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Preface

Welcome to the eleventh edition of the Ecuadorian Congress of Information and Communication Technologies (TICEC 2023). Hosted in the historic city of Cuenca from October 18 to 20, 2023, this event adopted a hybrid mode at the campus of Universidad de Cuenca (UC).

TICEC stands out as a pivotal conference in Ecuador dedicated to the advancements of Information and Communication Technologies (ICTs). Annually, it assembles a diverse group of researchers, educators, professionals, and students from across the globe, fostering an environment to share research findings and engage in enriching academic endeavors. These collaborations aim to pave the way for innovative ICT applications across various sectors.

This year, the event's organization was masterfully executed through a partnership between the Universidad de Cuenca and the Corporación Ecuatoriana para el Desarrollo de la Investigación y la Academia (CEDIA). The conference featured insightful oral presentations of scientific papers, spanning three primary domains:

- Data Science
- ICT Applications, and
- Software Development

As testament to its growing global influence, this edition witnessed submissions from 245 authors hailing from 12 countries. Ensuring the integrity and quality of our proceedings, all manuscripts underwent rigorous similarity checks and were subjected to a meticulous double-blind peer review by our esteemed TICEC 2023 Program Committee. This committee comprised 150 renowned researchers from 40 countries, with each manuscript evaluated by a minimum of three experts. From this rigorous process, we are proud to present 31 accepted full papers out of 120 received papers, marking an acceptance rate of 25%.

October 2023

Jorge Maldonado-Mahauad
Jorge Herrera-Tapia
Jorge Luis Zambrano-Martínez
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Finding an Integrated Ultraviolet Radiation Index Using Fuzzy Logic Techniques

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Abstract. The present study applies fuzzy logic techniques to find an integrated ultraviolet radiation index for Cuenca-Ecuador. This index integrates information on meteorological variables and ultraviolet rays, whose data were provided by the Research Department of the Institute for Sectional Regime Studies of Ecuador (IERSE), corresponding to 2018. Analysis techniques in data mining were used to process and segment this information. Subsequently, a fuzzy logic model with the Mamdani approach was generated to obtain an integrated ultraviolet radiation index. This model combines the values of the Ultraviolet radiation A and Ultraviolet radiation B components through 49 fuzzy inference rules. The results obtained were compared with the ultraviolet radiation indices of the tropospheric model. As a result, a slightly higher fuzzy index was obtained in terms of the index score concerning the tropospheric model.

Keywords: Ultraviolet Index · Fuzzy logic · Air quality · Data mining

1 Introduction

Nowadays, the monitoring and control of the radiation that comes from the sun has become fundamentally important in humanity because it can cause harmful effects on the skin and eyes of human beings [19]. The atmosphere of planet Earth, especially the ozone layer, is responsible for filtering the incidence of solar radiation [25]. According to Ipiña et al. [14], the ozone layer has been affected due to the increase in polluting gases from industries, vehicles, and others, negatively affecting radiation filtration.

The IERSE of the University of Azuay, together with the Municipal Company of Mobility, Transit and Transport of the city of Cuenca (EMOV EP), has implemented a plan for tracking and monitoring quality variables of the air in the city of Cuenca-Ecuador [24]. This plan allows for measurements of the

global incident radiation, raising the need to apply data mining and fuzzy logic techniques that give the possibility of generating knowledge for decision-making. As a fundamental aspect, there is data on atmospheric pollutants for the city of Cuenca-Ecuador for 2018.

Using as a base the data collected from the meteorological variables, solar radiation, ultraviolet radiation, and the definitions proposed by fuzzy logic, the present work focuses on the generation of an Ultraviolet (UV) radiation for the city of Cuenca-Ecuador through the application of data mining techniques and fuzzy logic in the atmospheric and meteorological variables that present a relationship with UV rays.

2 Related Work

This study aims to generate an integrated UV radiation index by applying fuzzy logic techniques to data related to solar radiation. The information provided by IERSE corresponds to the atmospheric variables and air pollutants of Cuenca-Ecuador in 2018, so it is essential to know what studies have been performed on these goals.

Therefore, it is necessary to know the importance and interference of UV radiation in human health. The study by Kyprianou et al. [18] declares an increase in the occurrence of skin cancer on a Mediterranean island with a high degree of solar radiation. Likewise, Umar et al. [23] mention that increased skin problems related to UV radiation have been observed worldwide since the fifties. Furthermore, the research by Bais et al. [3] highlight that the ozone layer is weakening due to air pollution, a product of the gases from industries, vehicles, paints, etc. This depletion of the ozone layer has caused the intensity of UV radiation to increase considerably over time.

The research by Ipiña et al. [14] relates the intensity of UV radiation to meteorological variables and air pollution. In the same way, the World Health Organization [26] comments on the importance of having a Ultraviolet Index (UVI) that allows the population to know the intensity of UV radiation and that it is an indicator to cause lesions in human skin.

On the other hand, various investigations and articles have applied fuzzy logic techniques because it is a methodology that solves complex problems in an elegant and simplified way and also admits the incorporation of expert knowledge in decision-making [9]. The study by Allana and Chua [2] propose using fuzzy logic through a fuzzy inference modelling system using MATLAB software to find an air quality index inside a bus.

Katushabe et al. [16] propose an air quality index, applying fuzzy logic to the data corresponding to the city of Kampala in East Africa. Similarly, Santigosa et al. [22] propose three models to obtain a daily global radiation index, the first model is based on linear regression, the second model on a non-linear regression and the third model on a fuzzy inference system. Likewise, Jaramillo et al. [15] suggest obtaining an integrated air quality index for Colombian cities by applying a fuzzy inference system. This study uses a similar model to get a UVI radiation,

whose variables are related to air pollution. In addition, variables related to solar radiation are considered, such as Ultraviolet A (UVA), Ultraviolet B (UVB) and UVI radiation.

The research performed by Huilca et al. [12] concludes that it is possible to find a UV radiation index for the city of Puno-Peru using a linear regression model. Consequently, In our study, we propose to generate a fuzzy model that obtains an integrated UV radiation index using air quality data corresponding to 2018 and considering atmospheric and meteorological variables in Cuenca-Ecuador. These data are compiled and studied by the Municipality of Cuenca, EMOV EP, and the Research Department of IERSE [24]. For its quantification, fuzzy logic is used since the relationship between the variables is complex, admitting fuzzification techniques in the selected variables [10].

3 Materials and Methods

The method to develop this work is structured as follows: i) Data understanding that allows to tackle the used variables, ii) The international standards about UVI, iii) The fuzzification process allowed to translate the preprocessed variables into linguistic variables, and iv) The defuzzification process where the new UV index was obtained.

3.1 Data Understanding

To generate a document with the specification of the objectives that leads to the generation of a fuzzy UVI, it is necessary to execute the following sub-tasks: i) Understand the study area, ii) Describe the variables of pollutants and air quality, iii) Detail the UV radiation variables, and finally iv) Generate the objectives of the research that highlights the obtaining of the fuzzy UV radiation index.

During this stage, the experts met to obtain information on the UVI standards. This phase allowed us to understand the process of collecting information on air quality variables. The variables that are part of the data collection in the city of Cuenca-Ecuador are Nitrogen dioxide (NO₂), Sulfur dioxide (SO₂), Carbon monoxide (CO), Ozone O₃, UV global radiation (RADGLOBAL_AV). The information was captured by a real-time continuous monitoring station that uses specialized sensors to collect data every second.

This information is processed to generate a data set at an interval of ten minutes. The information collected helps to identify the importance of having an integrated ultraviolet radiation index that facilitates generating knowledge about the intensity of UV radiation in Cuenca-Ecuador. According to the Ecuadorian National Institute of Census and Statistics (INEC) [13], Cuenca is the third city with the most inhabitants in Ecuador, located in the center-south of the country, at an altitude of 2,550 m above sea level. It is located on the Equatorial line, two seasons are recognized, winter (rain) and summer (dry); with an annual Relative Humidity (RH) of 75%, and an average daily temperature of 15°C, its maximum

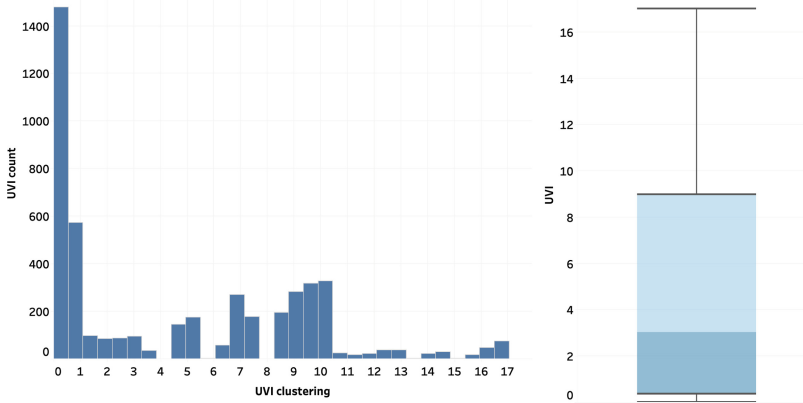


Fig. 1. Frequency and distribution of the UVI variable.

hourly temperature moves one or two hours after the maximum intensity of solar radiation, whose peak is around noon [11].

This study used the data on air pollutants and meteorological variables of the city of Cuenca-Ecuador for 2018. The data were provided by the Municipal of Cuenca, EMOV EP, and the Research Department of IERSE [24]. The information has been captured by a real-time continuous monitoring station belonging to the company EMOV EP. Each intake of air pollutants is performed at one-second intervals. However, the data provided for the study has a time interval of ten minutes [21]. The initial data set has 52,600 records, specifically the variables are: O_3 , CO , NO_2 , SO_2 , Particulate Matter of $2.5\ \mu m$ ($PM_{2.5}$), average temperature (TEMP), RH, Dew Point (DP), atmospheric pressure (PATM).

Figure 1 shows the data distribution corresponding to the UVI variable. As we can be observed, a bias or trend towards the zero value is identified due to the absence of radiation during certain hours of the day, especially between 6:00 pm and 6:00 am. Figures 2 and 3 show a similar situation with the variables UVA (315–400 nm) o “UVA_315_400” and UVB (280–315 nm) o “UVB_280_315”.

3.2 UVI Standards

During the targeting stage, it was essential to consider the scales that the World Health Organization (WHO) recommends for the measurement of UV radiation. These scales are used to inform about the possible damage that the intensity of UV radiation can cause in different areas of the planet. Although not strictly adopted by all countries, these scales are widely used as a reference. Solar radiation levels in regions of low and intermediate latitudes, where higher solar radiation intensity is observed, require more specific standardization or redefinition. Consequently, we decided to incorporate the scale proposed by Cañarte in the present research study [8].

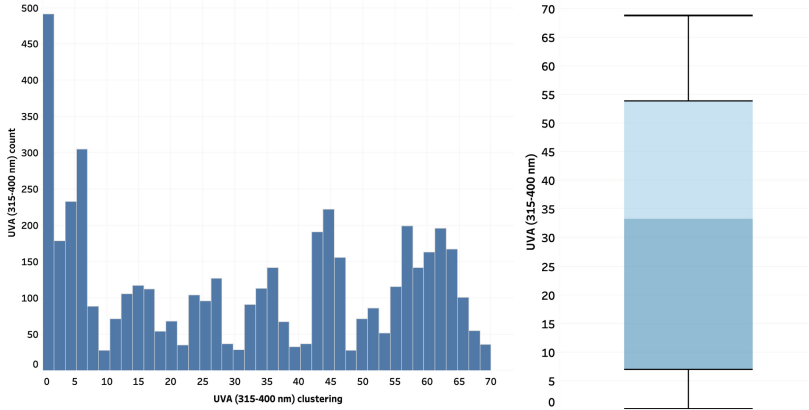


Fig. 2. Frequency and distribution of the variable UVA (315–400 nm).

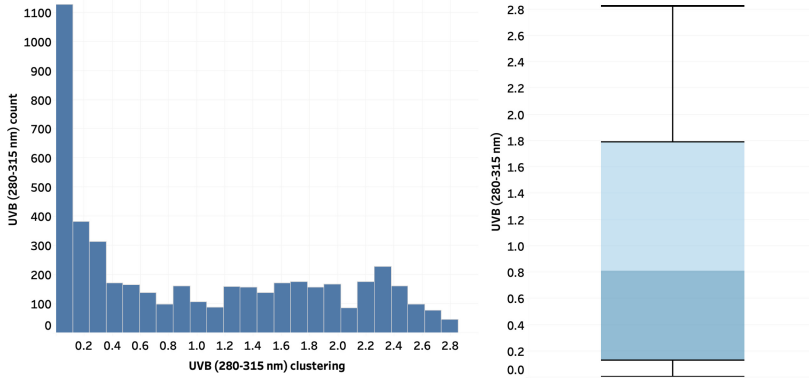


Fig. 3. Frequency and distribution of the variable UVB (280–315 nm).

Data Preprocessing. Once the objectives have been defined and the information on atmospheric variables and UV rays has been collected, the data preprocessing phase begins to assess its quality and apply data mining techniques that facilitate data collection. However, it is essential to consider that The data can present errors for various reasons, such as the lack of reliability of the sensor in the capture of information. Also, a small amount of data may need help capturing due to factors such as calibration or resetting of the sensors, creating a temporary gap in the information.

Likewise, it is essential to note that the sensors capture information on air pollutants every ten minutes, while meteorological variables are captured every minute. To solve this temporal dissonance between the variables, an average of ten one-minute records is used for each variable, thus achieving a ten-minute

average record that avoids discordance between the atmospheric and meteorological variables [21].

The raw data is described at this stage, and pre-processing techniques are applied to improve the data quality. The raw data contain information on the atmospheric variables taken in ten minutes in Cuenca-Ecuador, 2018. Regarding data preprocessing, i) data cleaning, ii) data selection and iii) elimination of outliers, which are activities proposed in the methodology.

Data Cleaning. All records containing missing data for any variable in the data set were removed during the first data removal tests. As a result of the deletion process, 34,230 undeleted records were obtained, which represents 65% of the total data. However, to maintain the integrity of the data set, the missing values were filled in to recover the remaining 35% that was removed in this process. The methods proposed in [21] were used to impute missing data for atmospheric and pollutant variables, demonstrating that the most common imputation methods may be missing critical information for variable correlation analysis. In addition, using the mean or median to fill in the missing values would present disadvantages and biases in the covariance matrix. After several tests, it was determined that the prediction of missing data using Lasso regression is the process that fits the purpose of this investigation. In addition, it was necessary to eliminate outliers to obtain a regression model that fit the data distribution. As a result of this stage, it was possible to maintain a total of 52,560 records without missing values, and a correlation matrix concerning UV radiation was generated.

Data Selection. This stage used the Troposphere Ultraviolet and Visible (TUV) model [5] to obtain the UV radiation of a particular region. This model uses meteorological, surface and time of day parameters, such as ozone, cloudiness, aerosols present in the air, height and measurement time, among other parameters. Thus, Cañarte et al. [8] conclude that Ecuador receives a high intensity of erythemal radiation most of the year due to its location.

Once the UV radiation variables such as UVA, UVB and UVI were obtained, it was possible to analyze the relationship between the atmospheric and meteorological variables since one of the main objectives is generating a fuzzy UV radiation index. For this reason, it is necessary to determine the atmospheric variables and air pollutants related to the UV radiation index.

The variable correlation was determined using the r-square coefficient method [7]. This method obtains the relationship coefficients of two variables simultaneously, and the coefficient determines how related the two selected variables are. As a result, a correlation matrix was obtained where a positive correlation can be seen between the variables *TEMPAIRE_AV*, *O₃*, *UVA_315_400*, and *UVB_280_315*. Bi [7] states that the r-squared value ranges between 0 and 1, where 0 indicates that the model does not explain any variability in the dependent variable, 1 suggests that the model explains all the variability in the dependent variable. Therefore, the closer the r-squared value is to one, the better the model's ability to explain the variability in the dependent variable.

The variables that most influenced the UV radiation index were identified as part of this process. Then, the records in which the radiation index was zero were eliminated since they did not contribute to the final model due to their equivalence being null or non-existent. Also, the data collected from 6 pm to 6 am were included since there is no radiation, and these values are close to zero. Applying these criteria, a final data set of 4,745 records was obtained.

Outlier Removal. To eliminate outliers that have been found in the variables related to *RADGLOBAL_AV*, the algorithm called Local Outlier Factor (LOF) was used. This algorithm determines which values are outside an established threshold. Such issues can affect and introduce biases in the search for a model that fits the distribution of the analyzed variable [1]. Therefore, this method was used to filter values within a threshold set to *UVA_315_400*, *UVB_280_315*, and *UVI*. By applying the LOF algorithm, 4,745 records were obtained, so it can be seen that there were no outliers in the range from 6 pm to 6 am, thus being 9% of the total records referring to the original data. The latest data facilitate the possibility of obtaining an index using fuzzy logic because each record in the data set provides relevant information on UV radiation.

3.3 Fuzzification Process

The modelling phase involved selecting, testing and using a fuzzy logic model based on Mamdanis' approach to meet the research expectations. We worked with previously prepared data in the data preprocessing phase. The first step was to define the discursive universe of each linguistic variable from the following variables obtained in the previous stage: *UVA_315_400*, *UVB_280_315* and *UVI*.

To define the division of the data set, the criterion of using 70% of the records to train the fuzzy logic model was followed, and the remaining 30% to validate the model, as indicated by Kaur et al. [17]. The *UVB_280_315* represents a wave of solar energy ranging between 280 and 315 nm. Decision trees generated by the RapidMiner Studio program were used to define the different ranges of UVB radiation intensity. The variable "CATEGORY_IUV" was defined as the variable to predict. This variable represents a categorisation of the numerical variable UVI. To form the rules defining the universe of discourse and linguistic variables, all columns except the numerical column *UVB_280_315* were dropped. Using the rate of profit as a criterion and a depth of six levels, seven categories were formed on the same scale.

The universe of discourse was defined by applying decision trees to the categorical variable *CATEGORIA_IUV*. This approach ensures an accurate classification of the samples into different radiation intensity categories, which was essential to generate the fuzzy logic model. Therefore, the values needed to create the trapezoids of the Mamdani approach, as shown in Fig. 4.

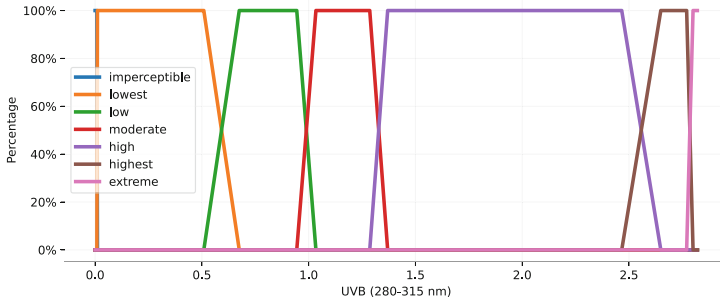


Fig. 4. Graphic trapezoidal definition of the variable UVB_280_315.

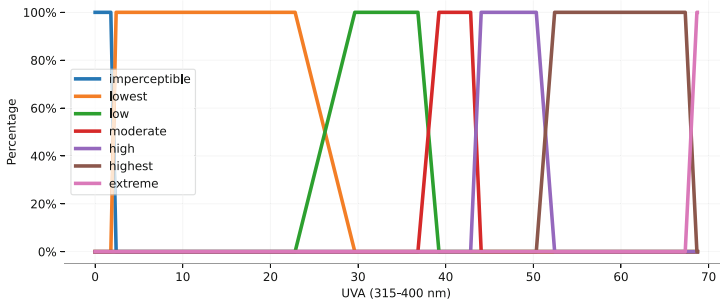


Fig. 5. Graphic trapezoidal definition of the variable UVA_315_400.

UVA_315_400 contains information about UVA radiation, a wave of solar energy with wavelengths between 320 and 400 nm. To define the range of intensity of *UVA_315_400* radiation, the same method was applied to the variable *UVB_280_315*. The definition of the universe of discourse of the linguistic variable *UVA_315_400* with which the universe of speech can be generated using the Mamdani method, as illustrated in Fig. 5.

After defining the linguistic variables and the discursive universe of each variable, the rules that the fuzzy logic algorithm will use with the Mamdani approach are detailed. Consequently, a Fuzzy Associative Matrix (FAM) table was used to define two entries that conform to the fuzzy rule [4].

The FAM table shows that if one of the components of UV radiation is high, that category is established as a general rule. However, when the intensity scale in any of the components converges on the “high” categorization, the general rule is to classify with the following score on the region’s normalized scale; for example, if *UVB_280_315* radiation is “high” and *UVA_315_400* radiation is “high”, it is classified with the following score on the scale, which in this case is “very high”. This decision is made based on the recommendations of the WHO, which indicates that a high rate means possible damage to human skin, so avoiding sun exposure and seeking shade is recommended.

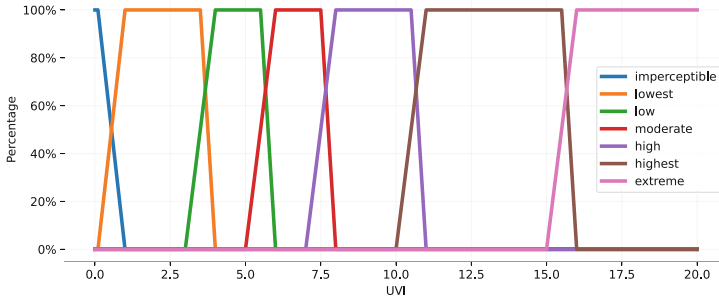


Fig. 6. Graphic trapezoidal definition of the UVI variable.

For the implementation of the linguistic variables and the definition of the fuzzy rules, the *fuzzy_expert* library of the Python programming language was used, where each variable is defined with its respective discursive universe through the *Fuzzy-Variable* module. Additionally, it has the *FuzzyRule* module where the rules defined in the FAM table are declared, whose implementations can be found in different programming languages such as Python.

3.4 Defuzzification Process

This stage evaluates each record of the data set obtained during the preprocessing phase to be used as input to the fuzzy model and, according to the decision rules, generates a unique output of a numerical value on a scale of 0 to 18, which corresponds to the intensity of the radiation in the UV radiation scale of the region. The process of converting inputs to unique outputs is called fuzzification. The *fuzzy_expert* library was used via the *DecompositionalInterface* module to implement a fuzzy model. The discourse universe of the UVI linguistic variable was defined by original data, reflecting the intensity of ultraviolet radiation in Ecuador on a scale from 1 to 16. This scale, proposed by Cañarte et al. [8], establishes that a value of one indicates a low level of radiation without health risk, while a value of 16 corresponds to an extreme level. Figure 6 illustrates how the trapezoids of Mamdani's approach were constructed.

To obtain the UVI for each record in the dataset, a fuzzification process was applied to the input variables *UVA_315_400* and *UVB_280_315*. Next, a fuzzy model with the Mamdani approach was used to fuzzy and assigned a unique numerical value to each record.

This numerical value represents the corresponding ultraviolet radiation index. The fuzzy model was designed so that the fuzzification of the data was considered in the assignment of the UVI. The entire data set used iteration and index calculation to obtain the most accurate value possible.

3.5 Evaluation

In this phase, the methodology analyzes the results obtained to verify if the model aligns with the requirements outlined in the research study. Therefore, the behavior of the fuzzy logic model is analyzed with the Mamdani approach. The r-square determines the performance of the models, also called the coefficient of determination. Thus, an r-squared value close to one means that the estimates obtained in the fuzzy UVI variable are more comparable to the UVI of the TUV model [20].

The general idea of the r-squared value is to validate how well the fuzzy model fits the model used as the TUV reference. In addition, the Root Square Mean Error (RSME) is used to assess how well the predicted value of the fuzzy UVI fits against the UVI of the TUV model. The RSME value measures the error between the actual value against the expected value; consequently, the lower this value, the better the fuzzy model [6].

4 Results and Discussion

This section presents the results of the fuzzy model compared to the TUV model. To facilitate the understanding of the variability of the different indices, graphs have been used to reduce the visualization of the results. Due to the large data set size, displaying some of the predicted values is only feasible. Therefore, 20 records corresponding to noon have been randomly selected since, during this day, the UVI value reaches its maximum value [11]. In this way, it is possible to observe the differences between the actual and predicted values, as shown in Fig. 7.

Figure 8 reveals that the fuzzy index tends to assign higher values when one of the UV radiation variables is “high”. The r-squared and RSME values were used to evaluate the performance of the generated model, and a more significant error was observed in the records where one of the components presented an “extreme” value. This behavior is attributed to the rules generated for the fuzzy model, where it is specified that any component of the UV radiation is “extreme”. The TUV model index is based on an inferential mathematical formula. Therefore, it is essential to consider these differences when selecting a model to assess UV radiation exposure, with violet being extreme and red being very high.

Figure 9 presents the average of the results obtained by the fuzzy model, which are slightly higher than those of the TUV model. This effect is more noticeable when one of the components of UV radiation presents extreme values. These findings are consistent with the rules of the fuzzy model, which assigns higher values to the fuzzy index when the UV radiation components are extreme. Consequently, these results suggest that the fuzzy model may be more suitable for assessing exposure to excessive levels of UV radiation.

Thus, in Fig. 10, we can be observed that if any of the components of the fuzzy model is “extreme”, it is very likely that the tendency is to locate the maximum value in the UV index. This finding is relevant since it suggests a

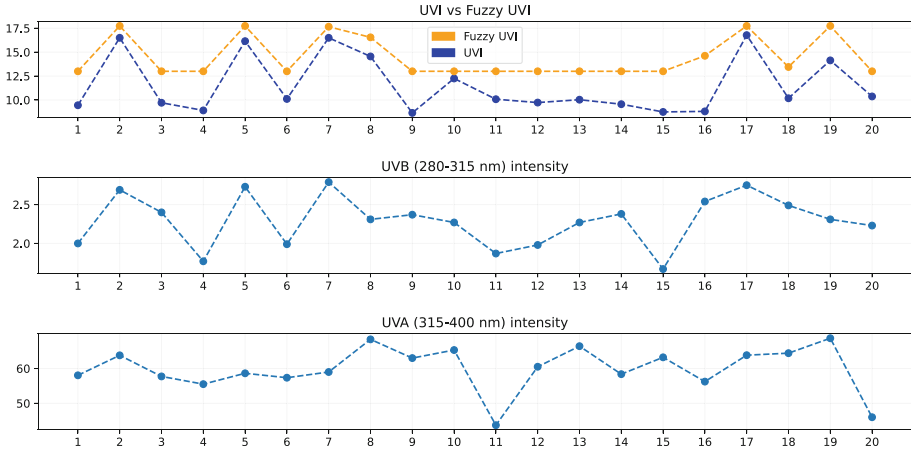


Fig. 7. Forecast values in the traditional method.

EC_TIME_STAMP	UVB_280_315	UVA_315_400	IUV	IUV_DIFUSO	luv_menos_luv_difus	luv_menos_luv_difuso_cuadr	luv_menos_luv_promed	luv_menos_luv_promedio_cuadr
2018-02-23 11:10:00	2,77	64,3	16,78	17,74	-0,96	0,9216	12,09481981	146,2846662
2018-02-23 12:10:00	2,77	61,83	16,54	17,74	-1,2	1,44	11,85481981	140,5367527
2018-02-25 12:10:00	2,76	59,81	16,34	17,74	-1,4	1,96	11,65481981	135,8348248
2018-02-27 12:10:00	2,77	60,87	16,71	17,74	-1,03	1,0609	12,02481981	144,5962915
2018-02-28 11:10:00	2,73	60,47	17	17,74	-0,74	0,5476	12,31481981	151,654787
2018-03-01 11:10:00	2,82	63,38	16,65	17,74	-1,09	1,1881	11,96481981	143,1569131
2018-03-01 12:10:00	2,81	64,58	16,63	17,74	-1,11	1,2321	11,94481981	142,6787203
2018-03-02 11:10:00	2,25	68,67	12,71	17,74	-5,03	25,3009	8,02481981	64,3977329
2018-03-03 11:10:00	2,31	68,7	14,14	17,74	-3,6	12,96	9,45481981	89,39361765
2018-03-03 12:10:00	2,81	58,71	16,08	17,74	-1,66	2,7556	11,39481981	129,8419185
2018-03-04 11:10:00	2,75	62,83	16,83	17,74	-0,91	0,8281	12,14481981	147,4966482
2018-03-04 12:10:00	2,74	63,01	16,52	17,74	-1,22	1,4884	11,83481981	140,0629599
2018-03-05 11:10:00	2,33	66,71	14,44	17,74	-3,3	10,89	9,75481981	95,15659953
2018-03-06 11:10:00	2,34	66,71	14,26	17,74	-3,48	12,1104	9,57481981	91,6771744
2018-03-07 11:10:00	2,8	62,11	16,65	17,74	-1,09	1,1881	11,96481981	143,1569131
2018-03-08 11:10:00	2,4	68,71	12,95	17,74	-4,79	22,9441	8,26481981	68,3072465
2018-03-09 11:10:00	2,25	68,69	11,41	17,74	-6,33	40,0689	6,72481981	45,22320148
2018-03-09 12:10:00	2,76	59,75	16,35	17,74	-1,39	1,9321	11,66481981	136,0680212
2018-03-10 11:10:00	2,77	61,7	16,92	17,74	-0,82	0,6724	12,23481981	149,6908158
2018-03-11 11:10:00	2,23	68,66	11,61	17,74	-6,13	37,5769	6,92481981	47,95312941
2018-03-12 11:10:00	2,42	68,66	12,99	17,74	-4,75	22,5625	8,30481981	68,97003208

Fig. 8. Values obtained through the proposed index. (Color figure online)

significant relationship between the model components and their impact on the UV index results.

When analyzing Fig. 11, we observe the distribution of the fuzzy index throughout the day, which is slightly above the index obtained by the TUV model. In addition, a clear separation is identified at the points of maximum radiation, which occur between 11 am and 2 pm.

Therefore, we visualize that the intensity of UV radiation reaches its maximum at the highest point of the sun, between 12 and 13h. The methodology used admits changes in the parameters to build a model that better fits the intensity of the UVA and UVB components. If one of the components had an “extreme” intensity, it was determined to be sufficient to classify the radiation intensity in a higher range on the UV radiation scale. In this way, an extreme component was prevented from being balanced by one of normal intensity.

In addition, the corresponding rules and values obtained through the fuzzy logic model are presented. To improve the accuracy of the fuzzy logic model,

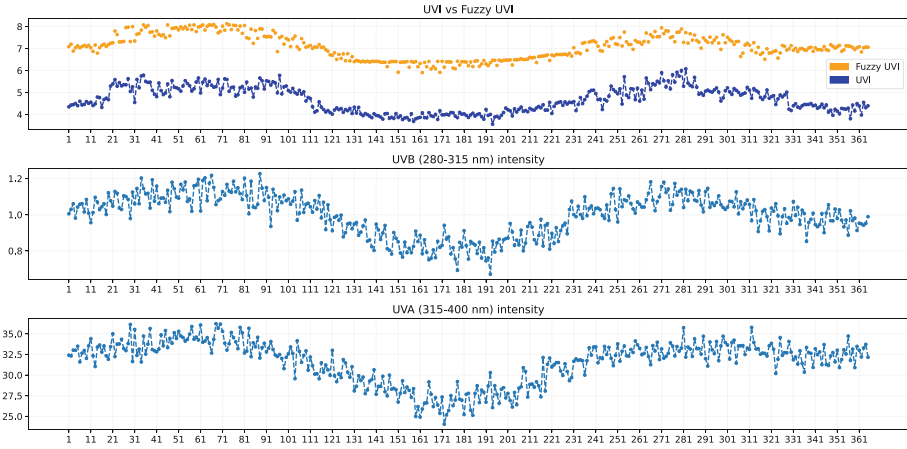


Fig. 9. Graph average value per day of the TUV model vs fuzzy UVI.

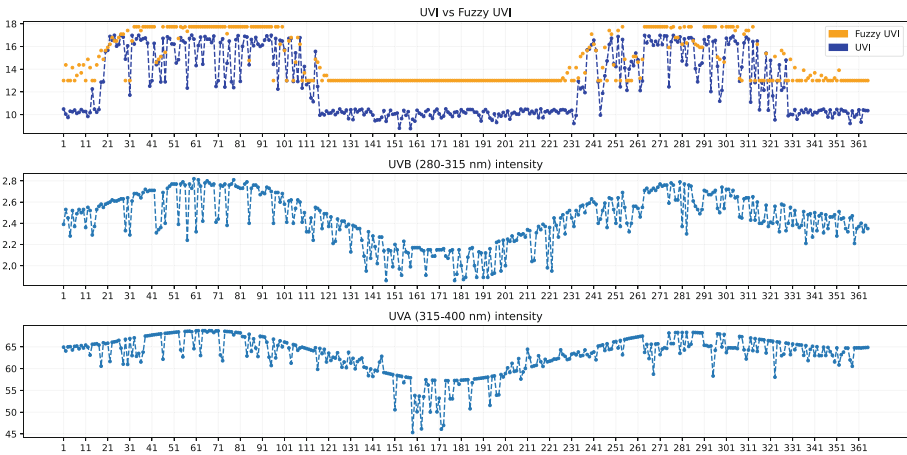


Fig. 10. Graph maximum value per day of the TUV model vs. fuzzy UVI.

the use of real data captured by UVA and UVB radiation sensors in the city of Cuenca-Ecuador is required. In this way, it will be possible to adapt the parameters of the fuzzy model to values obtained directly from a sensor, avoiding potential biases when using the TUV model.

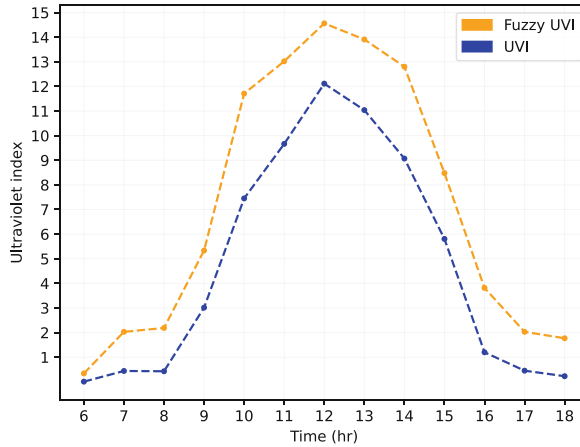


Fig. 11. Average graph year 2018 in the time range 6 am - 6 pm.

5 Conclusions

This research aims to demonstrate how to obtain a UV radiation index using a fuzzy logic model with a Mamdani approach. Therefore, it was shown that the fuzzy model is an effective alternative for getting a UV radiation index compared to the TUV mathematical model, and the integrated fuzzy index provides clear information when evaluating the components that make up the UV radiation index. The components are categorised on a scale from imperceptible to extreme, with seven levels between the scales, allowing understandable information transmission for decision-making. Furthermore, the model can be improved using accurate data from sensors corresponding to the study region to fit the fuzzy logic model precisely. In general, this approach is helpful for decision-making to report the harmful effects of UV radiation.

In this study, data mining techniques were applied to preprocess the information of the pollutant data corresponding to the city of Cuenca-Ecuador in 2018. Fuzzy logic was later used as a data model with the Mamdani approach to obtain data on UV radiation indices. For this, the values of the UVA and UVB components were combined using 49 rules, the results of which were compared with the UV radiation indices of the TUV model. As a result, we obtained a slightly higher fuzzy index in terms of the index score compared to the TUV model. The evaluation parameters used in the study were the coefficient of determination (r -square) with a value of 0.63 and the RSME with a value of 2.82. These parameters indicate that the fuzzy logic model with the Mamdani approach obtains an integrated UV index that resembles the TUV mathematical model. This model uses tropospheric ozone and other region parameters to calculate the UV radiation index.

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