Comparison and interpretation of solarimetric station data (diffuse solar radiation, UVB radiation, temperature, and relative humidity) from January 2017 to November 2018 in Zacatecas

Comparación e interpretación de los datos de la estación solarimétrica (radiación solar difusa, radiación UVB, temperatura y humedad relativa) del periodo enero 2017 a noviembre 2018 en Zacatecas

BERLANGA-MORENO, Edgar Darío†, GARCÍA-GONZÁLEZ, Juan Manuel*, GONZÁLEZ-CABRERA, Adriana Elizabeth and VILLEGAS-MARTÍNEZ, Rodrigo Cervando

Universidad Autónoma de Zacatecas. Unidad Académica de Ciencias Químicas Universidad Nacional Autónoma de México. Instituto de Geofísica.

ID 1st Author: *Edgar Dario, Berlanga-Moreno* / **ORC ID:** 0009-0002-2026-3644

ID 1st Co-author: *Juan Manuel, García-González* / **ORC ID:** 0000-0001-7259-5021, **CVU CONAHCYT ID:** 346241

ID 2nd Co-author: *Adriana Elizabeth, González-Cabrera* / **ORC ID:** 0000-0003-2802-6811

ID 3rd Co-author: *Rodrigo Cervando, Villegas-Martínez* / **ORC ID:** 0000-0003-0474-6734

DOI: 10.35429/EJT.2023.13.7.32.38 Received March 22, 2023; Accepted June 11, 2023

Abstract

In this research work, the data from the solarimetric station in Zacatecas during the period from January 2017 to November 2018 are compared and interpreted. The main objective is to analyze the climate and solar radiation characteristics in the region and identify possible correlations between variables. The methodology involved data collection using the solarimetric station and data processing in Excel. Hourly,daily, and monthly averages were calculated for diffuse solar radiation, UVB radiation, temperature, and relative humidity. In addition, graphs were generated using Excel,and two R codes were developed: one to obtain correlations among the analyzed variables and another to visualize the UVB index. This study provides a detailed analysis of climate data and solar radiation patterns in Zacatecas. The obtained results are relevant for the design and implementation of solar energy systems in the region and in areas with similar climatic conditions. In summary, this study compares and interprets the datafrom the solarimetric station in Zacatecas, aiming tounderstand the climate and solar radiation characteristics. The conducted analyses contribute to the development ofsolar energy strategies in Zacatecas and similar regions. solar radiation, climate analysis, Zacatecas.

Solar Radiation, Climate, Correlations

Resumen

En este trabajo de investigación, se comparan e interpretan los datos de la estación solarimétrica de Zacatecas del periodo de enero 2017 a noviembre 2018. El objetivo principal es analizar las características del clima y la radiación solar en la región, para identificar posibles correlaciones entre variables. La metodología se basó en la recopilación de datos mediante la estación solarimétrica y procesamiento en Excel. Se calcularon promedios horarios, diarios y mensuales de la radiación solar difusa, la radiación UVB,la temperatura y la humedad relativa. Además, se generaron gráficos utilizando Excel y se desarrollaron dos códigos en R: uno para obtener correlaciones entre las variables analizadas y otro para visualizar el índice UVB. Este trabajo ofrece un análisis detallado de los datos climáticos y patrones de radiación solar en Zacatecas. Los resultados obtenidos son relevantes para el diseño y la implementación de sistemas de energía solar en laregión y en áreas con condiciones climáticas similares. En resumen, este estudio compara e interpreta los datos de la estación solarimétrica de Zacatecas, con el objetivo de comprender las características del clima y la radiación solar. Los análisis realizados contribuyen al desarrollo de estrategias de energía solar en Zacatecas y regiones similares.

Radiación Solar, Clima, Correlaciones

Citation: BERLANGA-MORENO, Edgar Darío, GARCÍA-GONZÁLEZ, Juan Manuel, GONZÁLEZ-CABRERA, Adriana Elizabeth and VILLEGAS-MARTÍNEZ, Rodrigo Cervando. Comparison and interpretation of solarimetric station data (diffuse solar radiation, UVB radiation, temperature, and relative humidity) from January 2017 to November 2018 in Zacatecas. ECORFAN Journal-Taiwan. 2023. 7-13: 32-38

* Author's Correspondence (e-mail: jmgarcia@uaz.edu.mx)
† Researcher contributing as first author.

Introduction

In this research, a comprehensive comparative and interpretative analysis of the data collected at the solarimetric station located in Zacatecas during the period from January 2017 to November 2018 is carried out. The fundamental purpose of this study is to discern the complex characteristics of climate and solar radiation in that region, with a special focus on exploring possible correlations between the variables analysed.

A thorough understanding of the climatic conditions and solar radiation in a specific locality is of paramount importance in view of its profound impact on multiple sectors, such as agriculture, renewable energy and public health. This analysis encompasses a holistic perspective by integrating multiple climatic variables, thus surpassing other one-dimensional techniques that are limited to solar radiation or a single climatic aspect.

This study delves clearly and precisely into each of the characteristics under investigation, examining in detail the temporal and spatial variability of diffuse solar radiation, UVB radiation, temperature and relative humidity, with the aim of identifying patterns and interdependent relationships between them.

The problem addressed in this research focuses on the study of the interconnections between the various climatic variables analysed. Our central hypothesis postulates the existence of significant correlations between these variables. Therefore, through the careful analysis and interpretation of the data collected, we seek to validate or refute this hypothesis, which will lead to a better understanding of the intricate relationship between climate and solar radiation in this specific region.

The structure of the paper is organised into carefully delineated sections, which provide a thorough and rigorous exposition of the results and conclusions obtained. Through this methodical approach, we aim to provide new knowledge that can be applied to the development of solar energy strategies both in Zacatecas and in other regions that share the same characteristics as well as in other regions sharing similar climatic characteristics.

Solarimetric station

A solarimetric station is an infrastructure used to measure solar radiation at a given location. These stations measure various parameters related to solar radiation, such as global solar radiation, direct solar radiation and diffuse solar radiation. In Mexico, several solarimetric stations have been installed in different parts of the country as part of a network of stations that is part of the Consorcio Centro Mexicano de Innovación en Energía Solar, coordinated by UNAM through the Instituto de Energías Renovables and financed by the Ministry of Energy. These stations make it possible to evaluate the potential of solar energy in different regions of the country and are an important tool for the study of climate change and the development of renewable energy projects.

Variables analysed

Diffuse radiation: Diffuse radiation is a component of solar radiation that is scattered in the atmosphere and reaches the earth's surface in all directions. Unlike direct radiation, which comes from the sun in a straight line, diffuse radiation is reflected by clouds, air and other surfaces before reaching the earth's surface. [I].

Ultraviolet B radiation: Ultraviolet B radiation (UVB) is a type of electromagnetic radiation present in sunlight. Unlike UVA radiation, UVB radiation has a shorter wavelength and is largely absorbed by the ozone layer before reaching the earth's surface. Excessive exposure to UVB radiation can have detrimental health effects such as sunburn, premature skin ageing and skin cancer. It is essential to take precautions to protect against UVB radiation, such as applying sunscreen, wearing protective clothing and avoiding prolonged exposure to the sun during peak hours of solar radiation [II], [III].

Ambient temperature: Ambient temperature refers to the temperature of the air surrounding a specific object or location.

It represents the amount of thermal energy present in the air in a given area and can vary according to various factors, such as time of day, season, geographic location and environmental conditions. This temperature has significant impacts on living beings and structures, such as pavements, as well as on the structural behaviour of roads.

ISSN 2524-2121
ECORFAN® All rights reserved

In addition, ambient temperature can influence the blood pressure of animals, including dogs. In certain cases, the increase in ambient temperature may be related to the greenhouse effect phenomenon, both natural and anthropogenic, which may have adverse consequences for the environment and human health [IV], [V], [VI].

Relative humidity: Relative humidity is defined as the proportion of water vapour present in the air relative to the maximum amount it could contain at a specific temperature. It is expressed as a percentage and is used to characterise the sensation of humidity in the atmosphere. In the field of meteorology, relative humidity plays a key role as it can influence cloud formation, precipitation and thermal perception. In addition, relative humidity can affect various materials [VII].

Methodology to be developed

The methodology used in this research was based on a rigorous and precise scientific approach to the analysis of the data collected from the solarimetric station in Zacatecas. In order to examine and understand the characteristics of climate and solar radiation in the region, a series of steps were followed and specialised instruments and software were employed. These elements allowed for a detailed analysis and meaningful interpretation of the data, which contributed to the Mexican solarimetric network.

Data collection: Data collection from the solarimetric station in Zacatecas was carried out during the period from January 2017 to November 2018. These data comprised measurements of diffuse solar radiation, UVB radiation, temperature and relative humidity.

Data transfer and organisation: The collected data were transferred to Excel spreadsheets, where they were organised and prepared for further analysis. Columns were created for the variables of interest and data were entered accurately.

Calculation of temporal averages: Using the capabilities of Excel, hourly, daily and monthly averages were calculated for each of the variables analysed. These averages provided an overview of the temporal patterns and trends of the variables studied and were subsequently plotted in the same software.

Data visualisation: after data analysis and interpretation, graphs and tables were produced in Excel. These analyses provided a visual representation of the data and allowed a preliminary assessment of the characteristics of climate and solar radiation in the study region.

Use of R for advanced statistical analyses: The R programming language was used to carry out more advanced statistical analyses. Two different codes were developed in R: one to calculate correlations between the variables studied and another to generate customised UVB index graphs, using colours to highlight different levels of intensity.

Interpretation of results: The results obtained from the data analysis were interpreted and critically analysed. Patterns, trends and significant relationships between the variables studied were identified, and relevant comparisons and conclusions were made about the characteristics of climate and solar radiation in the Zacatecas region

Results

Month	Diffuse radiation W/m^2		Radiation UVB MED/h		Temperature°C		Relative humidity%	
	highest value	Day	highest valu	Day	highest valu	Day	highest value	Day
January	488.32	22	3.30	29	18.00	4	97.57	8
February	274.88	8	4.05	28	18.48	11	63.59	19
March	594.47	19	4.40	29	19.72	22	71.41	9
April	309.55	6	4.64	30	21.21	22	46.72	12
May	291.90	18	4.64	7	23.78	27	52.84	30
June	287.74	10	4.68	27	23.54	17	72.97	27
July	303.26	2	4.51	19	20.50	31	81.09	13
August	312.84	18	4.45	11	20.87	5	86.85	31
September	276.19	2	4.55	9	19.54	16	89.35	6
October	263.03	10	3.89	3	18.45	22	84.66	4
November	238.67	31	2.93	1	19.86	8	66.23	1
December	207.93	14	2.43	13	17.71		89.70	18, 24

Table 1 Months and days with the highest values of diffuse radiation, UVB radiation, ambient temperature and relative humidity in 2017
Own Elaboration

Table 1 shows the day with the highest value for each month of 2017 for each of the variables analysed. It can be seen that the diffuse radiation values for each month do not coincide with the number of days for the other properties measured. It can also be seen that on the 18th day of May and August the diffuse radiation was the highest of those two months, with the 19th of July being the day with the highest UVB radiation and the 22nd of March, April and October with the highest temperatures of each month respectively, finally the month of December had two days 18 and 24 with the same relative humidity which were the highest of the month.

ECORFAN® All rights reserved

June, 2023 Vol.7 No.13 32-38

Month	Diffuse radiation W/m²		Radiation UVB MED/h		Temperature °C		Relative humidity %	
	highest value	Day	highest valu	Day	highest valu	Day	highest valu	Day
January	251.60	31	2.78	30	14.20	9	88.15	29
February	242.43	7	3.66	24	18.09	16	84.37	9
March	194.43	2	4.35	15	20.55	26	50.15	30
April	540.78	12	4.44	29	20.45	26	59.22	11
May	304.65	13	4.45	19	25.93	31	70.18	7
June	295.53	21	4.30	16	24.07	1	82.19	13
July	307.62	30	4.07	17	22.10	25	72.30	10
August	265.45	6	4.25	2	19.84	18,24	87.03	13
September	436.95	30	4.17	28	18.80	5	95.31	12
October	502.20	3	3.77	9	18.73	13	86.61	21
November	241.49	1	2.89	3	14.15	2	52.14	2

Table 2 Months and days with the highest values of diffuse radiation, UVB radiation, ambient temperature and relative humidity in 2018, prepared by the authors

Table 2 shows the day with the highest value for each month in 2018. It is noticeable that the diffuse radiation values for each month do not coincide in the number of days of the other properties measured, as in 2017. It can also be seen that on the 30th day of the months July and September the diffuse radiation was the highest of those two months, and on the 18th and 24th day of the month the diffuse radiation was the highest of those two months

Month	Radiation diffuse (W/m²)	Relative humidity (%)	UVVB	Temperature (°C)
January	179.04	39.05	4	12.54
February	90.39	30.94	4	14.14
March	211.37	34.16	5	15.89
April	148.61	24.27	5	17.86
May	141.93	39.05	5	12.54
June	162.83	25.75	5	20.74
July	193.67	64.52	4	17.70
August	174.82	61.17	4	18.57
September	168.56	71.65	4	17.84
October	106.56	60.74	4	17.16
November	62.55	37.49	3	15.94
December	114.70	48.56	3	11.93

Table 3 Monthly average of the year 2017 of diffuse radiation, relative humidity uvb index and temperature
Own Elaboration

Month	Diffuse radiation (W/m²)	Relative Humidity (%)	UVVB	Temperature (°C)
January	101.47	42.92	3	11.77
February	145.77	49.84	4	14.56
March	86.74	24.98	5	17.57
April	143.78	28.71	3	18.18
May	133.49	42.92	3	11.77
June	162.57	39.85	2	18.06
July	174.32	54.26	2	18.57
August	155.91	59.81	2	18.07
September	185.86	76.31	3	17.67
October	161.07	68.76	4	15.88
November	159.30	55.68	2	13.72

Table 4 Monthly average of the year 2017 of diffuse radiation, relative humidity uvb index and temperature
Own Elaboration

Tables 3 and 4 show the monthly averages of diffuse radiation, relative humidity, UVV index and temperature for different months of the year. Table 1 shows that diffuse radiation has the highest values in January, March, June, July and August, while the months with the lowest diffuse radiation are February, April, May, October, November and December. Relative humidity is highest in September and lowest in April. The UVB index remains constant at 4 for most of the year, while in March and April it is 5. The highest average temperatures are recorded in June and the lowest in January.

On the other hand, table 4 shows that scattered radiation has higher values in February, September and October, while the months with the lowest scattered radiation are March, April and November. Relative humidity is highest in September and lowest in March. The UVB index has a value of 3 in March, April, July, August and November, while in the rest of the months it has a value of 2 or 4. The highest average temperature is observed in August and the lowest in November.

Thus, both tables provide valuable information on the monthly changes of the measured parameters in 2017 and 2018. These data can be used for a more detailed and comprehensive analysis in the future.

Variable 1	Variable 2	Correlation	Correlation type	Acceptable
Diffuse Radiation (W/m²)	UVVB	0.4511945	Positive	Yes
	Temperature (°C)	0.2877612	Positive	Yes
	Relative Humidity (%)	0.1791565	Positive	Yes
UVVB	Diffuse Radiation(W/m²)	0.4511945	Positive	Yes
	Temperature (°C)	0.4497433	Positive	Yes
	Relative Humidity (%)	-0.3198623	Negative	Yes
Temperature (°C)	Diffuse Radiation(W/m²)	0.2877612	Positive	Yes
	UVVB	0.4497433	Positive	Yes
	Relative Humidity (%)	0.0498341	Positive	No
Relative Humidity (%)	Diffuse Radiation(W/m²)	0.1791565	Positive	Yes
	UVVB	-0.3198623	Negative	Yes
	Temperature (°C)	0.0498341	Positive	No

Table 5 Correlation of the data in table 3
Own Elaboration

Variable 1	Variable 2	Correlation	Type of correlation	Acceptable
Diffuse radiation (W/m²)	UVVB	0.4511945	Positive	Yes
	Temperature (°C)	0.2877612	Positive	Yes
	Relative humidity (%)	0.1791565	Positive	Yes
	Diffuse radiation (W/m²)	0.4511945	Positive	Yes
UVVB	Temperaturae(°C)	0.4497433	Positive	Yes
	Relative humidity (%)	-0.3198623	Negative	Yes
Temperature (°C)	Diffuse Radiation (W/m²)	0.2877612	Positive	Yes
	UVVB	0.4497433	Positive	Yes
	Humidity relative (%)	0.0498341	Positive	No
Relative humidity (%)	Diffuse radiation (W/m²)	0.1791565	Positive	Yes
	UVVB	-0.3198623	Negative	Yes
	Temperature (°C)	0.0498341	Positive	No

Table 6 Correlation of the data in table 4
Own Elaboration

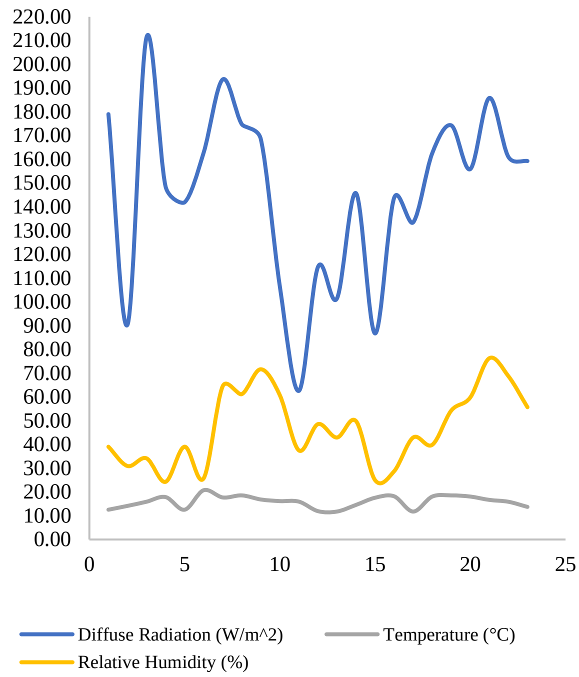
Tables 5 and 6 above show the results of correlations obtained with the R code, which is shown in the annex, both tables present the results of the Pearson correlation of the data for diffuse radiation, UVB, temperature and relative humidity. Pearson's correlation is a measure of the linear relationship between two variables, ranging from -1 to 1, while a value close to -1 indicates a strong positive correlation, while a value close to -1 indicates a positive correlation. In both tables, diffuse radiation and UVB have a strong positive correlation. In addition, temperature and relative humidity are also positively correlated, although to a lesser extent.

ISSN 2524-2121
ECORFAN® All rights reserved

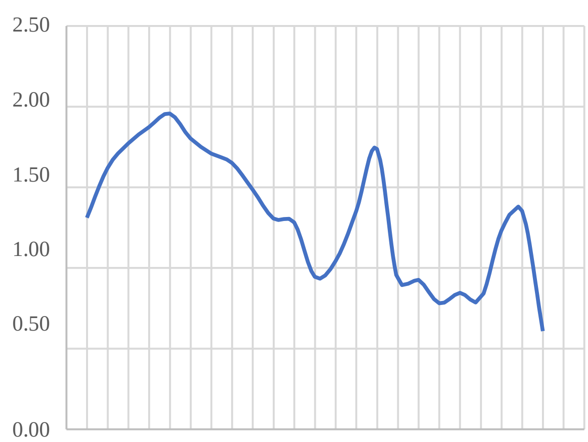
BERLANGA-MORENO, Edgar Darío, GARCÍA-GONZÁLEZ, Juan Manuel, GONZÁLEZ-CABRERA, Adriana Elizabeth and VILLEGAS-MARTÍNEZ, Rodrigo Cervando. Comparison and interpretation of solarimetric station data (diffuse solar radiation, UVB radiation, temperature, and relative humidity) from January 2017 to November 2018 in Zacatecas. ECORFAN Journal-Taiwan. 2023

On the other hand, in table 5, a negative correlation is observed between relative humidity and UVB, indicating that as humidity increases, UVB intensity decreases. However, in table 6, the correlation between relative humidity and UVB is not significant.

In general, these tables indicate the relationship between the variables measured in the study and may be useful to better understand how these variables are related in the region and how they may affect biological and ecological processes in the area.



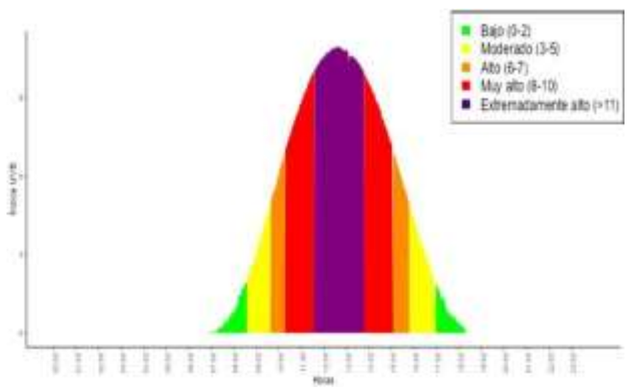
Graph 1 Comparison of diffuse radiation, relative humidity and temperature from 2017 to 2018
Own Elaboration



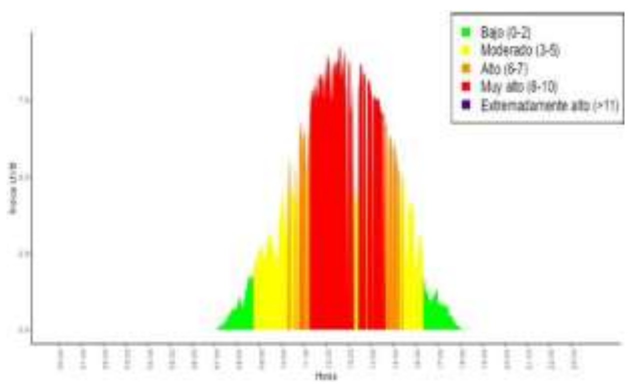
Graph 2 Comparison of UVB radiation from 2017 to 2018, prepared by the authors

Graph 1 shows the monthly average of diffuse radiation, temperature and humidity from 2017 to 2018, showing that in 2017 the diffuse radiation was higher than in 2018, the relative humidity was higher in 2018 and has a seasonal behaviour, i.e., depending on the time of year and climate there is more or less relative humidity and finally the temperature is the variable that has a more stable behaviour with seasonal increases and decreases.

Graph 2 shows the comparison of UVB radiation between 2017 and 2018, showing that 2017 had a higher UVB radiation compared to 2018, where there are clearly two peaks or very high increases compared to the rest of 2018.



Graph 3 UVB index on 30 April 2017
Prepared by the authors

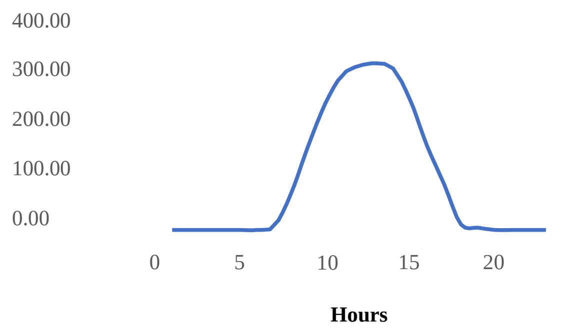


Graph 4 UVB index on the 24th of 2017, day with the highest diffuse radiation in that month
Own Elaboration

Graph 3 shows the UVB index on 30 April 2017, which shows a typical behaviour of a sunny day, with the highest UVB index at midday, while graph 4 shows the behaviour of the UVB index on 24 May, the day with the highest average diffuse radiation of that month, showing that even if there are clouds or any other pollutants in the atmosphere that cause high diffuse solar radiation, it is essential to use sun protection.

ECORFAN® All rights reserved

Annexes



Graph 5 Diffuse solar radiation in January 2017
Prepared by the authors

Graph 5 is a sample of the more than 190 graphs made for this research where the monthly average from 2017 to 2018 for each of the variables analysed is shown.

Acknowledgements

First of all, we would like to express our sincere thanks to the Universidad Autónoma de Zacatecas for their invaluable contribution to this research. The availability and access to the solarimetric station of this institution were fundamental to carry out this study. Without their support and collaboration, this research would not have been possible.

We would also like to express our deep appreciation to the Geophysics Unit of the National Autonomous University of Mexico (UNAM) for their advice and guidance during the development of this research. Their experience and knowledge in the field of solarimetry were of great value for the interpretation of the data and the understanding of the characteristics of climate and solar radiation in the Zacatecas region.

We sincerely thank all the researchers, professors and staff of both institutions who collaborated in this project. Their commitment and dedication in the acquisition and maintenance of the measurement instruments, as well as in the management of the data, were fundamental to the success of this research.

We would also like to extend our thanks to all participants and volunteers who contributed to the data collection. Their commitment and willingness to make accurate and reliable measurements were crucial to obtain high quality results.

Finally, we would like to thank all the people who, in one way or another, contributed to this research. Their support, comments and suggestions enriched our work and motivated us to move forward in the search for scientific knowledge.

Conclusions

In conclusion, this study provided a comprehensive view of diffuse solar radiation, UV radiation, temperature and relative humidity in the study locality during 2017 and 2018. The results obtained largely supported the hypothesis by demonstrating a significant correlation between diffuse and UVB radiation with temperature and relative humidity.

The findings revealed a seasonal variability in diffuse radiation and UVB radiation, with higher values in the summer and autumn months. Temperature and relative humidity also showed seasonal patterns, with peaks in May and September. These relationships between the parameters studied provide valuable information for solar energy system design, outdoor event planning and climate change analysis.

The results may also be useful in urban planning and agriculture, as information on solar radiation and temperature can guide building energy efficiency and occupant comfort, while UVB radiation and relative humidity can influence sun protection measures and irrigation in agriculture.

In summary, this study provides a solid basis for future research in the field of solar energy, climatology and climate change. The data and conclusions obtained are relevant for various applications and contribute to scientific knowledge in the area.

References

[I] Loachamín, J., & Gabriel, W. (2014).Análisis y modelamiento del impacto de la radiación difusa en la generación eléctrica usando paneles solares fotovoltaicos policristalinos.

ECORFAN® All rights reserved

[II] Martínez, R. I. P. ., Ortega, D. J. P. ., Velazco, C. A. R. ., Alomia, F. A. B. ., Paredes, E. D. O. ., & Medina, J. D. C. . (2022). Determinación del nivel de riesgo ocupacional por exposición a la radiación ultravioleta de origen solar en oficinas - estudio de caso en Pasto Colombia. South American SciencesISSN 2675-7222, 3(1), e22171. https://doi.org/10.52755/sas.v3i1.171

[III] Angeles Vásquez, R., García Corzo, A., & Angeles Suazo, J. . (2021). Gradiente altitudinal de la radiación ultravioleta en la región Junín rospectiva niversitaria, 18(1) 47–51. https://doi.org/10.26490/uncp.prospectivauniversitaria.2021.18.1415

[IV] López de la Fuente, J. (1998). La temperatura ambiental en Managua y el efecto invernadero, 1989-1998. Encuentro, 46, 3–15. https://doi.org/10.5377/encuentro.v0i46.3752

[V] Rojas Carrizales, A., Torres Gonzales,Y., Parejas Garavito, M., & HinojosaBenavides, R. (2021). Acción del agua y la temperatura ambiental extrema sobre pavimento flexible. GnosisWisdom, 2, 39–48. https://doi.org/10.54556/gnosiswisdom. v1i2.17

[VI] Cainzos, R. P., Koscinczuk, P., &Ferreiro, M. C. (2016). Influencia de la temperatura ambiental sobre la presión arterial del perro. Revista Veterinaria, 2, 154. https://doi.org/10.30972/vet.252510

[VII] Borbolla Gaxiola, C. (2021). Importancia del análisis del comportamiento higrotérmico de inmuebles históricos para la rehabilitación energética. Caso del archivo histórico general del estado de Sinaloa. Contexto, 22. https://doi.org/10.29105/contexto15.22-4

ECORFAN® All rights reserved