# UNIVERSIDAD DE INVESTIGACIÓN DE TECNOLOGÍA EXPERIMENTAL YACHAY

**Escuela de Ciencias Biológicas e Ingeniería**

## TÍTULO: Sensing of Psoriasis treatment with "SUNMED".

Trabajo de integración curricular presentado como requisito para la obtención

del título de Ingeniería Biomédica

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Urcuquí, junio 2020

UNIVERSIDAD YACHAY TECH

Urcuquí, 28 de junio de 2020

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## Dedicatoria

Dedico este trabajo a mi padre, madre y hermano ya que gracias a su dedicación y apoyo me han impulsado a completar una meta más en mi vida en mi desarrollo como profesional.

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**RESUMEN:**

La radiación ultravioleta es un factor muy importante en nuestras vidas debido a que su incidencia es beneficiosa a la vez que es peligrosa. Especialmente, la radiación UVB es la más peligrosa porque puede producir algunas enfermedades o estados de la piel como el cáncer de piel, quemaduras, entre otras. Sin embargo, también puede ser usada para el tratamiento de otras enfermedades. La radiación UVB representa tan solo el 5% de la radiación ultravioleta producida por el sol, hay diversos métodos de tratamientos que usan fuentes de radiación artificial como lámparas UVB en cámaras de radiación.

La psoriasis es una patología de la piel que, actualmente, no tiene cura y necesita un tratamiento continuo. Hay diversas maneras de alcanzar el aclaramiento de la piel, pero el método más usado con mejores resultados es UVB de banda estrecha que consiste en el uso de radiación UVB durante un tiempo determinado. Generalmente, los métodos desarrollados utilizan fuentes de radiación ultravioleta artificial con un rango de longitud de onda entre 296 y 313 nm. También, los fototipos de la piel son muy importantes debido a que la dosis de radiación difiere de acuerdo a cada uno de ellos. En Ecuador hay cámaras de lámparas UVB que no son controladas en cuanto a la energía que liberan.

Este proyecto presenta una comparación entre la radiación UVB emitida por fuentes artificiales y el sol. Se desarrolla un diseño de un dispositivo que mide la energía recibida por el paciente para determinar el correcto funcionamiento y la calidad de las fuentes de radiación. Y finalmente, se analiza un tratamiento para reemplazar la radiación UVB artificial con la proveniente del sol para lo cual se considera el día con mayor y menor radiación, durante el mediodía solar durante el 2018.

**Palabras clave:**

Psoriasis, banda estrecha, UVB, radiación y fototipos.

**ABSTRACT:**

Ultraviolet (UV) radiation is a very important factor in our lives due to its incidence can be beneficial and also harmful. Specially, UVB radiation is the most dangerous because can produce of some diseases or states of the skin such as skin cancer, burns, among others. However, also it can be used to treat some diseases. UVB radiation represents only the 5% of the total UV radiation coming from the sun, there are some methods of treatments that use artificial sources of UVB radiation as UVB lamps in UVB chambers.

Psoriasis is a skin pathology that does not have a cure and needs continuous treatment. There are several ways to achieve skin clearance, but the most widely used treatment with better results is Narrowband UVB which consists in the use of UVB radiation during a certain time. In general, the treatments developed use sources of artificial UVB radiation with a range of wavelength from 296 nm to 313 nm. Also, the phototypes of skin are very important due to the radiation dose differs according to them. In Ecuador, there are chambers of UVB lamps that are not controlled about the delivered power (or inclusive energy).

This project presents a comparison between the UVB radiation from devices and the sun. A design is developed of a device that measures the power received for the patient to determine the correct functioning and quality of sources of radiation. And finally, a treatment is analyzed replacing the artificial UVB radiation with that coming from the sun using the day with the highest and lowest radiation during 2018 at solar noon.

**KEYWORDS:**

Psoriasis, Narrowband, UVB, Radiation and Phototypes.

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# 1. INTRODUCTION – JUSTIFICATION

## 1.1 Human skin

Skin is a complex organ that protects its host from its environment, at the same time allowing interaction with its environment. It is much more than a static, impenetrable shield against external agents [1]. Rather, skin is a dynamic, complex, integrated arrangement of cells, tissues, and matrix elements that mediates a diverse array of functions: skin provides a physical permeability barrier, protection from infectious agents, thermoregulation, sensation, ultraviolet (UV) protection, wound repair and regeneration, and outward physical appearance [1].

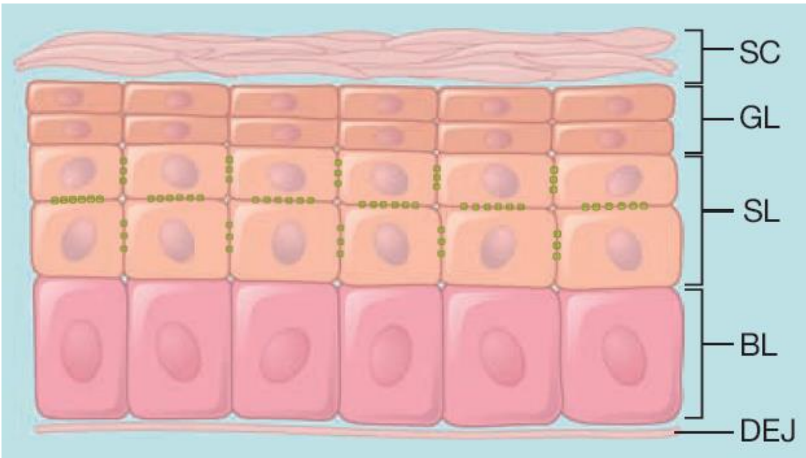


*Figure 1. Schematic layers of epidermis where the elements are: SC: stratum corneum, GL: granular layer cells, SL spinous layer, BL:basal cells, DEJ: dermal-epidermal junction [1].*

Figure 1 shows the schematic of epidermis; it is a cornified, stratified epithelium. In order to explain the different layers, it will enumerate explaining from the deepest layer: the basal cells (BL) layer. This one is over the dermal–epidermal junction (DEJ). The basal cells differentiate into the cells of the spinous layer (SL), then to become granular layer cells (GL). These cells will produce components of the cornified envelope. Finally, the terminally differentiated keratinocytes shed their nuclei and become the stratum corneum (SC), a cross-linked network of protein and glycolipids.

## 1.2 Psoriasis

Psoriasis is a non-communicable, chronic, painful skin pathology that consists of the appearance of symmetrical red platelets that may be covered by white dots that can cause pain and itching, as can be seen in Figure 2, in addition to affecting any age [2].

There is not a clear cause of psoriasis, but some studies show evidence that it is a genetic predisposition, furthermore, suggests it is an immune disease and it can be triggered by internal or external agents such as burns, drugs or infections [2].

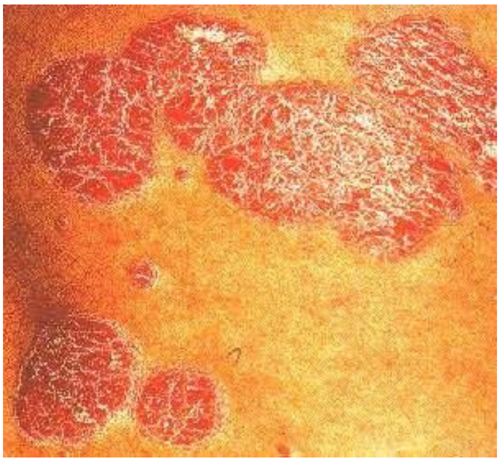

*Figure 2: Photograph of skin of patient with psoriasis [2].*

The symptoms of this disease may be too many, but it can trigger other diseases such as cardiovascular problems, depression, arthritis, that can be seen in Figure 3. In general, the diagnosis of psoriasis is not correct or delayed, so patients are subjected to inadequate treatments or do not have access to it [2]. The most common areas of appearance of spots are the scalp, elbows and knees. Apart from the physical consequences that are commonly observed such as disfigurement or disability, there are also psychological consequences due to individuals with psoriasis are excluded from society or discriminated against [2]. Current treatments are only based on the control of symptoms by decreasing skin stains, but so far there is no total cure so patients that suffer havoc [2]. The skin has a renewal process that involves the development of a new layer in the lower part, which matures and is placed in the upper layer after 30 days. This process is affected in patients with psoriasis due to psoriasic cells develop faster, so the process has a duration for 3 to 5 days, while eliminating normal cells [2].

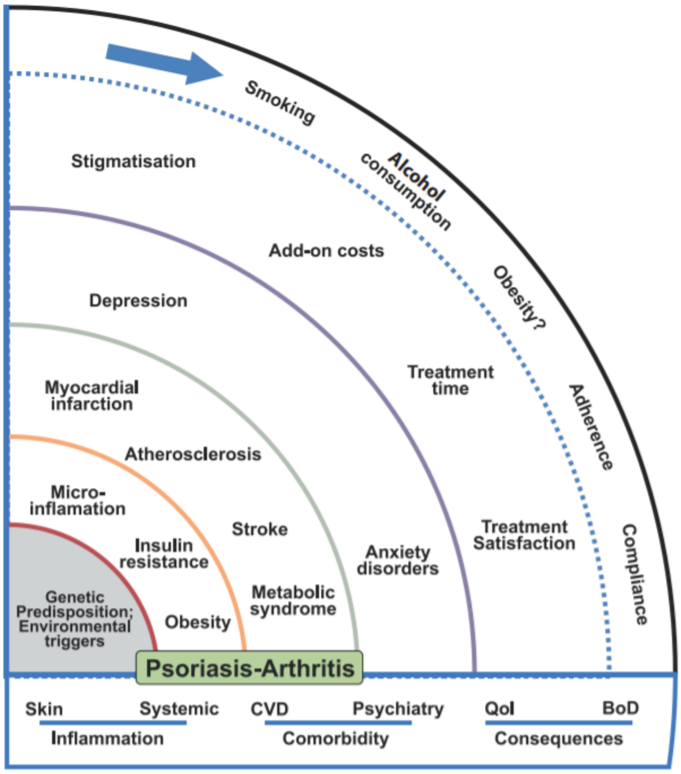


*Figure 3: Schematic of the consequences of psoriasis [1].*

According to World Health Organization (WHO), psoriasis is a global disease that affects all countries, around the world there are at least 100 million individuals with this disease. Figure 4 shows a world map of psoriasis cases, where the countries with dark green have more individuals affected.


*Figure 4: Cases of psoriasis in the world [1].*

### 1.3 Ultraviolet radiation and health

There are different sources of radiation, but they are mainly differentiated by being natural or artificial. The natural radiation is characterized by being always present in our environment among which are cosmic rays, sun, water, rocks, even the food we ingest. Regarding artificial radiation, we find it in medical centers produced by the equipment used as radiation chambers, tomographs, x-rays, among others. Industrial, fuel production processes are other sources of artificial radiation [3].

The radiation can be classified in ionizing and non-ionizing radiation. The ultraviolet (UV) radiation is in the range of non-ionizing radiation. The UV radiation can be divided into three different ranges depending on its wavelength; the first is the UVA radiation that goes from 400 to 320 nm, so it can penetrate the human skin reaching the dermis. In addition, this type of radiation is not absorbed by the ozone layer and it is the cause of skin burns [4]. The second type is UVB radiation that has a short wavelength that ranges from 320 to 280 nm, so it can only reach the outermost layer of the skin (epidermis) and it can cause diseases such as skin cancer. Like the UVA, it is not absorbed by ozone and is only 5% of the radiation produced by the sun. Finally, the third type is the UVC radiation, which is 0.5% of all the radiation that goes from 280 to 100 nm, and is also almost completely absorbed by the ozone layer [4].

In the field of health and the UV radiation there are elements that must be taken into account: solar irradiance, solar erythema, solar spectral irradiance, MED and UV index. First, *solar terrestrial irradiance* is the radiant power of the sun that affects the surface per unit area, it is expressed commonly with the units of $Wm^{-2}$. *Solar erythema* is defined as the redness of the skin as an inflammatory response of the skin to solar radiation [5]. The production of an erythema depends on the type of radiation and its wavelength.

*Solar spectral irradiance* is the irradiance at horizontal plane that reaches the Earth surface in function of the wavelength. Its unit is $Wm^{-2}nm^{-1}$ or $Wm^{-2}\mu m^{-1}$. Figure 5 shows a graph of spectral solar irradiance in function of wavelength [6]. In this figure, the extraterrestrial irradiance (in black line) is the irradiance out of the atmosphere, the terrestrial total global irradiance (in blue line) is the irradiance in the total range that reaches the terrestrial surface and the terrestrial direct normal irradiance (in red line) is the irradiance that reaches the terrestrial surface that comes directly from the sun without suffering dispersion.

The solar spectral irradiance can be measured by a spectrometer that give us the solar intensity per wavelength. For example, the Avantes spectrometer, AvaSpec-ULS2048CL-EVO model, has the following characteristics: wavelength range from 200 nm to 1100 nm; a resolution less than 20 nm; a stray-light less than 1%; with a CMOS linear image sensor; with optic fiber.

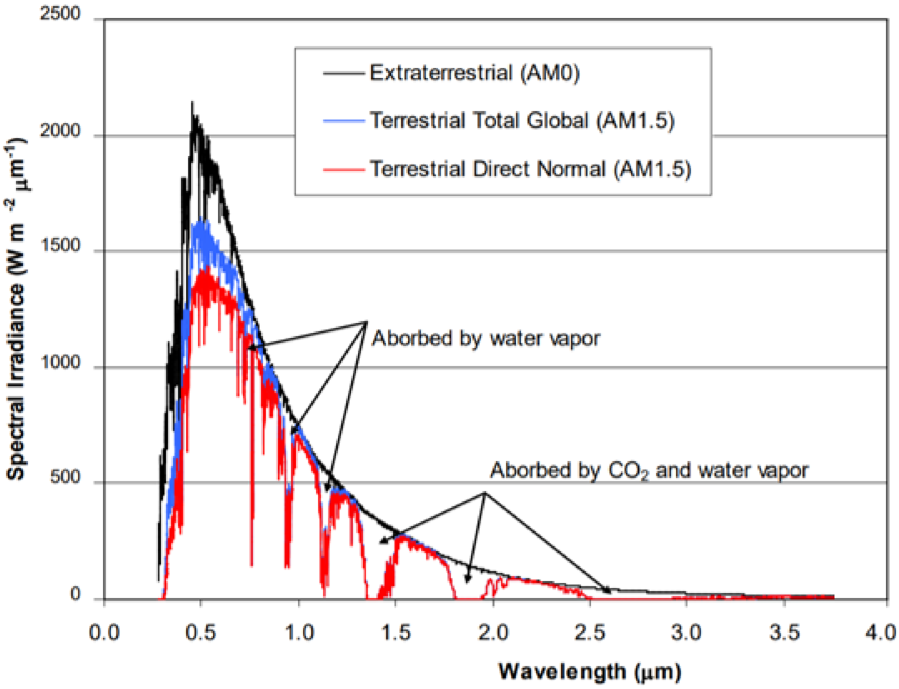


*Figure 5: Spectral solar irradiance in function of wavelength [6] .*

The MED and the UV index are very important in sun protection that allows to express the radiation risk with different approaches [5]. The *MED* or minimum erythemal dose is defined as the amount of ultraviolet energy to produce a minimum erythemal response and it depends on each type of skin. The *UV index* is a scale which shows the risk of biologically effective radiation, which can produce adverse effects on living organisms and thus promote sun protection [5]. Table 1 shows the scale of UV index in function of the category of risk.

| UV Index | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | <10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Category | LOW | | MEDIUM | | | HIGH | | VERY HIGH | | | EXTREME |

*Table 1: Uv Index scale according WHO/WMO.*

### 1.4 Treatments of psoriasis

According to Lapolla et al. [7], there are different treatments for psoriasis, but only one of them are especially used in Ecuador. The first is PUVA, which consists in the application of artificial UVA radiation with the use of a substance called psoralen (see Figure 6) that induce the apoptosis of cells.

This treatment has a good result in terms of skin lightening, but may cause some side effect, such as gastrointestinal disease due to the toxicity of the substance or the development of skin cancer [8].

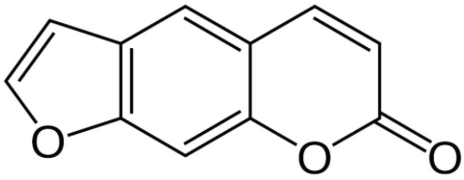


*Figure 6: Psoralen used in PUVA [3].*

The second treatment is with broadband UVB radiation, which uses the Goeckermann regime that consists of the use of tar with subsequent exposure to UVB radiation. According to Heckman et al. [8] , due to the toxicity effects, this treatment is not recommended.

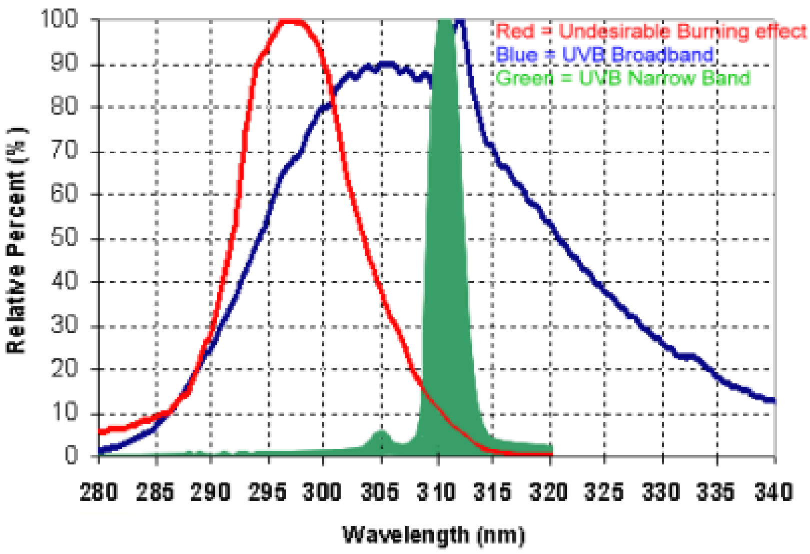


*Figure 7: Comparison between the UVB Broadband with UVB Narrowband treatment. Also, we can see the wavelength range of the undesirable burning effect [9]. Attwa E., Review of narrowband ultraviolet B radiation in vitíligo. World J Dermatol 2016 May 2; 5(2): 93-108*

Finally, the last treatment consists in the use of narrowband UVB radiation which uses artificial UVB radiation without any substance and obtains the same results as PUVA, but without side effects. Thus, this last treatment is the best way to treat psoriasis [7]. In the Figure 7, a comparison of UVB broadband (in blue line) with UVB narrowband (in green line) is can be seen, where the second has a shorter wavelength range than the first, so the time of exposure for the patient is small, the treatment is faster and it has fewer burning effects [9].

There are studies on the treatment of psoriasis using the climatotherapy technique, which consists in the use of suitable weather conditions for each case. The treatment consists of the solar exposure of the patient for an hour and a half, with increments every day as appropriate, where 45 minutes of exposure for the front of the body and another 45 min for the back for 15 days [10]. The use of this technique for treatment provides an average of 0.64 J / m$^2$ of UVB radiation for the first 10 days and a dose of 11.8 J / m$^2$ for the rest of the days. The treatment has better results in the clearance of the skin with respect to a treatment with pre-prescribed doses, but in turn it can cause side effects due to high doses, so it is advisable a pre-prescribed treatment [10].

### 1.5 Types of Skin

In the treatment of psoriasis, the skin phototype is very important because each type is based on the natural pigmentation of people and its reaction produced by the solar radiation exposure (tan or burn) and according Fitzpatrick it can be divided into six different types of skin (called phototypes) (see Table 2) [7]. Each has a different value of minimum erythemic dose (MED) [11].

| Skin Phototype | Effects | MED (in J m$^{-2}$) |
|---|---|---|
| I | Always burns and never tans | 200 |
| II | Usually burns and find it difficult to tan. | 250 |
| III | Mild burns sometimes and tans gradually. | 300 |
| IV | Burns rarely and easily tans. | 450 |
| V | Very rarely burns and easily tans. | 600 |
| VI | Never burns and tans very easily. | 1000 |

*Table 2: Different skin phototypes.*

### 1.6 Narrowband Treatment

According Lapolla et al. (2010), for the treatment with narrowband UVB, an initial dose of 0.7 MED is recommended for each type of skin and then increases from 10 to 20% in each session [7]. In the treatment of psoriasis, it is very important to consider the wavelength, the best range being from 296 nm to 313 nm [12].

Parrish and Jaenicke [12] showed that if wavelengths from 254 to 295 nm are used in the treatment, good results are not obtained because patients need a large number of sessions and high doses of energy that can produce side effects. However, using the range of 296 to 313 nm with a short number of sessions and low doses of radiation, the patient can reach a total clearance without problems.

| Treatment | |
|---|---|
| Starting dose | 0.7 MED |
| Frequency | Begin with 3 treatment per week, every other day up to 5 per week. |
| Increment | No erythema: Increase total dose by 30%.<br>Mild erythema: Increase total0 dose by 20%.<br>Moderate erythema: Repeat dose until erythema response diminishes, then start to increase again.<br>Severe Erythema: Stop until skin is fully recovered, then use 50% of last dose and increase by 10% increments thereafter. |
| End point | Treat until clinical remission, then stop irradiation. |

*Table 3: Treatment of psoriasis for Lapolla [7].*

Palmer et al. [13] found that patients with high phototypes adapt approximately the same as those with low phototypes in treatments that begin with 0.7 MED. The proposed treatment by Lapolla et al. [7] is showed in Table 3.

### 1.7 TUV MODEL

The TUV (Tropospheric ultraviolet radiation and visible radiation) model simulates the solar spectrum radiation and several outputs such us: UVB, UVA and visible irradiances, Photosynthetically active radiation, DNA damage irradiance, SCUP-mice and SCUP-human irradiances, standard human erythema irradiance, phytoplankton irradiance, cataracts in pigs irradiance, plant damage irradiance, previtamin-D3 irradiance, Non Melonoma Skin Cancer irradiance, etc. [14].

TUV models needs some entry parameters in order to modelling the atmosphere conditions and finally determine the value of irradiance in horizontal plane at sea level or any altitude. The model works with satellite measurements taking into account the total atmospheric ozone and cloud amount, to show a global climatology of total UV radiation that reach the surface of Earth [14]. This model uses the wavelength range of 121 to 750 nm and presents some features such as easy loading of weighting functions, temperature and pressure dependence, scattering by air, clouds and aerosols, absorption by oxygen ozone, and sulfur dioxide, among others [14].

### 1.8 EQUIPMENT TO PSORIASIS TREATMENT IN ECUADOR

Figure 8 shows a radiation chamber example used in CEDES, Ecuador. This equipment is a HOUVA II model (see Annex 1). This equipment has 85 inches of height (about 2.159 meters). It uses 48 UV-B Narrowband phototherapy lamps model Philips TL 100W/01 SLV/10 (see Annex 2). This type of lamps emits in the UVB range, in particular in the range 305-315 nm with a peak at 311 nm [15].

*Figure 8: UV chamber used in CEDES [9].*

One of the regulations is about of the correct functioning of the UV lamps used in the chambers due to they must produce the energy stipulated in the manual. A different energy can cause negative effects on the patient, so the use of an ultraviolet radiation sensor is necessary to monitoring the correct operation [16]. Each phototherapy lamp emits 100 Watts, and the manufactured proposes in the lamp manual that the lamp has a useful life of 1000 hours, with a depreciation at 1000 hours of 15%. Considering that the phototherapy is used 8 hours per day, 20 days per month, then in 6.25 months the lamp reaches the 1000 hours.

The system to measure the irradiance of this equipment will be presented in the present work, due to the irradiance chambers used in the treatment of psoriasis need to follow strict regulations to achieve positive effects on the patient, while ensuring its safety without side effects [17].

### 1.9 UV RADIATION SENSING

A transducer is a device that transforms one type of energy to another type. In order to traduce the irradiance parameter to and electrical data (voltage or current) it is necessary to find an adequate transducer. In the case of the phototherapy for psoriasis, the transductor must traduce irradiance (power per area unit, in $Wm^{-2}$) to voltage (in Volts) [16]. A different energy can cause negative effects on the patient, so the use of an ultraviolet radiation sensor is necessary to check the correct operation.

The system to measure the UV radiation from the lamps and determine its performance and the exposure time, needs of transductors that allows to convert the incident irradiance to an electrical parameter and uses its value to make calculations or show the information.

## 2. PROBLEM STATEMENT

According to CEDES [9] in Ecuador, no statistical data have been recorded on the cases of psoriasis in the country in the last years. The last data recorded was in 2002 where 290 patients with the disease were treated, and only patients of Hospital Carlos Andrade Marín of Quito were taken into account. Through a study carried out by the center of dermatological integral S.A. (Cadermint S.A.) it is known that there are currently approximately 100,000 Ecuadorians with this disease, where the majority of patients are in the age 40 to 60 years and with a predominance in the male gender [18].

Most of the cases of psoriasis in Ecuador have not been treated for two reasons. The first reason is that due to the use of artificial sources of UV radiation and that several treatment sessions are needed for total clearance. The cost of treatment is high around $ 3,500 per month [18]. So, people do not have financial resources to access it. The second reason is that most people are located in places where accessing a medical center with the necessary equipment for treatment is very difficult, in addition to the fact that in the country it only has two private centers specialized, located in Quito and Guayaquil, in the treatment of psoriasis and Public hospitals do not have the equipment to treat this disease [18].

On the other hand, Medical Centers located in Ecuador not possess a control by the appropriate entities so, there is no information about if the used biomedical equipment emits the necessary radiation for treatment or otherwise if it emits a high radiation that may cause adverse effects on patients. In addition, the equipment can be used in a wrong way due to lack of information or practice by specialists who handle them.

For the previously mentioned reasons, this study proposes a solution to the problem. Through the calculation of solar energies, we propose to use solar radiation as an alternative treatment for psoriasis for the city of Ibarra (0.366 °N, 78.11 °W). In order to determine the available solar irradiance resource (power per unit area) the TUV (Tropospheric ultraviolet radiation and visible radiation) model was selected. It was created by Madronich [14]. This model allows to calculate the solar erythemic spectral irradiance (depending on the wavelength) using certain input parameters: latitude, longitude, altitude, date and time, surface albedo, in addition to certain atmospheric data, such as total ozone column and optical depth of aerosols. Also, this model provides irradiation values: erythemic, DNA damage, cataracts and non-melanoma skin cancer.

Finally, the use of a radiation monitor created from electronic sensors mentioned in the introduction, will allows us to carry out a control of the specialized equipment in the treatment, in this case of UVB chambers. The dermatological center Cadermint SA of Quito is the closest to the city of Ibarra where the study was carried out, so the measurements with the developed sensor were carried out in this medical center, where the intensity of the radiation produced in the chambers and the quality of the equipment was determined.

## 3. OBJECTIVES

### 3.1 General Objective

- To develop a system to measure the performance of phototherapy for psoriasis, to determine the exposure time of session of these phototherapies.

- To develop an alternative treatment for psoriasis by modeling solar radiation in order to replace the artificial sources of UV radiation used in specialized centers, establishing the value of the radiation intensity necessary to start the treatment for three skin phototypes predominant in Ecuador.

### 3.2 Specific objectives

- To design and implement a UV radiation system that measure the power of phototherapies of psoriasis that patients receive in their treatment in specialized centers, in order to determine the evolution of performance of these lamps.

- To design and implement a UV radiation system that determine the adequate exposure time in real time that the patients receive in their treatment for psoriasis, in independence of the performance of the used lamps.

- To determine the time required for sun exposure to obtain the same results in the treatment of psoriasis, taking into account the climatic conditions of the area where the study is conducted and the different aspects that influence the treatment such as skin phototype, initial dose and increments in each session.

## 4. MATERIALS AND METHODOLOGY

### 4.1 Psoriasis treatment with solar radiation

Atmospheric and meteorological data were obtained in order to use as entries for TUV model. The required atmospheric parameters are: the total column of ozone and the optical depth of aerosols. They were obtained from the Giovanni/NASA satellite data base. With regard to the meteorological data such as: relative humidity, temperature acquired at 2 meters, precipitable water and albedo were obtained from the POWER Project data base from NASA [19]. Finally, carbon dioxide data was obtained through from the website of NOAA (National Oceanic and Atmospheric Administration).

One of the possible results of TUV model is the erythemal irradiance and it was calculated in first day and in the middle of each month ($1^{st}$ and $15^{th}$) of 2018 using the latitude and the longitude of Ibarra (0.366°N, 78.11°W), see the Table 4. Also, these determinations were carried out for the forty minutes around the solar noon. It is important to highlight that the condition of sky for these calculations was of clear sky, i.e. with a cloudiness less than 25%. Once the irradiances have been calculated, the most representative days of the year were determined: the day with the highest radiation and the day with the lowest.

| Day | Month | Erythemal Solar Irradiance ($W/m^2$) |
|---|---|---|
| 01 | January | 0.41 |
| 15 | | 0.43 |
| 01 | February | 0.49 |
| 15 | | 0.51 |
| 01 | March | 0.53 |
| 15 | | 0.48 |
| 01 | April | 0.48 |
| 15 | | 0.46 |
| 01 | May | 0.43 |
| 15 | | 0.40 |
| 01 | June | 0.39 |
| 15 | | 0.38 |

| Day | Month | Erythemal Solar Irradiance ($W/m^2$) |
|---|---|---|
| 01 | July | 0.35 |
| 15 | | 0.39 |
| 01 | August | 0.37 |
| 15 | | 0.40 |
| 01 | September | 0.41 |
| 15 | | 0.42 |
| 01 | October | 0.43 |
| 15 | | 0.42 |
| 01 | November | 0.45 |
| 15 | | 0.43 |
| 01 | December | 0.41 |
| 15 | | 0.40 |

*Table 4: Results of TUV model*

The erythemal irradiances are then integrated in function of time in order to find the exposure time corresponding to 1 MED and to 0.7 MED. All these calculations were obtained for the phototype I, III and IV case, and this implies a MED value between 250 to 1500 $Jm^{-2}$ [11]. Also, the calculations for the increments depending on the phototype and the erythema observable in the patient, whether 20 or 30%.

In addition, the possibility of a cloudy sky was considered. For this, measurements of erythemic solar irradiance in the city of Ibarra [20] were considered and the value of the optical depth of the cloud layer was modeled with the TUV model and applied to the days analyzed. In this way a new time interval could be obtained that completes the dose necessary for the treatment of the pathology.

Once this information was available, the energies of various biological effects, such as DNA damage, cataracts and non-melanoma skin cancer, were determined. It is considered extremely important to determine the biological side effects that sun exposure brings, and whose objective tissues are the eyes and skin.

### 4.2 SUNMED system design

The SUNMED system will consist of two big blocks:

1- An ultraviolet sensor that determines the evolution of output of power in the phototherapy chamber that allows monitoring the performance of the equipment;

2- An UV index sensor in real time that calculates the dose that the equipment delivers and calculate the required exposure time for the real output of the lamps.

In order to design this complete system, it is necessary to follow some steps. The first necessary step is to find the adequate transducer. This design also needs of the development a software that acquires the radiation data, calculates the doses and shows the information to the user.

#### 4.2.1 Transducers

The first step was to decide what kind of transducer is needed. In the first case, it is necessary an ultraviolet transducer that absorbs light in the wavelength of emission of lamps or near of it. In this case, it was necessary to consider that the wavelength in the emission peak of the lamps is at 311 nm. For this purpose, the selected UV transducer was the ML8511 with a spectral response range between 280-390 nm, and is mainly used to obtain ultraviolet intensity from a source in relation to its output voltage (see Figure 9, Left) [21]. The spectral responsivity of this transducer is shown in figure 10.


*Figure 9: Left: UV Sensor ML8511 [22]. Right: UV Sensor GUVA-S12SD [23].*

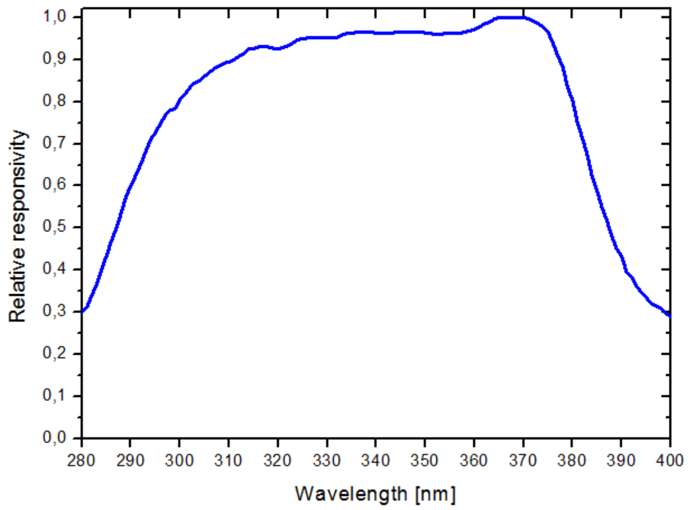


*Figure 10: Spectral responsivity ML8511 [22].*

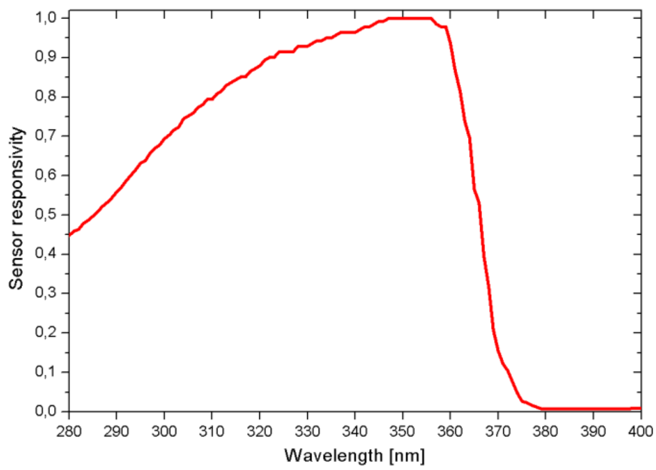


*Figure 11: Spectral responsivity GUVA S12SD [23].*

According Lapolla et al., for the treatment with narrowband UVB, an initial dose of 0.7 MED is recommended for each type of skin and then increases from 10 to 20% in each session [7].

### 4.2.2 Board design

The transducers itself are used with an electronic board, which is an open source electronic platform based on hardware and software [24]. The main function of Arduino boards is read one type of input such as light of a sensor or a finger on a button and convert it into an output such as activating a motor or turning on an LED [24].

In this project, the input is the light captured by the ultraviolet sensor and the voltage intensity data as output, this is carried out by a programming code with Arduino language to send instructions to the microcontroller board [24]. Both sensors are inside a circuit consisting mainly of an amplifier and a photodiode (Figure 12) [22, 25], where the amplifier is responsible for transforming a photo-current into a voltage level [22]. On the other hand, the photodiode produces a current through the excitation of light [26].

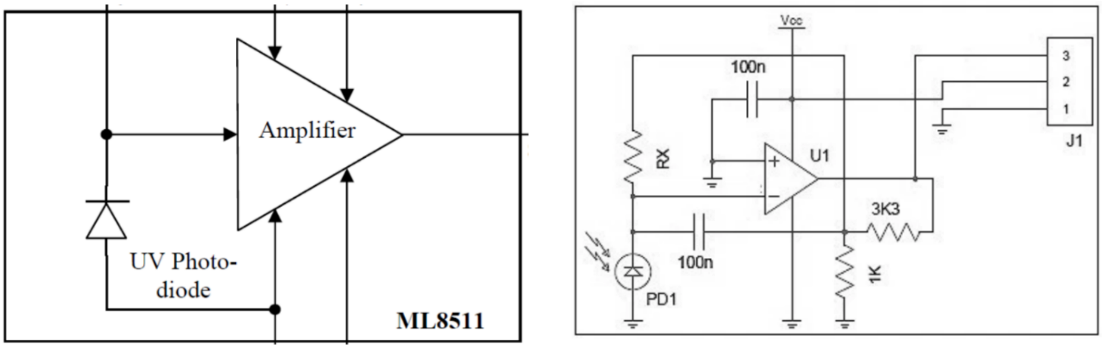


*Figure 12: Left: Circuit of sensor ML8511 [22]. Right: Circuit of sensor GUVA S12SD [25].*

Another part of the final circuit is the display 16x2 I2C (see Figure 13). It is a display of 16 characters and two lines with a blue backlight and white letters connected to a bus that facilitates communication between other devices such as microcontrollers or memories, and it only requires two signal lines and a voltage source [27].

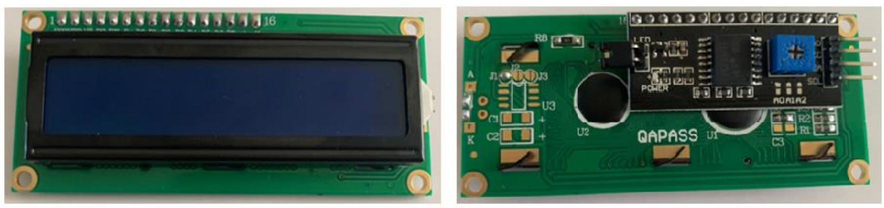

*Figure 13: Right: Display. Left: Bus I2C [14].*

In order to design an UV sensor for measure the phototherapy UV radiation, an electronic experimental board was designed which includes the selected transducers. In addition, the Arduino board is connected to a computer to visualize the data obtained.

The UV sensor included not only the hardware, but also an algorithm must be introduced in the Arduino software for each of the sensors to take the necessary measurements in each case. As mentioned earlier, the ML8511 sensor shows the intensity of the radiation exposed by means of the code proposed by the sensor's Data Sheet [21], while the second GUVA S12SD sensor shows the UV index with the algorithm proposed by its data sheet [23]. The UV index is used to obtain the erythematic irradiance, which helps to obtain a control of the time necessary to reach the dose of the treatment and not allow a lack or overexposure during the use of the UVB chamber. This process takes into account the skin phototype and the number of sessions to stablish the necessary dose. Table 5 shows how the algorithm works to interpret the corresponding UV index.

| UV Index | Vout (mV) |
|---|---|
| **0** | <50 |
| **1** | 227 |
| **2** | 318 |
| **3** | 408 |
| **4** | 503 |
| **5** | 606 |

| UV Index | Vout (mV) |
|---|---|
| **6** | 696 |
| **7** | 795 |
| **8** | 881 |
| **9** | 986 |
| **10** | 1079 |
| **11** | 1170 + |

*Table 5: Vout corresponding to UV index.*

The display is connected to the Arduino board to show the data of UV intensity obtained through ML8511 sensor and UV Index through GUVA S12SD. In the Figure 14 it can be seen the diagram of Sunmed Sensor.

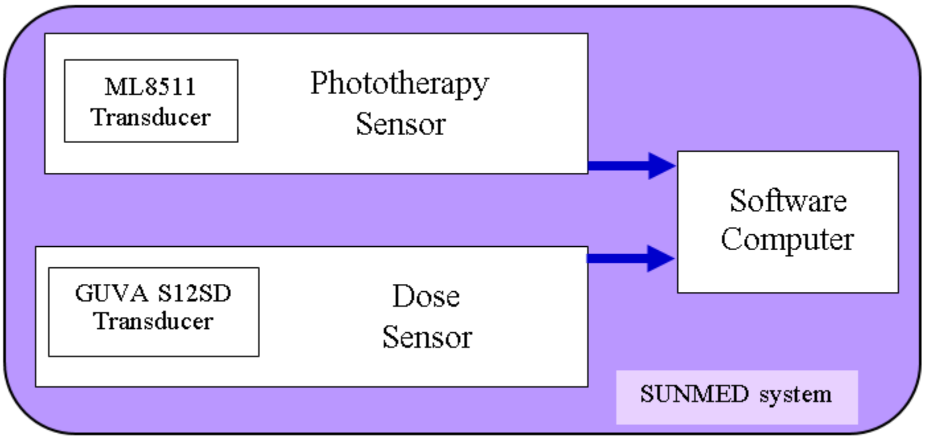


Figure 14: Diagram of complete Sunmed sensor.

To conclude and create a web page without domain, it is necessary applications to create a server in the Internet network that shows the data obtained by the ML8511 sensor. The application used is Amazon WSS that allows to obtain an instance for the creation of the server. Subsequently, the server is created from a web development framework called Django that uses the Python programming language. Then, in the program, a script is created with the data obtained from the sensor. Finally, Putty program is used to create a file with the last data of the script and upload to the server created before, so the data is showed in the web page.

## 4.3 Sensor calibration

### 4.3.1 The pattern sensor

The EVSpec-ULS4096CL series EVO (see Annex 3) spectrometer is an electronic device that allows the measurement of absorbance, transmittance and absolute or relative irradiance of a radiation source; this device works with a wavelength range from 200 to 1100 nm comprising ultraviolet, visible and infrared radiation. In order to carry out the measurements with this device, it is necessary to establish a dark measurement (in which it is not subjected to any radiation) and a reference measurement (that allows to obtain a representation of the measurements in the whole mentioned range) [28]. The Avantes spectrometer can be used like a pattern sensor because it was calibrated recently and it has a resolution of 375,000 counts per µW per ms integration time.


*Figure 15: Avantes spectrometer.*

### 4.3.2 The calibration processes

Once that the sensor is designed and implemented, the following step is to obtain the calibration curve of ML8511 transducer. For this purpose, it is necessary to measure with our sensor board and another sensor (a pattern) which output be already calibrated. For this objective, measurements of spectral solar irradiance were made with an AvaSpec-ULS2048CL-EVO spectrometer, Avantes, whose owner is the University Yachay Tech. Measurements with transducer and the spectrometer at the same time were made.

Then, the spectral responsivity graph of the ML8511 sensor is digitized to combine them with the spectrometer data. The combination of solar spectral irradiance and the spectral responsivity of the sensor will permit to obtain the effective spectral irradiance that measures the sensor. Then, the integration of the effective spectral irradiance will give the effective irradiance that measure the sensor.

The comparison between this last value and the value of sensor output will be made in order to obtain a factor or function of calibration.

## 5. RESULTS, INTERPRETATION, AND DISCUSSION

### 5.1 Solar radiation in Ibarra and its equivalent to phototherapy

Figure 16 shows the calculated erythemal solar irradiance for the city of Ibarra with the TUV model. It is clear that March 1st has the highest radiation (0.53 [$Wm^{-2}$]) and July 1st is the day that has less (0.35 [$Wm^{-2}$]). The annual average is around (0.43 ± 0.05) [$Wm^{-2}$].

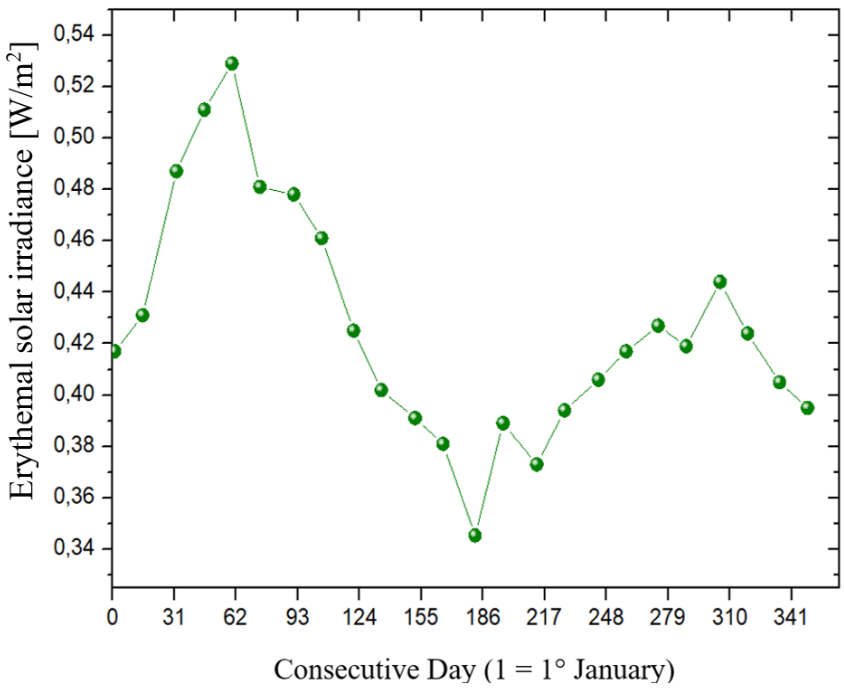


*Figure 16: Annual evolution of erythemal solar irradiations for the city of Ibarra obtained with the TUV model.*

Solar noon occurs at 12:21 local time in the case of March 1 and at 12:16 local time in the case of July 1. A DEM of 300 $Jm^{-2}$ (lower limit of the range suggested by Parrish and Jaenicke) was considered for a skin phototype III and the integration was made as a function of the time of the erythemal solar irradiance, around the solar noon of both. The calculation was also repeated for a dose equal to 210 $Jm^{-2}$ (0.7 DEM).

All calculations were repeated for phototypes I and VI, which are the minimum and maximum phototypes in order to get an idea of the limits in the time intervals to consider in the treatment proposed. In the first case, a DEM dose of 200 $Jm^{-2}$ and 0.7DEM of 140 $Jm^{-2}$ was considered. In the case of phototype VI, the value of 1000 $Jm^{-2}$ and 0.7 DEM the value of 700 $Jm^{-2}$ was taken as the DEM dose. The results are shown in Table 6.

| DATE | PHOTOTYPE | 1 DEM | | 0.7 DEM | |
|---|---|---|---|---|---|
| | | HOURS | MIN | HOURS | MIN |
| 15 March | I | 12:17 to 12:26 | 9 | 12:19 to 12:25 | 6 |
| | III | 12:16 to 12:27 | 11 | 16:17 to 12:25 | 8 |
| | VI | 11:53 to 12:50 | 57 | 12:02 to 12:42 | 40 |
| 1 July | I | 12:11 to 12:23 | 12 | 12:13 to 12:21 | 8 |
| | III | 12:10 to 12:24 | 14 | 11:11 to 12.21 | 10 |
| | VI | 11:41 to 12:54 | 73 | 11:51 to 12:42 | 51 |

*Table 6: Recommended exposure times to obtain the desired dose.*

As can be seen in Table 6, there is a large dispersion of time intervals according to the phototype. Considering only phototype III, typical in Latin America and Ecuador, it is a range of 8 to 10 minutes, where the sun could cover the needs of a psoriasis treatment for phototype III with a dose of 0.7 DEM.

In the case of phototype I (the lightest skin of the Fitzpatrick classification), with 8 to 6 minutes of exposure the sub-dose is covered and in the case of phototype VI (the darkest skin) the times extend to the range of 40 to 51 minutes of treatment.

According to Lapolla et al. [7], the increments for each session depend on the erythema observed in the patient, so they can be 30%, 20% or none. Taking into account that the dose of 20% and 30% for each phototype are the following:

| PHOTOTYPE | 20% DOSE ($Jm^{-2}$) | 30% DOSE ($Jm^{-2}$) |
|---|---|---|
| I | 28 | 42 |
| III | 42 | 90 |
| IV | 140 | 210 |

*Table 7: Increment Doses.*

Table 8 shows the dose corresponding to each percentage and the time to which it is equivalent in each of the days.

| DATE | PHOTOTYPE | 20% | 30% |
|---|---|---|---|
| | | MIN | MIN |
| 15 March | I | 1 | 2 |
| | III | 2 | 2 |
| | VI | 8 | 12 |
| 1 July | I | 2 | 2 |
| | III | 2 | 3 |
| | VI | 10 | 15 |

*Table 8: Increment time.*

Table 9 shows the corresponding dose with increments of 20% according to the session number.

| PHOTOTYPE | SESSION (s) | DOSE ($Jm^{-2}$) |
|---|---|---|
| I | Initial (1) | 200 |
| | 2 | 228 |
| | 3 | 200 + ((s-1) *28) |
| III | Initial (1) | 300 |
| | 2 | 342 |
| | 3 | 300 + ((s-1) *42) |
| VI | Initial (1) | 1000 |
| | 2 | 1140 |
| | 3 | 1000 + ((s-1) *140) |

*Table 9: Dose per session.*

Subsequently, the possibility of a cloudy sky was considered. For this, measurements of erythemic solar irradiance in the city of Ibarra [20] were considered, in particular the data of September 3, 2017 at 1:20 p.m. because this day present a very high cloudy condition. The value of the optical depth of the cloud layer was modeled with the TUV model resulting in a value of 21.6. This value was applied to the days analyzed for the case of phototype III. The resulting intervals can be seen in Table 10, where the sub-dose

(0.7 DEM) would be covered with 20 to 26 minutes of sun exposure on a cloudy day. This implies an increase in exposure time by a factor of 2.5 and 2.6 in the case of March 15 and July 1, respectively.

| DATE | PHOTOTYPE | 1 DEM | | 0.7 DEM | |
|---|---|---|---|---|---|
| | | HOURS | MIN | HOURS | MIN |
| 15 March | III | 12:08 to 12:37 | 28 | 12:12 to 12:32 | 20 |
| 1 July | III | 11:41 to 12:19 | 38 | 11:47 to 12:13 | 26 |

*Table 10: Recommended exposure times to obtain the desired dose considering a cloudy situation.*

Once the time necessary to cover the DEM and the sub-dose to begin the treatment (0.7 DEM) was determined, the energy (or dose) for each type of biological effect analyzed in said time interval was calculated for the case of clear sky day. These results can be summarized in Table 11. The energy decrease ratio of each biological effect when reducing the DEM was 27.27% for March 15 and 28.56% for July 1, for all effects.

| DATE | DOSE [J/m$^2$] | CATARACTS | NO-MELANOMA SKIN CANCER | DNA DAMAGE |
|---|---|---|---|---|
| 15 March | 1 DEM | 866.04 | 631.28 | 8.62 |
| | 0.7 DEM | 629.88 | 459.17 | 6.27 |
| 1 July | 1 DEM | 874.08 | 635.48 | 8.01 |
| | 0.7 DEM | 624.48 | 453.99 | 5.72 |

*Table 11: Dosage of biological effect with the suggested doses.*

As can be seen in Table 11, the energies (or doses) of cataracts are about one hundred times higher than those of DNA damage. Unfortunately, no information was found in the literature regarding the limit energies for these biological effects, so a further analysis of their danger degree is recommended.

## 5.2 SUNMED system

### 5.2.1 Design and implementation of SUNMED system

As it was explained before, the SUNMED system will consist of two big blocks or components:

1- A *phototherapy sensor* that monitors the evolution of performance of lamps sensor. This stage contains the ML8511 transducer and gives the power emitted by lamps. The software shows and stores the evolution of this parameter.

2- A *dose sensor* that determines required exposure time for the real output of the lamps. This stage contains the GUVA S12SD transducer and gives the energy (dose) emitted by the lamp. The Software calculates the exposure time for each case.

### 5.2.2 Sensor and display software implementation

This algorithm is shown in Figure 17. The program starts including the libraries necessary for software development; then the variables are defined and initialized. After, the data are obtained from the sensors transforming them into the analog signals using the formulas proposed by the Arduino page and using calibration curve of this transducer (that will be determinate forward), while the data of GUVA S12SD use the calibration curve of Figure 18 to establish the correct UV index. The next step is to read the transformed data. The data obtained with their respective units is then printed, but for the ML8511 sensor, an average is made of 8 measurements for printing. Finally, the data is sent to the display for presentation with its respective movement.

### 5.2.3 Sensor for dose software implementation

This algorithm is shown in Figure 19. To start this software, the variables to be used during the process are defined; then they are initialized. Later, the values obtained by the sensor are read and the transformations are performed. Then the data is entered by the user of the phototype and session number. It is also determined the DEM value for the treatment of each of the phototypes and the values to be added depending on the session number. The program receives the voltage output produced by the sensor to perform the calculations of the irradiance emitted by the source using the different conditions, to establish the corresponding UV index with an average of 8 measurements and so, to obtain the irradiance using the formula of the same that divides the UV index with a constant of 40 $Wm^{-2}$. It can be seen in the Figure 20 the dose program.

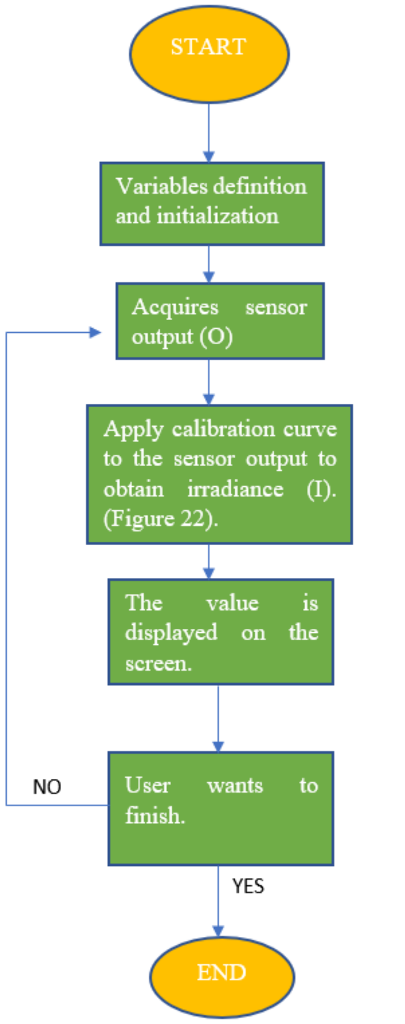


*Figure 17: Pseudocode for irradiance and UV Index software.*

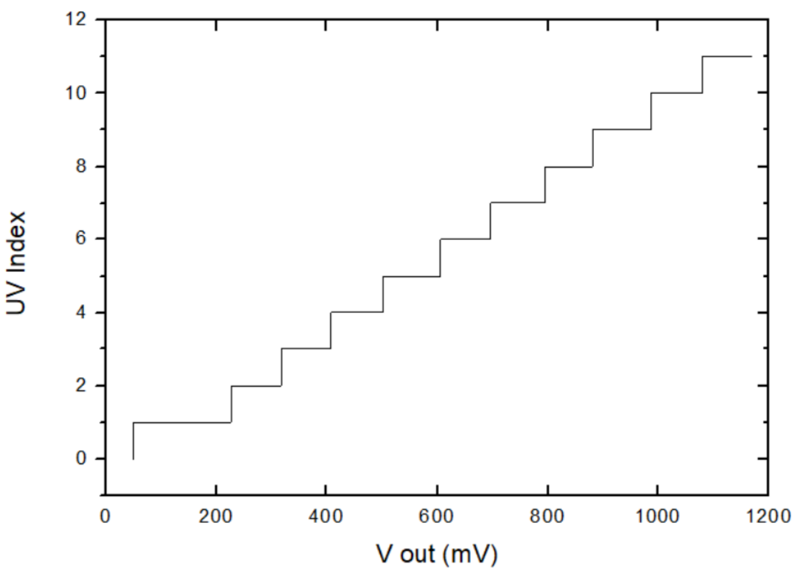


*Figure 18: Calibration curve GUVA S12SD*

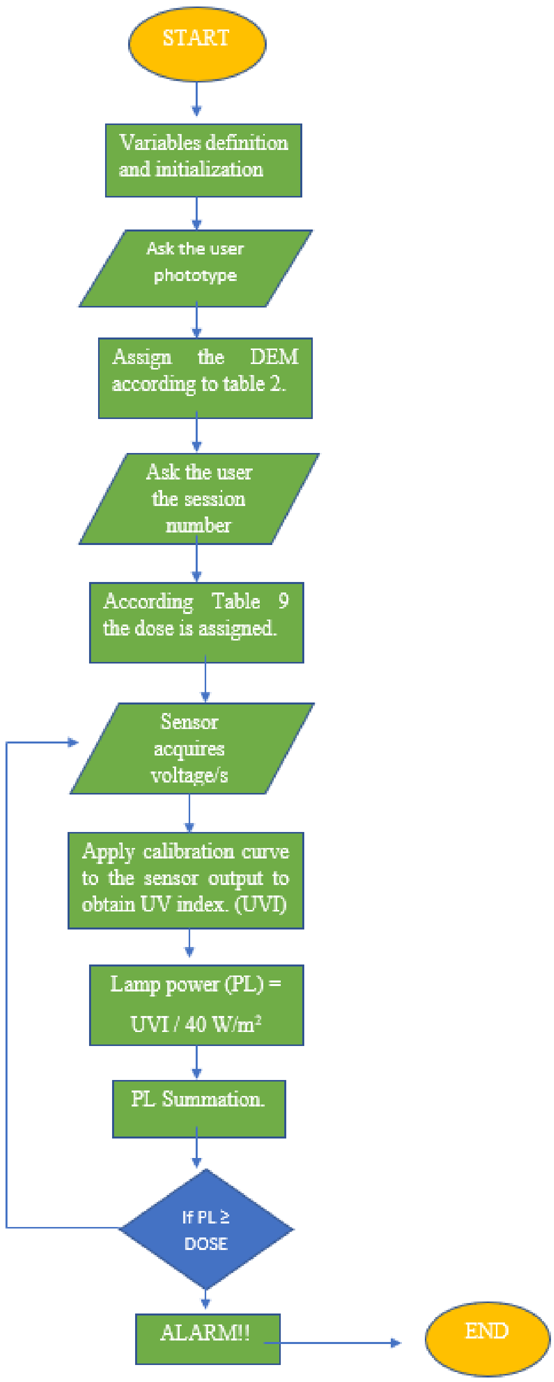


*Figure 19: Pseudocode for dose calculation software.*

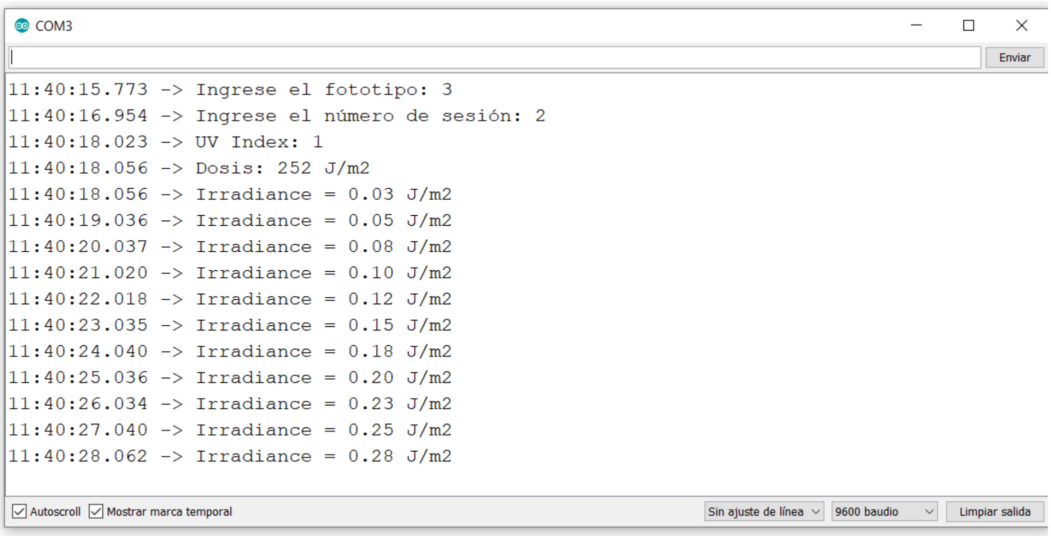


Figure 10: Dose program.

At this point, the dose value is established according Table 9. Finally, the sum of the irradiance value obtained by the sensor is performed every second until it reaches the dose value and its impression on the monitor. This software helps to calculate the necessary dose for a patient with psoriasis quickly depending on their skin phototype and the session number of the treatment, at the same time allowing to assure that the dose will receive will be the correct one, despite some malfunction of some UVB chamber lamp.

### 5.2.4 Calibration of phototherapy sensor (with ML8511 transducer)

On January 24$^{th}$ at 9am and on February 5$^{th}$ at 12:15 pm, solar spectral irradiance was measured with the Avantes spectrometer and the SUNMED system. Figure 21 shows the example of solar spectral irradiance measured on January 24$^{th}$ at 9 am in black line, and the result of the solar spectral irradiance absorbed by the ML8511 sensor (violet line) modeling through the application of the sensor responsivity curve (red line). At the same time that the solar spectral irradiance was made, the ML8511 sensors measurement were obtained. The corresponding measurement of the ML8511 sensor for this case was 5.9 $mWcm^{-2}$.

This method of modeling the solar spectral irradiance absorbed by the ML8511 sensor consists in the product wavelength by wavelength of solar spectral irradiance and the sensor responsivity curve.

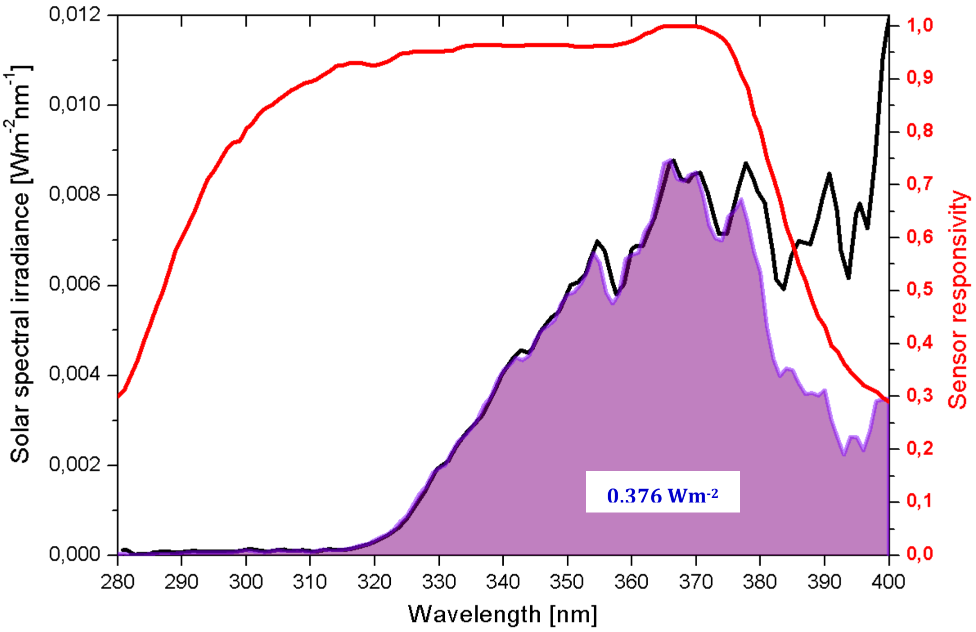


*Figure 21: Solar spectral irradiance measured on xxx at xxx with the Avantes spectrometer (black line), ML8511 sensor responsivity (red line) and the solar spectral irradiance that the sensor absorbs (violet line). The violet area represents the integral in wavelength of the violet curve and its value is 0.376 Wm$^{-2}$.*

Then, the solar spectral irradiance absorbed by the ML8511 sensor is integrated in wavelength; in this case the result is 0,376 Wm$^{-2}$ (see the violet area in Figure 21).

If this technique is repeated with each measurement, and compared with the corresponding measurement obtained by the photosensor, we can obtain the calibration curve. The importance to compare the sensors measurements with the Avantes spectrometer is about of the last is a pattern meter because this sensor was calibrated recently.

In order to achieve the calibration curve, the measured data in each day were averaged and the results are:

- January 24th at 09:00 measurement modelled with Avantes spectrometer = (0.37 ± 0.12) Wm$^{-2}$ and measurement with ML8511 sensor = (60.68 ± 3.00) Wm$^{-2}$.
- February 5th at 12:00 measurement modelled with Avantes spectrometer = (0.42 ± 0.03) Wm$^{-2}$ and measurement with ML8511 sensor = (168.54 ± 11.39) Wm$^{-2}$.

These averaged data appear like red stars in Figure 22. Also, Figure 22 shows the calibration curve of ML8511 sensor.

$$Irrad_{UV\ PHOTOTHERAPY} = 0.341872 + 0.000464 \cdot Irrad_{ML8511}$$

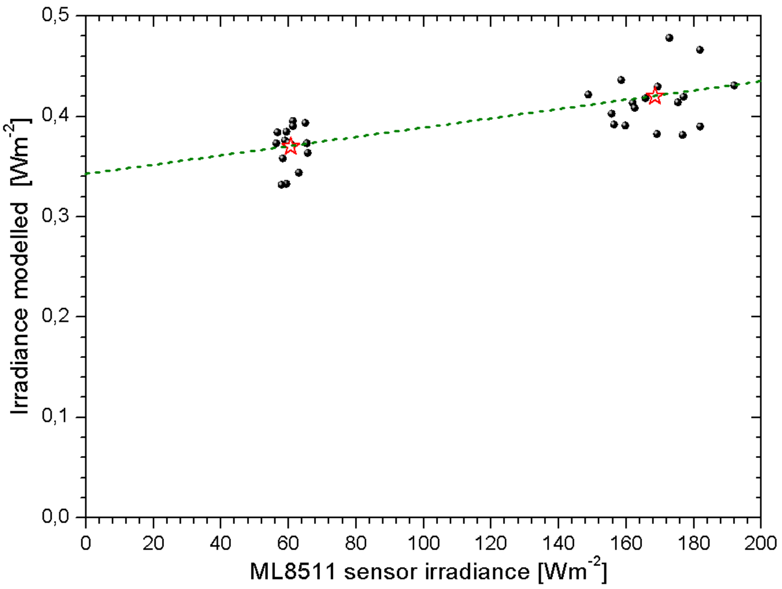


*Figure 22: Calibration curve (in green line) that related the irradiance measured with ML8511 sensor and the irradiance modelled by Avantes spectrometer (in filled black circles). Average data measured on the same day (In red stars).*

As it can be seen, the calibration function that links the irradiance obtained by the spectrometer and the sensor is a linear function, then it is necessary to calculate the slope (m) and the intersection with vertical axis (b). In this sense, the obtained values are: m = 0.000464 and b = 0.341872. This function can be seen in green line in Figure 22.

Price is a very important factor when we compare the proposed treatment with the treatments that are currently used. The treatment offered by medical centers in the country has an average price of 1500 dollars per month, while the proposed treatment does not have a cost, so this benefits people with scarce economic resources.

## 6. CONCLUSIONS AND RECOMENDATIONS

Erythemal irradiances provided by the sun were calculated for the city of Ibarra in the 2018 to determine the extreme exposure times (maximum and minimum) necessary to cover the dose recommended by Lapolla et al. [7] in a psoriasis treatment in the case of a patient with phototype I, III and IV, with their respective increments between each of the sessions. In addition, irradiances of certain biological effects that could occur in direct exposure to the sun (DNA damage, cataracts and non-melanoma skin cancer) were modeled.

The proposed treatment has advantages compared to the treatment that uses climatotherapy, because a protocol already adapted to psoriasis patients is used and there is no overexposure, at the same time it does not cause adverse effects, while treatment with climatotherapy can cause these problems.

For the implementation and design of the SUNMED sensor, the ML8511 and GUVA S12SD sensors were chosen as they are the easiest sensors to use in an electronic system, while they are the sensors with the best response to ultraviolet radiation found in the country market. The implementation of a software for the ML8511 sensor helps to obtain the intensity at which a patient with psoriasis undergoes in a UVB chamber, and thus control if it is adequate for treatment avoiding adverse effects and early clearance, in addition to inspecting the correct operation of each lamp included in the UVB chamber (called *phototherapy sensor*).

The implementation of a software with the GUVA S12SD sensor is complementary to the software of the other sensor because it allows to quickly calculate the necessary exposure time at real time for a patient with psoriasis depending on their skin phototype and the treatment session number, at the same time as ensures that the dose that will be received by patient will be the correct one, despite some malfunction of a UVB camera lamp.

## Future work and recommendations

It is essential to improve the electronic system of the SUNMED sensor because the use of an Arduino board with a computer makes it difficult to handle it inside a UVB chamber or to carry out measurements, so it is recommended to use a programmable integrated circuit that facilitates the use of the SUNMED sensor and fulfills the same functions as the arduino board and the computer.

It is the first time that studies are carried out for the development of a treatment for psoriasis using solar radiation, so carrying out more measurements during the year is essential due to they are only taken two days of the year, at the same time as performing the same studies for phototypes II, IV and V, obtaining a more complete treatment. Setting radiation limits for possible biological effects is also necessary as they can be a negative treatment factor.

The treatment presented can be complemented with some techniques for better results. Studies have been carried out that submit psoriasis patients in water baths from volcanoes, in addition to the use of mud on the skin. The combination of this technique with the proposed treatment may be a better alternative for patients and achieve better results in skin clearance.

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# 8. ANEXXES

## ANEXX 1:

HOUVA II®

con Tecnología PhotoSense®

117cm (46") de Anchura

124 cm (49") de Profundidad

216 cm (85") de Altura Total

191 cm (75") de Altura de la Puerta

58 cm (23")

ANCHO APROXIMADO CON LA PUERTA ABIERTA ES 178 CM (70")

**¡Su mejor oferta!**

Houva II® es el pináculo de la tecnología en fototerapia del líder en dispositivos fototerapéuticos: National Biological Corporation.

- Control de exposición PhotoSense® para un manejo preciso en el tratamiento
- Elementos de seguridad sin igual que incluyen un circuito protector a prueba de averías
- Seis configuraciones de lámparas, incluida la de 311nm de banda estrecha y la de UVA-1
- Compromiso a un servicio continuo y excelente con nuestra garantía de respaldo total y nuestra línea de ayuda gratuita
- Se incluyen dispositivos externos de medición sin costo adicional (pueden usarse con todo el equipo de fototerapia)
- Línea completa de accesorios fototerapéuticos en existencia en todo momento

NATIONAL BIOLOGICAL

23700 Mercantile Road, Beachwood, OH 44122 USA
Phone: 00 1 216-831-0600 — Fax: 00 1 216-765-0271
Email: info@PhototherapyExperts.com
Web: www.PhototherapyExperts.com

**ESPECIFICACIONES**

ESPECIFICACIONES ELÉCTRICAS

- 120/240 V, 3 cables, monofásico, neutro sólido, 50/60 Hz. Se requiere un cuarto cable (verde) para conectarlo a una tierra aislada.
- 30 amperios por clavija.
- 3 metros (10-pies), 4 conductores #10 AWG se incluye cable de alimentación en cada unidad.
- Base internacional opcional 220-240 V, 50/60 Hz.

Nota: Para otros sistemas y voltajes de suministro, incluido el uso internacional, comuníquese con National Biological Corp.

CERTIFICACIÓN ELÉCTRICA

- Certificada según la Canadian Standards Association y CMDCAS
- National Biological Corp. es un sistema de calidad con certificación ISO-13485

DIMENSIONES (anchura x altura x profundidad)

117 x 124 x 216 cm (46" x 49" x 85")

GARANTÍA

- Todas las partes (exceptuando las lámparas) tienen una garantía gratuita de reemplazo de 5 años. Todo trabajo tiene una garantía de 5 años, "SIN CARGO" a partir de la fecha de instalación para reposición.
- También hay garantías extendidas disponibles.
- Las lámparas tienen una garantía de 90 días.

LÁMPARAS

- Opción 1: 36 lámparas F72T12 BL/HO UVA y 12 lámparas FSX72T12 UVB/HO BB UVB
- Opción 2: 48 lámparas F72T12 BL/HO UVA
- Opción 3: 48 lámparas UVA-1 F72T12BL9/HO
- Opción 4: 12 lámparas FSX72T12/UVB/HO BB UVB y 36 lámparas TL100W/01 FS 72 311-NB UVB
- Opción 5:48 lámparas TL100W/01 FS 72 311 NB UVB

*National Biological solo usa lámparas de UVB de banda estrecha marca Philips TL*

- Opción 6: 24 lámparas F72T12 BL/HO UVA y 24 lámparas TL100W/01 FS 72 311-NB UVB

Todos los productos se envían F.O.B. Beachwood, OH.

H2-1210-Sp
© 2010 National Biological Corp.

HOUVA II®

Sistema Fototerapéutico con Tecnología PhotoSense®

NATIONAL BIOLOGICAL

S.E.E. The Light!

SEGURO, EFECTIVO Y ECONÓMICO

HOUVA II®

**Características del Houva II®**

- Utiliza un circuito protector a prueba de averías que automáticamente apaga el dispositivo si percibe un posible funcionamiento defectuoso.
- Interruptores de encendido y apagado con llave para seguridad.
- Visor con cristal contra rayos UV para comodidad del paciente.
- Perímetro exclusivo de flujo de ventilación para comodidad del paciente.
- Paneles de reflexión completa para maximizar la salida de las lámparas.
- Piso elevado para el tratamiento apropiado de la parte inferior de la pierna.
- Barandillas de mano para seguridad del paciente.
- Tapete antideslizante para seguridad del paciente.
- Pantallas sólidas para proteger las lámparas.

Características

***Control de exposición PhotoSense®***

*Para asegurar la precisión en el tratamiento*

Como el Houva II® tiene controles de exposición PhotoSense® separados para luz UVA y UVB y dispositivos de medición de luz UVA y UVB, usted y sus pacientes se benefician de un tratamiento preciso sin importar el régimen que se elija. Como medida adicional de seguridad, se puede reajustar un tiempo máximo de exposición para minimizar el riesgo de sobreexposición.

**Las ventajas de National Biological**

- Personal experimentado de profesionales de ingeniería de tiempo completo expertos en tecnología UV
- Instalación en el sitio y capacitación en el funcionamiento y los beneficios del Houva II®.
- Servicios ofrecidos en su establecimiento.
- Pruebas completas, inspección y documentación de todos los dispositivos y componentes por el personal de nuestro departamento de garantía de calidad.
- Construido con cuidado y atención a los detalles para garantizar la calidad.
- Respaldo total con la garantía más completa en la industria.

Visor con cristal contra rayos UV para supervisar al paciente durante el tratamiento

Barandillas de mano para seguridad del paciente

Las pantallas de seguridad permiten una salida máxima de energía y se desprenden para reemplazar la lámpara con facilidad

Perímetro exclusivo de flujo de ventilación para mayor comodidad del paciente

Piso elevado para el tratamiento apropiado de la parte inferior de las piernas

**Houva II™ Cuadro Comparativo de la Lámpara**

| | UVA | UVA-1 | BB UVB | NB UVB* | Dispositivos de Medición |
|---|---|---|---|---|---|
| **Opción 1** | — | — | — | 48 | UVB-NB |
| **Opción 2** | 24 | — | — | 24 | UVA y UVB-NB |
| **Opción 3** | — | — | 12 | 36 | UVB y UVB-NB |
| **Opción 4** | — | 48 | — | — | UVA |
| **Opción 5** | 48 | — | — | — | UVA |
| **Opción 6** | 36 | — | 12 | — | UVA y UVB |

** La investigación reciente ha mostrado que la luz UVB de banda estrecha tiene una ventaja terapéutica sobre la luz UVB de banda ancha en el tratamiento de la psoriasis. Los estudios han mostrado un aclaramiento más rápido y una resolución más completa de la enfermedad con base en la respuesta del eritema a un tratamiento con NB-UVB más intenso y persistente en comparación con el tratamiento con BB-UVB. Estos beneficios se describen en muchos artículos y estudios publicados. (Los artículos están disponibles previa solicitud.)*

ANEXX 2:

PHILIPS
Lighting

# UV-B Narrowband TL

## TL 100W/01 SLV/10

More than 400 independent clinical studies have proven that the UVB Narrowband TL lamps are safer and more effective than any other lamps in their class. That is because these lamps emit only a very narrow waveband from the 'B' bandwidth of the UV spectrum (290 to 315). This narrow waveband is between 305 and 315 nm and peaks at 311 nm: the most efficacious waveband for the treatment of psoriasis. This means that treatment is much more focused and exposure times are much shorter. This in turn leads to a reduction of side effects such as reddening of the skin and itching. All of this makes them ideal for phototherapy treatment of diseases such as psoriasis and vitiligo. What's more, because the overall dosage of this narrowband radiation can be closely controlled, these lamps are suitable for home therapy.

### Product data

| | |
|---|---|
| **General Information** | |
| Base | R17D [ R17d (RDC)] |
| Main Application | Phototherapy Systems |
| Life to 50% Failures (Nom) | 1000 h |
| Useful Life (Nom) | 1000 h |
| **Light Technical** | |
| Color Code | 01 |
| Color Designation | Ultra Violet B |
| Chromaticity Coordinate X (Nom) | 216 |
| Chromaticity Coordinate Y (Nom) | 208 |
| UV Depreciation at 500 h | 10 % |
| UV Depreciation at 1000 h | 15 % |
| **Operating and Electrical** | |
| Power (Rated) (Nom) | 100 W |

| | |
|---|---|
| Lamp Current (Nom) | 0.97 A |
| Voltage (Nom) | 126 V |
| **Mechanical and Housing** | |
| Cap-Base Information | Adaptor |
| **UV** | |
| UV-B Radiation 100 hr (IEC) | 16.1 W |
| UV-B Radiation 5hr (IEC) | 18.4 W |
| **Product Data** | |
| XUCDM.COPY.Product.Title | TL 100W/01 SLV/10 |
| EAN/UPC - Product | 8718696662335 |
| Order code | 323188 |
| Numerator - Quantity Per Pack | 1 |
| Numerator - Packs per outer box | 10 |

Datasheet, 2019, October 8

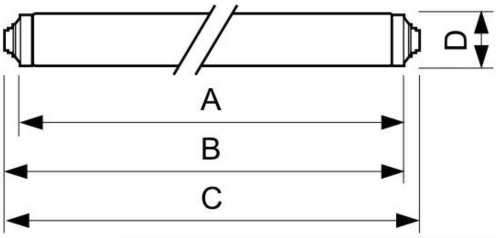
data subject to change

## UV-B Narrowband TL

| | |
|---|---|
| **Material Nr. (12NC)** | 928034900130 |
| **Net Weight (Piece)** | 0.470 kg |

### Warnings and Safety

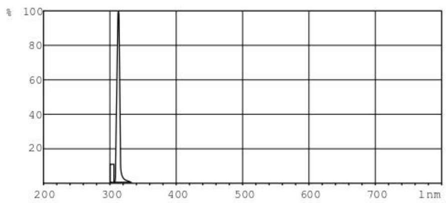
### Dimensional drawing

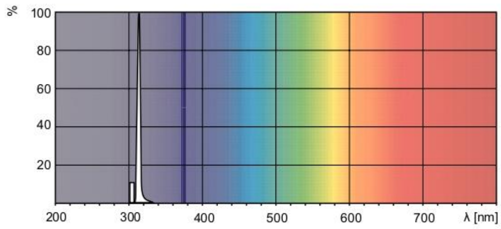



TL 100W/01 R17d

| Product | D (max) | A (max) | B (max) | B (min) | C (max) |
|---|---|---|---|---|---|
| TL 100W/01 SLV/10 | 40.5 mm | 1763.8 mm | 1770.9 mm | 1768.5 mm | 1782.2 mm |

### Photometric data




XDPB_XUMTL_01-Spectral power distribution B/W



www.lighting.philips.com
2019, October 8 - data subject to change

ANEXX 3:

NEW

# EVO Series, with 4k CMOS detector: StarLine AvaSpec-ULS4096CL-EVO Spectrometer

Another new member in our EVO series: the AvaSpec-ULS4096CL-EVO.
Using CMOS technology instead of the conventional CCD technology, this spectrometer offers you the latest technology; ready for the next decade.
The dominant position of CCD detectors in the spectrometer field is fading and new technologies like CMOS have evolved and become a suitable alternative. The AvaSpec-ULS4096CL-EVO offers you this latest technology ensuring a spectrometer platform for the coming years.
In combination with our latest AS-7010 electronics it offers you a versatile device including USB3.0
Communication with 10x higher speed compared to USB2, and a second communication port which offers Gigabit Ethernet for integration in your company network and possibility for long distance communication at an affordable price.

Besides the high speed communication options, the EVO also offers a fast microprocessor and 50x more memory which can help you to store more spectra onboard and realise more functionality.

Options include a detector collection lens to enhance sensitivity in the 200-1100 nm range and order-sorting filter to reduce 2nd order effects. Furthermore,the AvaSpec-4096CL is available with a wide range of slit sizes, gratings and fiber-optic entrance connectors.
It comes complete with AvaSoft-Basic software, USB cable and an extensive manual.

The AvaSpec-ULS4096CL-EVO is also available as OEM unit, Bench only or Rackmount version.
With the 4096 pixels these spectrometers are tailored for high resolution applications like Plasma and LIBS.

EVO series: AvaSpec-ULS4096CL


**Technical Data**

| | |
|---|---|
| Optical Bench | ULS Symmetrical Czerny-Turner, 75 mm focal length |
| Wavelength range | 200-1100 nm |
| Resolution | 0.05 –20 nm, depending on configuration (see table) |
| Stray-light | 0.19-1.0%, depending on the grating |
| Sensitivity | 218.000 counts/µW per ms integration time |
| Detector | CMOS linear Image Sensor |
| Signal/Noise | 335:1 |
| AD converter | 16-bit, 6 MHz |
| Integration time | 9 µs – 40s |
| Interface | USB 3.0 high-speed, 5 Gbps<br>Gigabit Ethernet 1 Gbps |
| Sample speed with on-board averaging | 0.70 ms /scan |
| Data transfer speed | 0.70 ms/scan (USB3), 1.31 ms (ETH) |
| Digital IO | HD-26 connector, 2 Analog in, 2 Analog out, 13 Digital bidirectional, trigger, sync., strobe, laser |
| Power supply | Default USB3 power, 532 mA<br>Or 12VDC, 300 mA |
| Dimensions, weight | 177 x 127 x 44,5 mm (1 channel), 1155 grams |

EVOlutionary spectroscopy:
- SPEED
- NETWORK INTEGRATION
- MULTICHANNEL BENEFITS

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