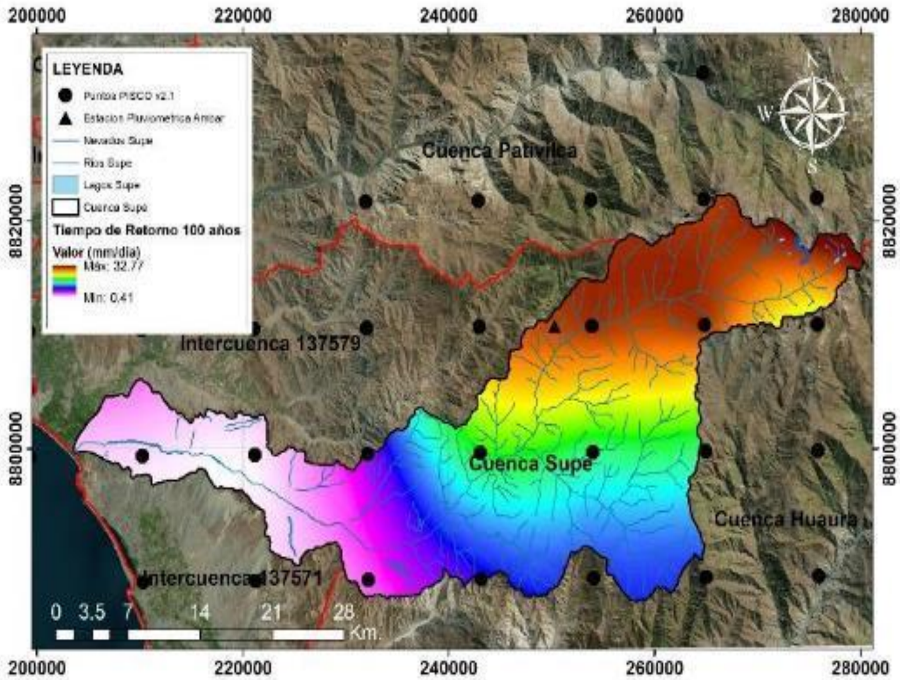


Figure 10. Intensity of the 100-year return time – PISCOp v2.1

In Figure 11, RAIN4PE is applied for the return time of 100 years, evidencing the maximum precipitation value of 32.77 mm/day located in the center of the basin; while to the southwest it registers 0.41 mm/day.

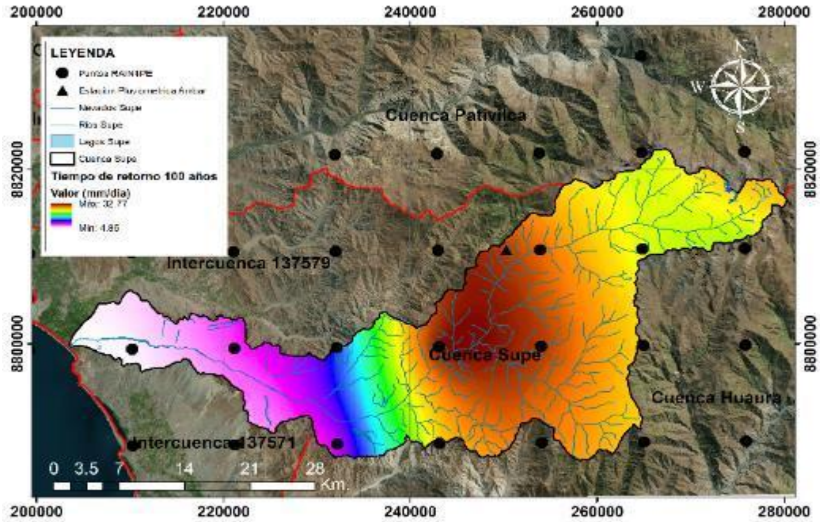


Figure 11. Intensity of the return time 100 years – RAIN4PE

In figures 10 and 11, the maximum value precipitation both PISCOp v2.1 and RAIN4PE have the same result; however, the change is observed in the minimum values. In this case, PISCOp v2.1 is the one with the lowest precipitation value, reaching very close to zero.

In figure. 12, the intensity of the return time of 1000 years is shown by applying PISCOp v2.1 where the maximum value of precipitation is 44.96 mm/day located in the northeast of the basin and in the part near the Peruvian coast is the minimum rainfall with a value of 0.56 mm/day.

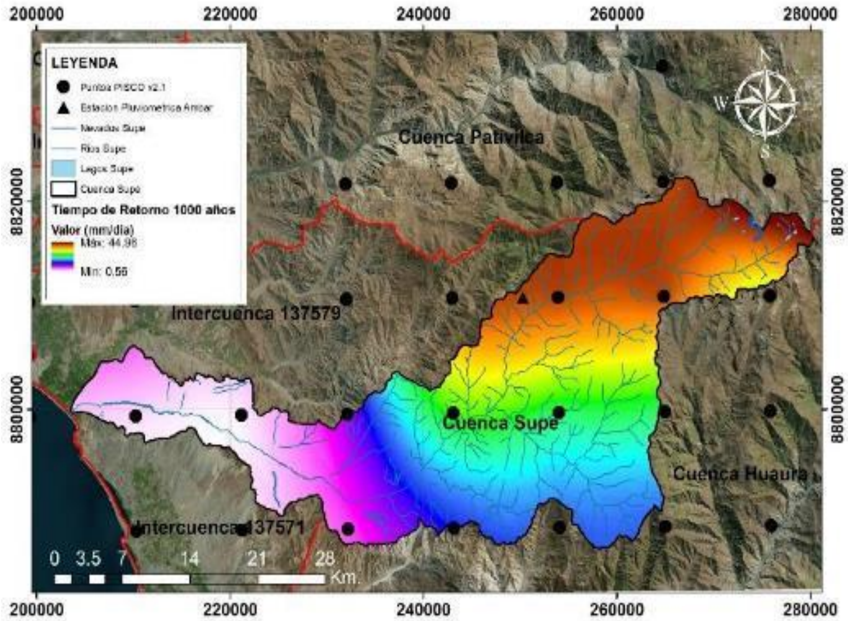


Figure 12. Intensity of the return time 1000 years – PISCOp v2.1

In figure. 13, RAIN4PE is used for the return time of 1000 years, where the maximum precipitation value is 46.39 mm/day located in the central part of the basin; while the southwest registers 7.10 mm/day.

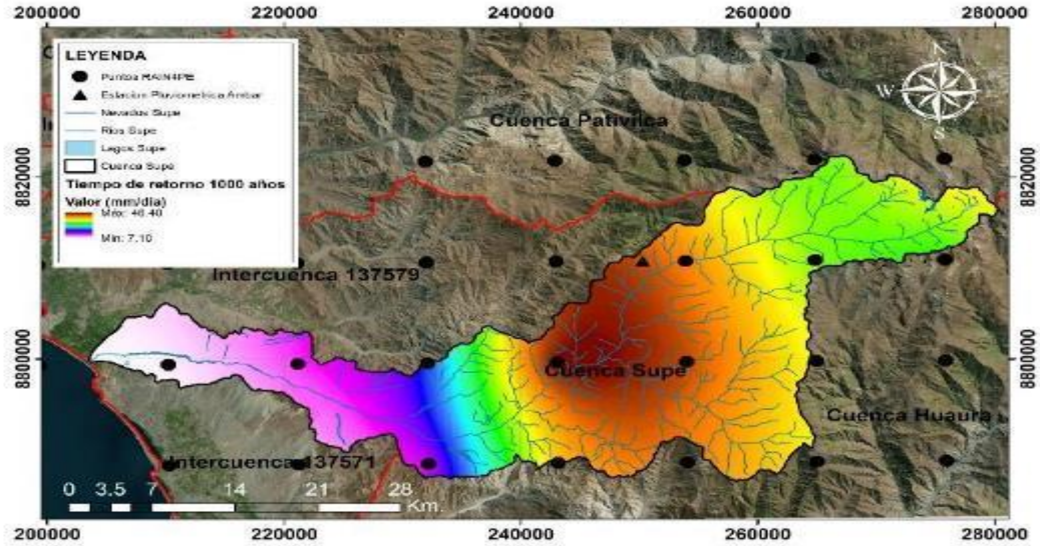


Figure 13. Intensity of the return time 1000 years – RAIN4PE

In figures 12 and 13, the return time recorded for the RAIN4PE data shows greater intensity in the center of the lower Sierra; as for PISCOp v2.1, its maximum intensity is present along the Sierra and not so much in a single sector as in the case of RAIN4PE.

In figure. 14, the intensity of the return time of 10000 years is shown by applying PISCOp v2.1 where the maximum value of precipitation is 57.12 mm/day located in the northeast of the basin and in the part near the Peruvian sea is the minimum rainfall with a value of 0.71 mm/day.

Figures 14 and 15 show that the maps with respect to PISCOp v2.1 keep increasing their intensities in the upper part of the basin and gradually extend to the lower part; However, in RAIN4PE the intensity is maintained in the upper part of the basin, very close to the Sierra Alta and the lagoons, while in the Sierra Baja its intensity increased more, in the return time of 10000 years, but there is something that has to be taken into account that here at that time there will be greater global warming which would generate more rainfall.

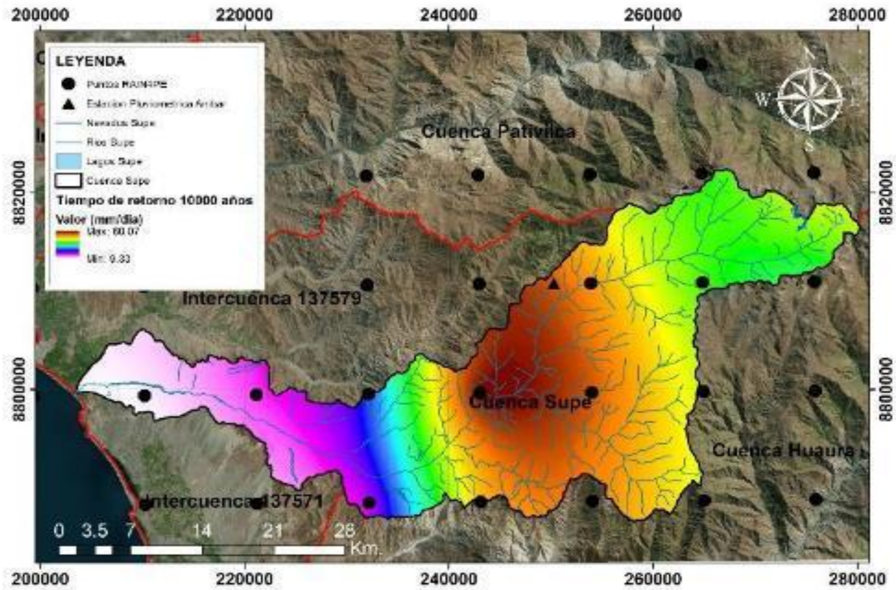


Figure. 14 Intensity of the return time 10000 years - PISCOp v2.1

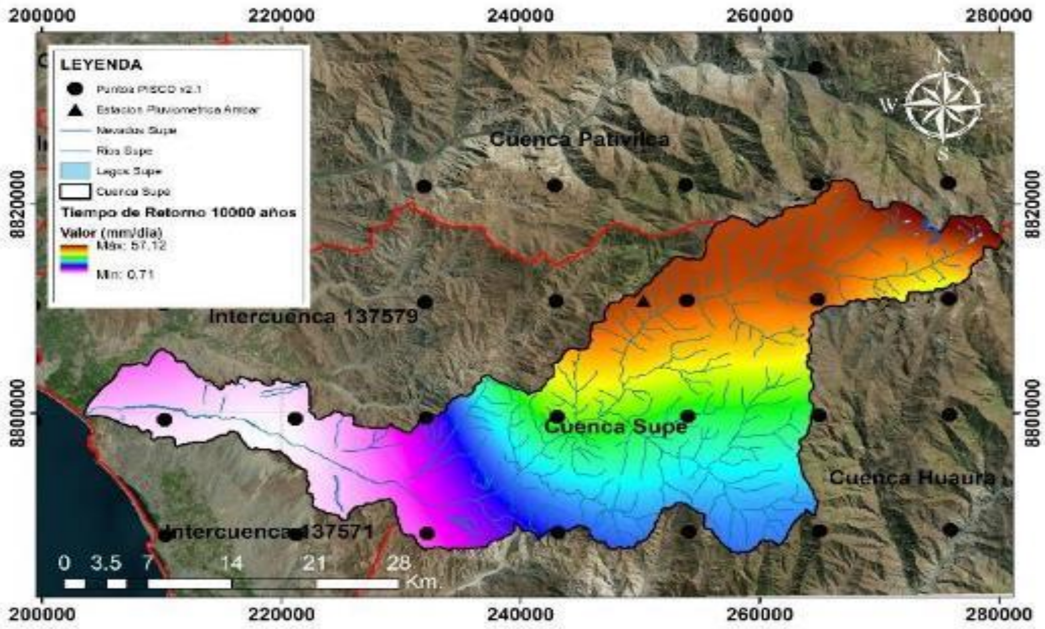


Figure 15. Intensity of the return time 10000 years - RAIN4PE

In addition, it is interpreted that at the mouth of the Supe River it has the lowest intensities because it is the desert; therefore, it will not be necessary to analyze the intensities in detail since the results that will be obtained will be close to zero.

Return Period Summary Table Using PISCOp v2.1 and RAIN4PE for the Supe Basin Area

Table 2 was made to numerically compare the maximum, minimum and average intensities for the PISCOp v2.1 and RAIN4PE grilled products. The data are as follows:

Table 2. Maximum, Average, And Minimum Data for Different Piscop V2.1 And Rain4pe Return Times

TR	PISCOp v2.1 (mm/day)			RAIN4PE (mm/day)		
-	Max.	Prom.	My.	Max.	Prom.	My.
10	20.59	10.43	0.26	19.39	10.99	2.59
100	32.77	16.59	0.41	32.76	18.81	4.85
1000	44.96	22.76	0.56	46.39	26.75	7.10
10000	57.14	28.93	0.71	60.07	34.70	9.33

In figure. 15, RAIN4PE is used for the return time of 10000 years, where the maximum precipitation value is

60.07 mm/day located in the central part of the basin; while to the southwest it registers 9.33 mm/day.

The data are similar with little variation; the differences lie in the fact that the maximum precipitation values in the return times in RAIN4PE in 1000 and 10000 years are higher than in PISCOp v2.1; however, PISCOp v2.1 shows minimum rainfall values.

Return Period Summary Table Comparing Piscop V2.1, RAIN4PE And the Amber Rainfall Station for the Supe Basin Area

Table 3 was made to analyze with point 13 of the Supe basin, whose coordinates are -77.25 and -10.75, in order to compare the intensities of the maximum rainfall in relation to the return times of the study.

Table 3. Results of Piscop V2.1, Rain4pe and Amber for Different Return Times in the Supe Basin

TR	PISCOp v2.1	RAIN4PE	AMBAR
2	12.36	10.83	15.67
5	16.32	15.17	21.86
10	19.32	18.45	26.54
25	23.28	22.78	32.73
50	26.27	26.06	37.41
75	28.03	27.98	40.15
100	29.27	29.35	42.09
500	36.23	36.96	52.97
1000	39.23	40.24	57.65
10000	49.18	51.14	73.20

Annual Maximum Precipitation (MAP) Trend Lines for PISCOp v2.1, RAIN4PE, and Amber

Figure. 16 shows the following graph of trend lines of the PISCOp v2.1 product, RAIN4PE and the Ambar rainfall station.

The results of the analysis at point 13, of coordinates -77.25 and -10.75, show an unusual discrepancy with respect to the Ambar rainfall station as it provides data that does not allow the trend line to be maintained with the grilled products. This greatly influences the maximum precipitation intensity in return times.

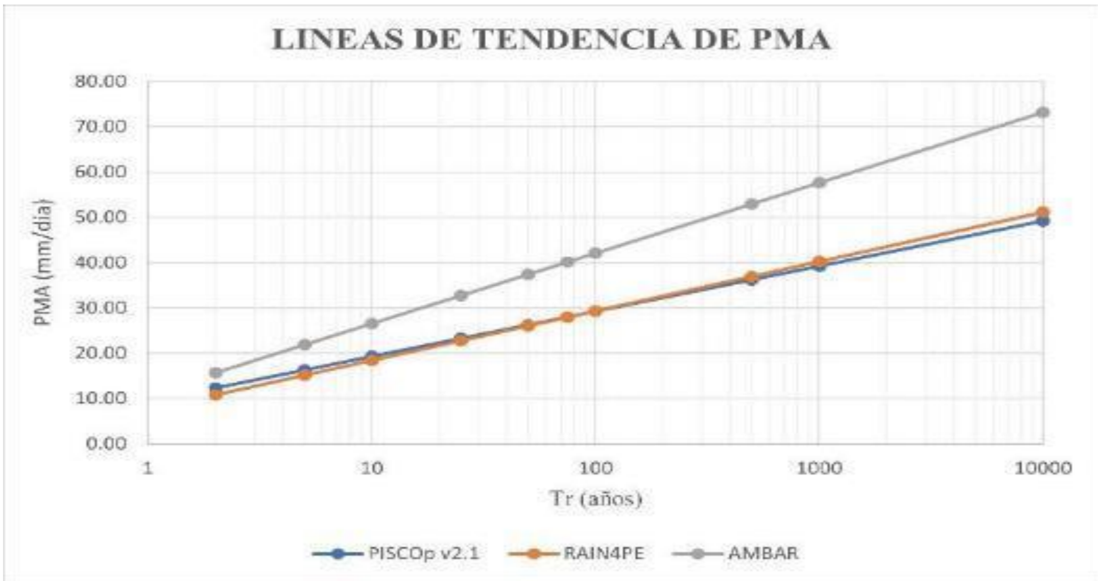


Figure 16. Trend line graph with data from the PISCOp v2.1, RAIN4PE and Amber grilled products

CONCLUSIONS

The purpose of this study was to evaluate the extreme precipitation events in Supe River basin, as well as the return period (return period of 10, 100, 1000, and 10,000 years) of extreme precipitation events using PISCOp v2.1 and RAIN4PE gridded products. The most important results are maximum precipitation amounts of the 10,000 years return period: 57.12 mm/day of PISCOp v2.1 and 60.07 mm/day of RAIN4PE. The statistical testing through the Weibull method proved that the obtained return periods are valid, and they were similar in both products. Kriging interpolation algorithm was able to create some useful data on the spatial pattern of rainfall in the basin in the form of continuous precipitation maps. Comparison of the results of PISCOp v2.1 and the RAIN4PE revealed that both products gave a similar outcome as the highest precipitation but the value of minimum rainfall varied marginally. PISCOp v2.1 had lower minimum values, whereas RAIN4PE had a wider range of rainfall intensities especially at middle and upper parts of Supe basin. This implies that RAIN4PE might provide a finer picture of the precipitation patterns particularly in the regions where rainfall declines and declines are inconsistent. Statistically, the calculations of the return period by the Weibull method were useful in understanding frequency and intensity of extreme rainfall events, which were useful in flood risk assessment and hydrological planning.

Further development of such gridded products should be done in the future with better accuracy in the form of more high-resolution observational data of ground stations. Additionally, machine learning models integration may bolster the forecasting abilities of the extreme precipitation events. Also, exploring the impact of the climate change on rainfall would be essential in long term management of flood and infrastructure planning.

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