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Multivariate Analysis of the Historical Precipitation of Nicaragua, Costa Rica, and Honduras with the Global Historical Precipitation from Worldclim

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Keywords: *worldclim, correlation analysis, multivariate, precipitation, hydrology.*

GJSFR-H Classification: *UDC: 551.58*

MULTIVARIATEANALYSISOFTHEHISTORICALPRECIPITATIONOFNICARAGUACOSTARICAANDHONURASWITHTHEGLOBALHISTORICALPRECIPITATIONFROMWORLDCLIM

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Summary- The present investigation includes the analysis of the correlation of the variable historical precipitation of the Nicaraguan airport station, the El Indio coffee plantation station, San Vito-Puntarenas in Costa Rica, and the Amapala station in Honduras versus the historical precipitation of global data from WorldClim, based on of the multivariate correlation analysis technique. The research questions are formulated in relation to the correlation of historical precipitation data at three different points in the Central American region versus the WorldClim global precipitation database, and that these can be used to perform specific hydrological analyzes at lack of them. As a result, four possible combinations were produced, where Y were the global WorldClim data, the data from the Nicaragua station, then the data from the Costa Rica station and finally the data from the Honduras station, determining R2 correlations of the order of 0.98, 0.98, 0.99 and 0.95 respectively, this goodness-of-fit correlation indicates that there is a lot of precision, demonstrating that the data from WorldClim or from another station in the Central American region can be used from the calculated coefficients to perform hydrological studies in the absence of information.

Keywords: worldclim, correlation analysis, multivariate, precipitation, hydrology.

I. Introduction

In order to be certain of the simultaneous effects of several variables, multivariate statistical methods are used to analyze the behavior of the set of different random variables. The main objective of the multivariate analysis is highly variable in relation to what we want to achieve with them, which raises the different scenarios that explain the objective of the multivariate analysis.

In this sense, there are some applications of multivariate analysis for hydrometeorological factors, such as (Soley & Alfaro, 1999) proposes multivariate analysis methods that by the year 1999, were being applied in the Geophysical Research Center in the projects of study of climatic variability, and names three methods: principal component analysis, singular value decomposition, and the canonical correlation method. (Soley & Alfaro, 1999) in their scientific publication, conclude that, despite the fact that the precipitation fields of the Pacific and the Caribbean are climatologically different, the anomalies could show similar behaviors when affected by large-scale processes.

It can be mentioned that (Entrajes, Varni, Gandini, & Usunoff, 1996) carried out a research work based on the analysis of principal components (PCA), of homogeneous regions of precipitation in the area of the Arroyo del Azul basin (6237 km2), which is located in the center of the province of Bs. As., Arg. The identification of these regions allowed researchers, among other applications, their inclusion in hydrological models of water flow (surface and groundwater), and in the agroecological regionalization of the area.

As a result (Entrajes, Varni, Gandini, & Usunoff, 1996), determined from the analysis of data from 12 stations from the period 1985-1994, two components were selected that, together, consider more than 89% of the variance. total contained in the original data. Precipitation being a continuous spatial function, and that the principal components derived from them are also continuous and, therefore, the load distribution maps express the association between the precipitation at each point in the basin and that registered at the hypothetical station. What does each principal component represent?

The main objective of this research work is to analyze the correlation of the historical precipitation variable of three stations located in Nicaragua, Costa Rica and Honduras, with the global historical precipitation data from WorlClim, implementing multivariable statistical methods to answer the following question.: Will historical precipitation data for Nicaragua, Costa Rica, and Honduras be correlated with WorldClim global historical data, and can WorldClim global historical data be used for a timely hydrological analysis in the absence of that?

II. Objectives

a) General Objective

Analyze the correlation of the historical precipitation variable of Nicaragua, Costa Rica, and

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Honduras with the global historical precipitation of WorldClim.

III. Especifics Objectives

Detail historical precipitation data for each area of interest, as well as global data.

Develop the multivariable correlation model between the precipitation data of each area of interest with the global data.

Examine the influence of global precipitation data in the studied area of interest.

IV. Methodological design

a) *Kind of Investigation*

The present work was designed under the methodological approach of the quantitative approach, since this is the one that best adapts to the characteristics and needs of the present investigation.

The quantitative approach uses data collection and analysis to answer research questions and test previously established hypotheses, and translates into: "the sequential and probative. Each stage precedes the next and we cannot "jump" or avoid steps. The order is rigorous, although of course, we can redefine some phase. It starts from an idea that is being delimited and, once defined, objectives and research questions are derived, the literature is reviewed and a theoretical framework or perspective is built. From the questions hypotheses are established and variables are determined; a plan is drawn up to test them (design); variables are measured in a certain context; the measurements obtained using statistical methods are analyzed, and a series of conclusions regarding the hypothesis or hypotheses are drawn". (Sampieri, Fernández Collado, & Baptista, 2014. Page 5).

The observation technique was taken from the quantitative approach, the database information is collected and can be quantified. Data collection is done through quantitative observation, since it allows quantifying the behavior of precipitation over time.

b) *Execution Time*

In the development of the research work, there were three months, of which one month to obtain the precipitation data of a series from 1960 to 2021 global climate of WorldClim, one month to process the data from different sites of study interest. at the regional level, and one month to obtain and write the final report, in the period from April to June 2023.

c) *Data Collection Technique and Method*

By downloading high-resolution global weather-climate data of precipitation, for mapping using the WorldClim spatial model. The data is used for mapping and spatial modeling. Since the data is provided for use in research and related activities.

By obtaining precipitation data from the INETER database, from the airport station, Managua Nicaragua.

By obtaining precipitation data from the database of the National Meteorological Institute of Costa Rica.

By obtaining precipitation data from the database of the Center for Atmospheric, Oceanographic and Seismic Studies.

Microsoft Excel will be used, since it brings together the statistical applications used for this study.

i. *Primary Sources*

WorldClim Portal, Global Climate and Weather Data: Historical Climate Data, Historical Monthly Weather Data for Precipitation.

Portal of the Nicaraguan Institute of Territorial Studies, historical monthly precipitation data.

Portal of the National Meteorological Institute of Costa Rica, historical monthly precipitation data.

Portal of the Center for Atmospheric, Oceanographic and Seismic Studies of Honduras, historical monthly precipitation data.

ii. *Secundary Sources*

Scientific articles related to the use of multivariable statistical methods.

Bibliography related to multivariate statistics.

Library of the Nicaraguan Institute of Territorial Studies of Nicaragua (INETER), meteorology department.

d) *Universe*

Regional precipitation data for Nicaragua, Costa Rica, Honduras, and global precipitation data fromWorldClim.

e) *Population*

The precipitation database for the Aeropuerto station in Nicaragua, the El Indio coffee station, San Vito-Puntarenas in Costa Rica, and the Amapala station in Honduras, as well as the precipitation database for the Central American region.

f) *Sample*

Airport station precipitation database for the period 1958-2020 in Nicaragua, El Indio coffee station precipitation database, San Vito-Puntarenas for the period 1968-2020 in Costa Rica, Amapala precipitation database in the period of 1952-2020 in Honduras, and database of global precipitation in the period of 1960-2021 of Worlclim.

g) *Inclusion Criteria*

We worked with precipitation data in raster format from regional WorldClim in Central America, precipitation data measured from the Nicaraguan airport station, precipitation data measured from the El Indio coffee station, San Vito-Puntarena in Costa Rica, and precipitation data measured from the Amapala station in Honduras.

Global Journal of Science Frontier Research (H) Volume XXIII Issue III Version I Year 2023

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h) Exclusion Criteria

All those precipitation data that are not measured from the stations: airport in Nicaragua, El Indio coffee plantation, San Vito-Puntarena in Costa Rica, and Amapala in Honduras, and that are not studied in the 1958-2020 ranges, 1968-2020, 1952-2020 and 1960-2021 established by each station respectively.

V. Theoretical Aspects

There are many definitions of multivariate statistics, according to the complexity of the problem, there are techniques that range from the simplest to the most complex. There is no single definition, therefore, the definition in which the study carried out in this investigation is most accurately adapted will be used.

According to (García, 2021), defines multivariate statistics as different methods that study and examine the simultaneous effect of multiple variables. (García, 2021) also describes that multivariate methods are used to analyze the behavior of the set of more than one random variable.

There is a wide multivariate technique used for the analysis of multiple data, and they are available in various statistical studies, some of which will be mentioned.

a) Matrix Chart

This Matrix Graph technique, (García, 2021) states that in this technique it is used to show the pairs of X-Y graphs of a set of quantitative variables. It is an excellent technique if it is required to detect pairs of highly correlated variables, and it can also detect cases with outliers.

b) Correlation Analysis

(García, 2021), on this occasion he defines in his blog, that it is a process of correlation analysis and its objective is to summarize two or more columns of numerical data. Calculate summary statistics for each variable, as well as the correlation and covariance between the two.

c) Spider Diagram

Taking (García, 2021) as a reference, he defines this technique as a spider diagram that is also known as a radar graph, it is used to show the values of various quantitative variables depending on the situation.

Then there is the *Factorial Analysis* technique (García, 2021), he defines it as the analysis that produces a linear combination of multiple quantitative variables, these variables represent the highest percentage of variation. These types of analyzes are used to narrow the scope of the problem in order to better understand the factors that affect the variables studied.

d) Logistic Regression Analysis

(García, 2021), states that the logistic regression analysis, is also known as a selection model, is a multiple regression variable that allows predicting events and studies the influence of two types of variables on each other: dependent variables and non-dependent variables. The first is an explanatory variable, while the second is a non-explanatory variable. The first variable describes the current state of the database, and the second interprets the data through the dependency between two variables. (García, 2021) ensures that it is a technique that helps predict the choices that consumers can make when choosing alternatives.

Finally, not the last, but if one of the most important, you have the *Linear Discriminant Analysis,* (García, 2021), describes that it is a technique that was designed to help distinguish two or more sets of data based on a set of quantitative variables. This is achieved by establishing a discriminant function or linear combination of variables.

To mention a few more, there is *Correspondence Analysis, Multidimensional Scaling, and Canonical Correlation.*

The multivariate analysis technique is based on optimizing the data or simplifying the structure of the data, ordering and grouping the data, investigating the dependency relationship between variables, predictive relationship between variables, construction and testing of hypotheses. And it is from here that logistic regression analysis has been identified as the most important technique.

VI. Results

According to the preparation of the data, certain years are discriminated until measurement homogeneity is reached in the same year. In this case, the analysis is carried out from 1968 to 2020, which is where the data is complete in a homogeneous manner. See table 1:

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Table 1: Cumulative, Global and Station presentation data for Nicaragua, Costa Rica and Honduras

Year	WorldClim	Estation NIC	EstationCR	Estation H
	Accumulated	Accumulated	Accumulated	Accumulated
1968	2371.86	1266.60	1271.6	1401.90
1969	2571.41	1368.50	2297	1458.30
1970	2517.08	1082.00	1714.2	1294.80
1971	2043.23	1293.40	1803.3	1231.60
1972	2021.77	669.70	1000.5	847.00
1973	2327.46	1742.90	1617.6	1299.10
1974	2137.27	868.80	1358.8	1092.60
1975	2168.22	1365.00	1374.2	1175.20
1976	2013.26	744.40	1025.7	896.40
1977	1918.44	812.70	1124.4	926.60
1978	2297.52	1008.10	1417.8	1024.70
1979	2563.92	1058.70	2410.1	1507.10
1980	2466.21	1376.00	1831.1	1468.00
1981	2623.52	1306.10	1721.9	1535.10
1982	2280.63	1354.40	1590.5	1331.00
1983	2189.58	806.70	1237	933.10
1984	2385.22	1151.90	1600.8	1036.20
1985	1994.12	1251.90	1136.2	1010.10
1986	1955.51	780.20	1530.2	1132.80
1987	1975.43	1102.80	905.2	977.70
1988	2474.85	1679.60	2117.3	1898.80
1989	2171.58	785.20	1163.4	1059.40
1990	2266.09	755.80	1040.2	1111.70
1991	2052.21	980.50	1039.4	788.80
1992	2196.25	704.80	1143.5	921.40
1993	2281.27	1420.00	1533.4	1456.70
1994	1908.26	1018.90	851.9	891.80
1995	2400.96	1360.20	2061.2	1715.10
1996	2372.41	1608.60	1601.9	1655.20
1997	2193.98	862.40	1246.6	1096.40
1998	2342.17	1565.00	1891.5	1933.70
1999	2295.39	1253.90	1815.4	1130.50
2000	2133.99	957.10	1317.1	1005.10
2001	2149.15	862.00	1289.6	814.70
2002	2163.02	1224.60	1208.6	1227.80
2003	2179.96	1229.60	1672.2	1089.50
2004	2271.23	819.20	1512.5	1065.20
2005	2307.87	1395.10	2086.8	1589.10
2006	2423.60	683.30	993.5	1042.50
2007	2184.45	1411.90	1830.3	1556.00

Global Journal of Science Frontier Research (H) Volume XXIII Issue III Version I Year 2023

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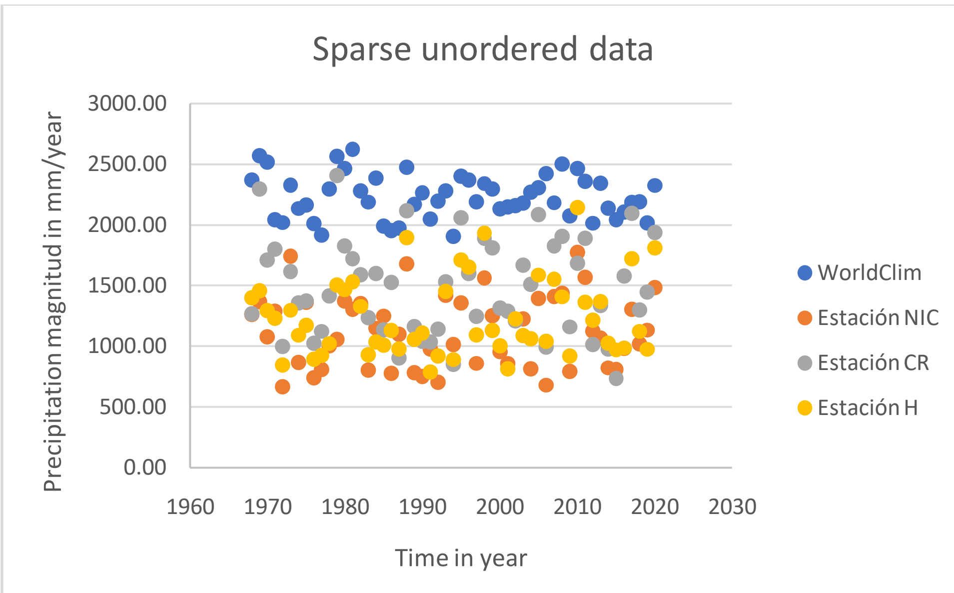
2008	2500.90	1439.50	1907.6	1410.20
2009	2078.57	796.10	1162	921.60
2010	2466.79	1775.90	1684.6	2146.80
2011	2359.83	1569.70	1892.8	1364.80
2012	2016.52	1126.00	1017.7	1215.70
2013	2346.10	1070.40	1339.4	1369.70
2014	2138.03	825.60	980.4	1027.60
2015	2044.55	813.80	736.3	971.30
2016	2109.52	986.10	1581.2	986.90
2017	2185.27	1309.00	2096.2	1722.20
2018	2192.44	1022.90	1301.1	1124.70
2019	2021.07	1136.20	1448	976.90
2020	2326.52	1484.60	1939.4	1811.70

Source: (CENAOS, 2023), (DatosMundial, 2023), (INETER, 2023), (WorldClim, 2023)



Note: figure created from the database

Figure 1: Behavior of Precipitation Data Over Time Without Manipulation

From the data, from a series of 53 data, we continue to order them from lowest to highest and the correlation analysis technique is implemented, see Table 2.

Table 2: Sorted database

Year	WorldClim	Estation NIC	EstationCR	Estation H
	Accumulated	Accumulated	Accumulated	Accumulated
1	2021.77	806.70	736.3	986.90
2	2043.23	812.70	851.9	1005.10
3	2044.55	813.80	905.2	1010.10
4	2052.21	819.20	980.4	1024.70
5	2052.70	824.20	993.5	1027.60
6	2078.57	825.60	1000.5	1036.20
7	2083.28	862.00	1017.7	1042.50
8	2109.52	862.40	1025.7	1059.40
9	2133.99	868.80	1039.4	1062.80

Global Journal of Science Frontier Research (H) Volume XXIII Issue III Version I Year 2023

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10	2137.27	878.20	1040.2	1065.20
11	2138.03	957.10	1124.4	1089.50
12	2149.15	964.80	1136.2	1091.80
13	2163.02	980.50	1143.5	1092.60
14	2168.22	986.10	1162	1096.40
15	2171.58	1008.10	1163.4	1111.70
16	2179.96	1018.90	1208.6	1116.40
17	2184.45	1022.90	1237	1124.70
18	2185.27	1058.70	1246.6	1130.50
19	2189.58	1070.40	1271.6	1132.80
20	2192.41	1082.00	1289.6	1136.70
21	2192.44	1102.80	1301.1	1139.80
22	2193.08	1126.00	1317.1	1156.70
23	2193.98	1136.20	1339.4	1175.20
24	2196.25	1151.90	1358.8	1215.70
25	2202.48	1209.80	1374.2	1227.80
26	2266.09	1224.60	1417.8	1231.60
27	2271.23	1229.60	1448	1294.80
28	2280.63	1251.90	1512.5	1299.10
29	2281.27	1253.90	1530.2	1319.30
30	2295.39	1266.60	1533.4	1331.00
31	2297.52	1293.40	1581.2	1364.80
32	2307.87	1306.10	1590.5	1365.00
33	2321.65	1309.00	1600.8	1369.70
34	2326.52	1320.10	1601.9	1401.90
35	2327.46	1354.40	1617.6	1410.20
36	2342.17	1360.20	1672.2	1422.10
37	2346.10	1365.00	1684.6	1456.70
38	2351.24	1368.50	1714.2	1458.30
39	2359.83	1376.00	1721.9	1468.00
40	2371.86	1383.60	1803.3	1507.10
41	2372.41	1395.10	1815.4	1530.60
42	2385.22	1411.90	1830.3	1535.10
43	2400.96	1420.00	1831.1	1556.00
44	2423.60	1420.50	1891.5	1589.10
45	2457.28	1437.60	1892.8	1638.90
46	2466.21	1439.50	1907.6	1644.10
47	2466.79	1484.60	1939.4	1655.20
48	2474.85	1565.00	2061.2	1715.10
49	2500.90	1569.70	2086.8	1722.20
50	2517.08	1608.60	2096.2	1811.70
51	2524.46	1679.60	2117.3	1898.80
52	2563.92	1742.90	2297	1933.70
53	2571.41	1775.90	2410.1	2146.80

Source: (CENAOS, 2023), (DatosMundial, 2023), (INETER, 2023), (WorldClim, 2023)

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The statistical analysis of correlation is conjugated from the variable Y as the dependent variable in this case the WorldClim data versus three independent variables in this case the data from the stations in Nicaragua, Costa Rica and Honduras. Itstarts from the following equation 1, see table 3.

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 \quad \text{equation 1}$$

Where:

Y = WorldClim dependent variable
b_0, b_1, b_2 = multipliers or correlation coefficient
X_1, X_2, X_3 = independent variables.

Table 3: Result of the combination of AND as Dependent Data WorldClim

Regression Statistics	
Multiple correlation coefficient	0.992616997
Determination coefficient R ^ 2	0.985288502
R ^ 2 adjusted	0.984387798
Typical error	18.51376303
Observations	53
Coefficients	
Interception	1692.141097
Variable X 1	0.070414031
Variable X 2	0.292750521
Variable X 3	0.045092026

Note: application of expression 1, the data was processed in Microsoft Excel

In case two, the hypothesis of variables dependent on the data from the Nicaragua station is proposed, and the other databases as independent data. See table 4.

Where:

Y = dependent variable Station Nicaragua
b_0, b_1, b_2 = multipliers or correlation coefficient
X_1, X_2, X_3 = independent variables.

Table 4: Result of the Combination of Y as Dependent data Station Nicaragua

Regression Statistics	
Multiplecorrelationcoefficient	0.99080164
Determinationcoefficient R ^ 2	0.9816879
R ^ 2 adjusted	0.98056675
Typical error	36.6662142
Observations	53
Coefficients	
Interception	-212.430625
Variable X 1	0.27618618
Variable X 2	0.61337983
Variable X 3	-0.08863901

Note: application of expression 1, the data was processed in Microsoft Excel

In case three, the hypothesis of dependent variables is proposed, the data from the Costa Rica station, and the other databases as independent data. See table 5.

Where:

Y = dependent variable Station Costa Rica
b_0, b_1, b_2 = multipliers or correlation coefficient
X_1, X_2, X_3 = independent variables.

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Table 5: Result of the Combination of AND as Dependent Data Station Costa Rica

Regression Statistics	
Multiple correlation coefficient	0.996108937
Determination coefficient R^2	0.992233015
R^2 adjusted	0.991757485
Typical error	36.11292278
Observations	53
Coefficients	
Interception	-2136.585477
Variable X 1	0.595007754
Variable X 2	1.113867553
Variable X 3	0.279408289

Note: application of expression 1, the data was processed in Microsoft Excel

The last case proposes the hypothesis of variables dependent on the data from the Honduras station, and the other databases as independent data. See table 6.

Where:

Y = dependent variable Station Costa Rica

b_0, b_1, b_2 = multipliers or correlation coefficient

X_1, X_2, X_3 = independent variables.

Table 6: Result of the Combination of AND as Dependent Data Station Honduras

Regression Statistics	
Multiple correlation coefficient	0.980746102
Determination coefficient R^2	0.961862916
R^2 adjusted	0.959527993
Typical error	55.7493155
Observations	53
Coefficients	
Interception	-338.2848118
Variable X 1	0.408873935
Variable X 2	-0.204914086
Variable X 3	0.665875578

Note: application of expression 1, the data was processed in Microsoft Excel

Four possible combinations were produced, making Y the global data from WorldClim, the precipitation data from the Nicaragua station, the precipitation data from the Costa Rica station, and the precipitation data from the Honduras station, for each of the combinations made, an R2 correlation was obtained. fitted around 0.98, 0.98, 0.99, and 0.95 respectively, indicating a very precisely corrected measure of goodness-of-fit and that the model is collectively explained by all independent variables.

Regarding the typical error, a variation is observed for each of the combinations, which have the following magnitudes 18.51, 36.66, 36.11 and 55.74, this tells us how well the studied data fit, reaching a maximum value when deviating from the mean of the sample analyzed with respect to the mean of the total population.

Figures 2, 3, 4 and 5 can be seen to see the correlation trend.

Global Journal of Science Frontier Research (H) Volume XXIII Issue III Version I Year 2023

60

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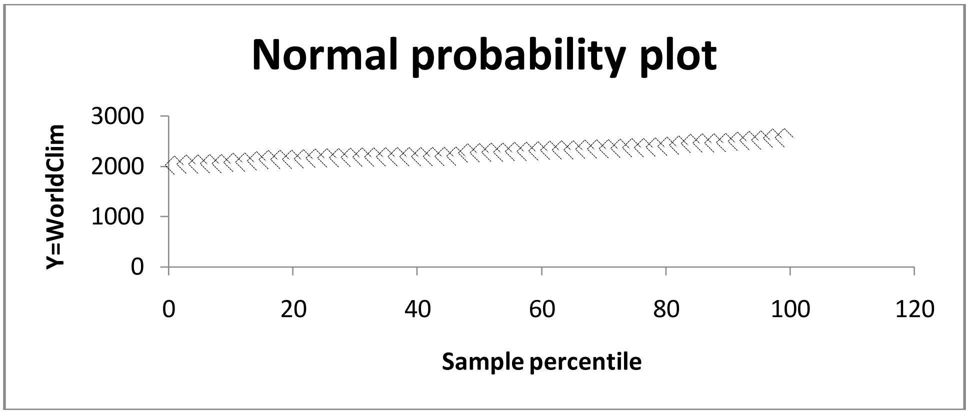
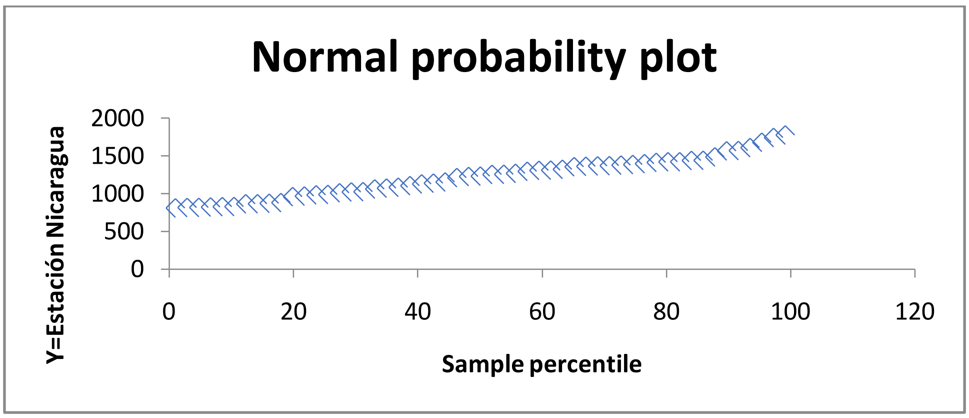


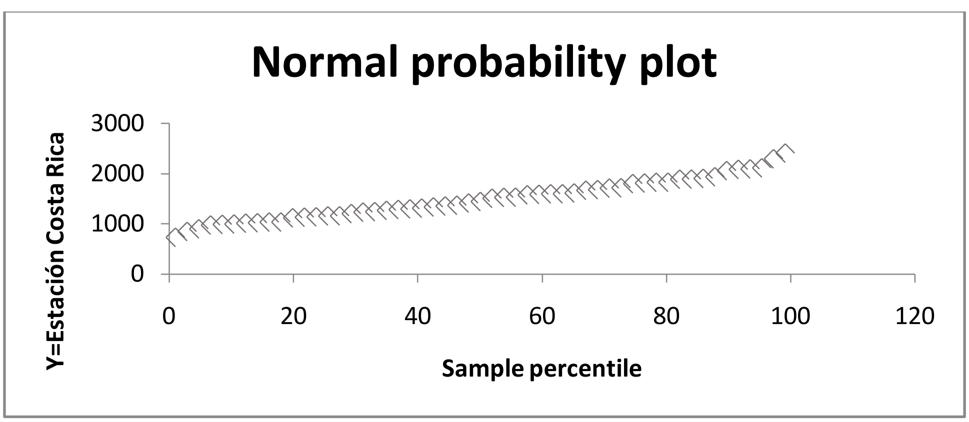
Note: Own Elaboration Obtained from the Modeling in Microsoft Excel

Figure 2: Behavior of the trend with the variable Y worldClim



Note: Own Elaboration Obtained from the Modeling in Microsoft Excel

Figure 3: Behavior of the Trend with the Variable Y Station Nicaragua



Note: Own Elaboration Obtained from the Modeling in Microsoft Excel

Figure 4: Behavior of the Trend with the Variable Y Station Costa Rica.

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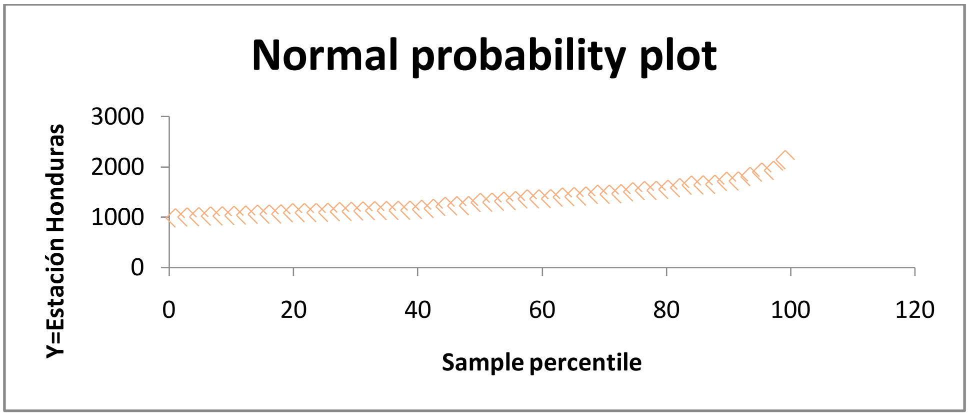

Note: Own Elaboration Obtained from the Modeling in Microsoft Excel

Figure 5: Behavior of the Trend with the Variable Y Station Honduras

The normal probability graphs for each of the combinations represent the behavior trend, its trend is linear. No variable momentum is observed that makes the data unscattered and maintains a strong correlation.

VII. Conclusion

The analysis of the correlation of the historical precipitation variables of Nicaragua, Costa Rica, Honduras versus the global historical precipitation of WorldClim, produced four possible combinations using the multivariate statistical analysis technique of correlation analysis, where Y were the global data of WorldClim, the Nicaragua station data, the Costa Rica station data, and the Honduras station data, with correlation magnitudes of R2 098, 0.98, 0.99, and 0.95, respectively.

According to the results, the goodness-of-fit correlation measure indicates a lot of precision in the different combinations, and that the model is collectively explained by all the independent variables, being able to use the global historical data from WorldClim with two other random stations to to be able to carry out a punctual hydrological analysis in the absence of information.

Gratitude

First of all, to God, our father, who has given me a hand to continue on the right path and achieve my goals.

To my mother Beatriz Picado, for showing me the way to success.

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Bibliography

1. CENAOS. (27 de 07 de 2023). *Centro de Estudios Atmosféricos, Oceanográficos y Sísmicos*. Obtenido de http://cenaos.copeco.gob.hn/
2. DatosMundial. (27 de 07 de 2023). *DatosMundial*. Obtenido de https://www.datosmundial.com/ america/costa-rica/clima.php
3. Entraigas, I., Varni, M., Gandini, M., & Usunoff, E. (1996). Aplicación del análisis multivariado en el definción de regiones homogéneas de precipitación. *CONGRESSO ARGENTINO DE METEORLOGIA*, 115-116.
4. García, M. (03 de septiembre de 2021). *Crehana*. Obtenido de https://www.crehana.com/blog/ transformacion-digital/analisis-multivariado/
5. INETER. (27 de 07 de 2023). *INETER*. Obtenido de https://www.ineter.gob.ni/
6. Sampieri, H., Fernández Collado, C., & Baptista, L. (2014). *Metodología de la Investigación.* México D.F.: McGraw-Hill/Interamericana Editores, S.A. de C.V.
7. Soley, F. J., & Alfaro, E. J. (1999). Aplicación de análisis multivariado al campo de anomalías de precipitación en Centroamperica. *Topicos Meteorológicos y Oceonograficos*, 1-23.
8. WorldClim. (27 de 07 de 2023). *WorldClim*. Obtenido de https://www.worldclim.org/data/index.html.

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