

# Erythematous UV Dose and UV Index Measurement at 37th North Latitude and Its Possible Effects on Humans

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## Research Article

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# Abstract

In this study, UV irradiance and UV erythema and UV index data of May, June, July and August measured in Adana (longitude=36 E, latitude=37 N altitude=140m) between 2013 and 2019 were analyzed. As a result of the analysis, the average of four months was 14.16 MED (2.9736 J/m<sup>2</sup>) and the highest value of these four months was calculated as 15.6 MED (3.276 J/m<sup>2</sup>) in July. The percentage frequency of the total daily UV dose was also calculated and it was determined that the region was under the effect of 70-80% high UV dose. In addition, it was calculated to have a high UV index according to local time (10.00-14.00). It was concluded that this situation poses a great risk for workers working in agricultural areas in the region and for people who spend their summer holidays by the sea.

UV Dose-Ozone, UV Dose-temperature, UV Dose-humidity and Ozone-temperature correlations were also calculated. As a result of the comparison, it was found that there was an R= -0.64 correlation between UV-ozone, an R= -1.00 correlation between temperature and ozone, and a direct correlation of R= 0.60 between UV radiation and temperature.

## 1. Introduction.

Although this study is not a clinical study, it was conducted to determine the value of erythema UV and UV index in Adana region (Çukurova) from the analyzed data. Çukurova region bears the Mediterranean climatic features, with its hot and humid summers. It is also the region where intensive summer holidays and agricultural production take place. The population living in the region is over 3 million. At the end of the analysis of the data, it was aimed to determine whether the agricultural workers living here and working in the fields are at risk of developing skin cancer. These measurements are also required in order to determine the change of UV light, which has a negative relationship with ozone, from the poles to the equator. With the Vienna Convention in 1985 and the 1987 Montreal Protocol, agreements were signed between the relevant countries in order to reduce the emission of ozone-depleting gases and other polluting gases into the atmosphere. (<https://ozone.unep.org/treaties/vienna-convention>), (<https://ozone.unep.org/treaties/montreal-protocol>).

In the Environmental Impact Assessment Panel (EEAP), it was stated that the time required to bring ozone depletion to the level before 1960 is uncertain and it is unclear whether stratospheric ozone has an impact on climate change, and it is not yet fully understood (Bais, et al., 2018). Regarding UV radiation, many scientific studies have been carried out for the purpose of UV measurement and analysis, scientific literacy, clinical studies and warning the world public opinion. Such studies are also guiding for countries across the world in order to make plans for a sustainable environment and industrial production. These studies can be roughly grouped under two headings. The first is to test people's scientific literacy, and the second is to determine the positive or negative values that arise in the atmosphere due to human-induced pollution. As a result of the study on whether UV light causes cancer or not, 86.7% of the participants stated that it causes cancer (Haney et al 2018). In the survey conducted with nurses working in the hospital, 93.9% of the participants stated that UV radiation causes cancer (Andsoy et.al 2013). It has

been tested how much UV radiation the teachers who wear polysulphone film dosimetry are exposed to. From the records of the dosimeters on the teachers who were outside during the breaks between classes, it was determined that they were under the influence of 91 J/m<sup>2</sup> UV dose in winter and 63.3 J/m<sup>2</sup> dose in summer (Downs et al., 2019). 23.5% of 2445 athletes who train outdoors stated that they are protected from the sun. While this rate was 33% for women, it was 17% for men. Although 50% of the participants knew that UV rays were harmful, they did not take precautions while training outdoors (Duarte et al 2018). In a study conducted to determine the relationship between ozone depletion and climate (van der Leun et al. 2008), it was determined that global warming increases cancer by 3-7% per temperature (°C). It has been observed that the effect of cancer increases by 5.5% per temperature (°C) for squamous cell structures and 2.9% per °C for carcinoma cells in summer. In addition, in order to determine the effect of climate change on cancer, the effect of UV incidence in SCC and BCC-based cells was investigated with climate models. It was estimated that the increase in SCC between 2100 and 2200 will be 4.3%, 5.8% - 21.4%, 40.5%. Similarly, they predicted that the BCC increase for the same years would vary between 2%, 2.8% - 9.9%, 18.2% (Piacentini et. Al., 2018). To identify the effect of UV light on the skin, in a study on rats (Yang et al., 2019), they were exposed to 60 mJ/cm<sup>2</sup> (600 J/m<sup>2</sup> - 2.85 MED) UV-B rays for 25 weeks. As a result, they detected cancer traces in 'epidermal hyperplasia, and the actinic keratosis' at the points where UV-B was applied. In the study of Sánchez-Pérez et al., the effect of UV light on the skin was investigated (Sánchez-Pérez et al,2019). It has been determined that UV radiation from the sun causes more burns and cancer risk on fair skin, and also has negative effects on the eyes. In another study on the interaction between the eye and UV radiation ( Izadi et. al., 2018), it was stated that UV radiation causes major damage to the ocular tissues of the eye and the cornea. Park et al., on the other hand, emphasized that since UV radiation constitutes 5% of the solar spectrum and causes cancer, it is therefore important for instant measurement of UV with a portable UV measuring device (Park et al 2019).

## 2. Data Collection And Analysis And Findings

In this study, the results of erythemal UV and UV index measurements obtained by Eppley UV radiometer, UV-AB radiation data and UV sensors since 1993 are discussed. UV measurement tools are located at 'Cukurova University Space Sciences and Solar Energy Research and Application Center' at an altitude of ~ 130 m, at 37 degrees 04' North Latitude and 35 degrees 21' East Longitude. In the article, the data recorded in 2013, 2014, 2017, 2018, 2019 were analyzed. Unfortunately, most of the data for 2015 and 2016 could not be used for analysis due to the corruption of the recording disk. In the study, data recorded as 1636 days, approximately 196320-5 minutes were analyzed. Hourly and daily UV dose, UV index, humidity, and temperature values were created from the recorded data of 5 minutes. In addition, the ozone values (Dobson Unit) obtained from the Tropospheric Emission Monitoring Internet Service (TEMIS) and measured for the city of Adana were compared with the UV radiation values reaching the surface. ([http://www.temis.nl/uvradiation/UVarchive/stations\\_uv.html](http://www.temis.nl/uvradiation/UVarchive/stations_uv.html)). Thus, the correlation results between the measured and calculated data and the data obtained from TEMIS were compared and it was determined that there was a considerable consistency between each other.

## 2.1. UV Dose

196320 five-minute average (UV dose and UV index) data were divided into two parts as May-August and annual averages. Firstly, the changes in UV radiation values during the months of May, June, July and August, when the sunshine duration is more, and secondly, throughout the year were examined. The change in the total UV dose value of 1636 days between 2013 and 2019 is given in Figure 1.

Adana is a region where both agricultural areas and summer holiday activities are intense. Agricultural workers work in very thin clothes or half-naked. With the onset of summer vacation, people are sunbathing almost every hour to get suntan, despite all warnings. Therefore, people in this area are exposed to severe UV radiation. In Table 1, the total daily mean UV dose (MED) calculated in May, June, July and August and the graph of this table are given in figure 2.

Table 1  
Total UV Dose (MED) between the years 2013-2019

Years	May	June	July	August
2013	12.50	13.90	14.10	11.80
2014	10.61	12.19	11.81	11.20
2017	11.88	15.88	16.31	13.10
2018	13.41	15.73	18.15	16.50
2019	14.89	15.78	17.65	15.72

As can be seen from Table 1, the average UV dose values for the months of May, June, July, and August are different during the years 2013-2019. However, when both tables are examined, the 4-month average dose amounts decreased in 2014. However, from 2017 to 2019, increases are observed in all 4 months. The largest increase was calculated in 2018. It was calculated that the average increase in July reached a maximum value of 18.15 MED (3811.5 J/m<sup>2</sup>). This increase continued in 2019 and the measured average UV dose value was calculated as 17.65 MED (3706.5 J/m<sup>2</sup>). When the change in July is taken into account, the increase that started in 2017 reached its maximum in 2018, and in 2019 slightly began to decline. In Figure 2, the average values of 4 months and standard deviation values of the data taken during the years 2013-2019 are given on the graph. The UV dose obtained from the averages of the 4 months selected between 2013-2019 was calculated as 14.16 MED or 2973.6 J/m<sup>2</sup>.

In Figure 3, the annual mean and standard deviation values of the 4 months are given on the graph. As can be seen from the figure, the increase continues based on the data for the year 2014. The mean dose values of the last three years were 14.29, 15.95, and 16.01 MEDs, respectively.

Table 2  
Daily UV Dose frequency distribution in May-June-July August during the period 2013-2019.

Years	N of D	Low	Mid.	High	V.High	Extreme	Total %
2013	123	0	0.02	0.06	0.37	0.55	1.00
2014	98	0	0.01	0.10	0.73	0.16	1.00
2017	123	0	0.05	0.05	0.21	0.69	1.00
2018	123	0	0.00	0.03	0.08	0.89	1.00
2019	114	0	0.00	0.02	0.13	0.85	1.00
Average	116.2	0	0.02	0.05	0.30	0.63	1

## 2.2. UV Index

The instantaneous effect of UV light is also extremely important. The UV index tells us the effect value of the instantaneous UV radiation. One of the results obtained in this study is the instantaneous UV index. The percentage frequency of the UV index between May and August was determined during the years 2013-2019. In Table 3, UV index percentage frequencies are given according to the values accepted by the WHO determined in this study.

Table 3  
During the years 2013 -2019, UV index instantaneous frequency distribution between May and August.

Years	Months	N of D	Low	Mid.	High	V.High	Extreme
2013	May to Agust	25092	0.477	0.279	0.241	0.003	0
2014	May to Agust	20046	0.501	0.266	0.225	0.009	0
2017	May to Agust	25092	0.489	0.273	0.233	0.004	0
2018	May to Agust	25092	0.509	0.263	0.225	0.004	0
2019	May to Agust	23333	0.484	0.272	0.242	0.003	0

According to the WHO UV index scale, it was determined that the instantaneous UV index value in Adana region has a very high value between 6 and 10 in total. As expected, this frequency is greater between the hours 10.00 and 14.00. In Table 4, the percentile frequency of the hourly UV index between May and August is given. As can be seen from both tables (3&4), the extreme value is not reached in the UV index. This is thought to be due to the diffusion of UV light resulting from high humidity.

Table 4  
Instantaneous UV index frequency distribution between 10.00-14.00, between May-August during the years 2013 -2019.

Years	hours range	N of D	Low	Mid.	High	V.High	Extreme
2013	10-14	7380	0.036	0.144	0.192	0.628	0
2014	10-14	5880	0.061	0.133	0.288	0.517	0
2017	10-14	7380	0.059	0.231	0.399	0.31	0
2018	10-14	123	0.05	0.145	0.222	0.584	0
2019	10-14	6859	0.04	0.121	0.267	0.572	0

According to the criteria determined by WHO (6-10 UV index), the instantaneous effect percentage of the UV index varies between 70%-83% between 10-14 hours (high + V High).

### 2.3. UV Dose-Ozone relationship

The ozone-UV radiation relationship was another result of this study. In this study, Ozone exchange from TEMIS was also investigated. The relationship between ozone and UV was compared with the average of the months of May-August and the average of the measurement years. The changes in ozone values are given on the graph in figure 4. In Figure 4, it is seen that ozone exchange decreases almost every month (May-August). It can be observed that the UV dose increases in response to the decrease in ozone.

The correlation between ozone and UV dose in Figure 4 was found to be  $R = -0.64$ . It can be observed that there is a negative relationship between ozone and UV dose, although not very strong, as expected, the UV dose increases as ozone decreases. While the average value in UV dose was a maximum 15.60 MED in July, the average value of ozone was determined to be a minimum 295.16 DU. In May, the average value of UV dose is a minimum 12.66 MED, while the average value of ozone is a maximum 333.79 DU. These changes can be explained by the expansion of the atmosphere and the onset of thinning of the ozone layer, with the increase in the tilt of the earth and the atmospheric temperature. The effect of anthropogenic gases on ozone with the release of anthropogenic gases into the atmosphere can be seen in annual averages. In Figure 5, annual averages are shown on the graph.

As seen in Figure 5, while the ozone amount was low (308.9 DU) in 2013, the UV dose was high (13.08 MED). In the year 2014, there seems to be a recovery in the ozone. It can be observed that while the amount of ozone was 315.9 DU, that of UV was 11.45 MED. In 2019, the decrease in the amount of ozone was 304.40 DU, while the ozone value increased (16.01 MED) as expected. The correlation coefficient between the annual UV and Ozone average data measured during 2013-2019 was found to be  $-0.86$ . This negative relationship can be easily seen from the figure. The result of the analyzed data states that while ozone decreases, UV radiation increases (Baldermann et al., 2019, Pastukhova et al., 2019).

The average values of the 12 months between 2013-2019 are given in figure 6 on the graph. As can be understood from these average values, the ozone amount started to decrease from March to October. On

the other hand, there are two reasons for the increase in UV radiation. The first is the axial tilt of the earth. Towards and during the summer months, the duration of sunbathing increases, causing more UV radiation to reach the surface. The second reason is that with the increase in temperature, the ozone layer begins to thin between these months. (David et al., 2015).

## 2.4. Comparison of Data

One of the findings obtained in this study is the relationship between UV dose, ozone, temperature and humidity. The average values of the data obtained between 2013-2019, for the months of May, June, July, and August are given in Table 5. The correlations of the mean values of these months with each other are also given in Table 6.

Table 5  
Average OZONE, UV Dose, Temperatur, Humidity, change from May to August between 2013-2019.

	May	June	July	August
UV Dose	12.66	14.70	15.60	13.67
OZON	333.79	312.95	295.16	292.51
Temp.	22.33	24.89	27.61	28.17
Hum.	57.17	60.12	58.55	58.38

Table 6  
During the years 2013-2019, May - August between the measured ozone, UV Dose, Temperature, Humidity Correlation Between Value.

Data	R
UV Dose- Ozone	-0.64
UV Dose-Temp	0.60
UV Dose-Hum.	0.65
Ozone -Temp.	-1.00

Although the correlation value  $R = -0.64$  between UV dose and ozone is not very strong, it means that as ozone decreases, UV Dose increases. Similarly, there is a positive ratio of 0.60 between UV dose and temperature. Although it is not a very strong ratio, it can be stated that the temperature increases as the UV radiation increases. Similarly, there is a positive increase between UV Dose and Humidity ( $R = 0.65$ ). It can also be stated that the UV ray diffuses owing to humidity. The most surprising finding is the negative

relationship between Ozone and Temperature ( $R=-1.00$ ). It indicates that the negative relationship causes the ambient temperature to rise due to the ozone depletion of UV rays passing through the atmosphere.

### 3. Results And Discussion

If no precautions are taken, the world will probably experience a rapid environmental disaster. Meteorological and atmospheric measurements are important in terms of revealing the importance of environmental disasters. Measurement and analysis of anthropogenic gases polluting the atmosphere are essential at all times. Local measurements are as important as extra-atmospheric measurements. Therefore, the locally measured amount of UV radiation is necessary for the detection of cancer caused by damage to the skin. Although this study is not a clinical study, data analysis was conducted to determine whether people living in this region are under the influence of UV radiation. In the study, according to the values obtained from the annual and monthly averages of May, June, July and August from 2013 to 2019, it can be concluded that the region is under a very strong UV threat. The four-month average annual dose (MED) ( $2973.6 \text{ J/m}^2$ ) and monthly mean doses were determined as 12.66 MED, 14.7MED, 15.60 MED, 13.67 MED, respectively. In a study conducted in Northern Australia, it was determined as 0.91 SED (0.43 MED) in winter and 0.63 SED (0.3 MED) in summer in measurements made with polysulphone dosimeters (Downs et. al. 2019). The findings obtained in Adana have much higher values than the findings obtained in Northern Australia. According to this comparison, people living, having holidays and working in Adana are also at a greater risk for cancer. In a laboratory study on hairless mice exposed to 2.85 MED UV-B irradiation for 25 weeks (Yang et al., 2019), cancer traces were detected on the skin at the points where UV light was applied. Although UV-AB was measured in this study, the cancer effect on humans of 14.16 MED obtained from the annual average of four months would be considerably higher than the above study. In order to understand the effect of temperature on cancer, studies on mice revealed that temperature triggers non-melanoma skin cancer (van der Leun et al. 2018). In the findings obtained in this study, the correlation between UV radiation and temperature was found to be 0.60 in the positive direction (Table 6). It can also be stated that in the Adana region, both the UV dose and the temperature are high, and people are at risk of developing skin cancer. It has been calculated that the UV dose percentage frequency (very high + extreme in Table 2) varies between 89% and 98% in light cloudy and clear weather conditions reaching the surface. In the results obtained in the study conducted in Seoul, Korea, which is at the same latitude, the atmospheric transmittance for the erythemal UV dose was calculated as 77.6% in less cloudy conditions. The results of these two studies are almost parallel (Lee, et al.,2019). Climate change has increased rapidly in the last half century, and while international cooperation has focused on environmental and economic consequences, its effects on human diseases such as skin cancer have been relatively underrepresented. As a result of a study conducted in the UK, it was stated that as people start to spend more time outside in hotter, drier weather, the duration of exposure to more UV rays will increase. As a result, there will also be an increase in the incidence of skin cancer brought on by behavioral change rather than environmental change. These should be considered and acted upon to protect the public from this avoidable threat (Bharath, et. Al., 2009, Baldermann, et al., 2019). In the findings obtained in this study, the annual UV dose variation was

calculated as 20%, and the annual average value between May and August was calculated as 11%. The UV rate is also quite high in the Adana region. Therefore, it can be stated that the people in the region are under the threat of cancer. In summary, when the findings obtained as a result of the analysis are compared with the findings obtained in the relevant literature, it can be concluded that the people in the Adana region are at risk. According to these results, it was concluded that the public should be educated about UV dose and that people should be warned about taking UV radiation protection measures between the hours 10.00 and 14.00., especially in summer, considering the regional conditions.

## Declarations

**Ethics approval:** There was no use of animals or animal products at any stage of this work.

**Consent to participate:** No one has contributed to this article. Everything (data acquisition and evaluation) belongs to me.

**Consent for publication:** This paper is an unpublished work and a product of original research. The paper has not been published in any language and not under consideration elsewhere.

**Availability of data and material:** The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Competing interests:** There is no conflict of interest in this article. The author do not declare competing interests.

**Funding Statement:** No financial support is provided for this article. Code availability: FORTRAN 95 program available upon request

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## Figures

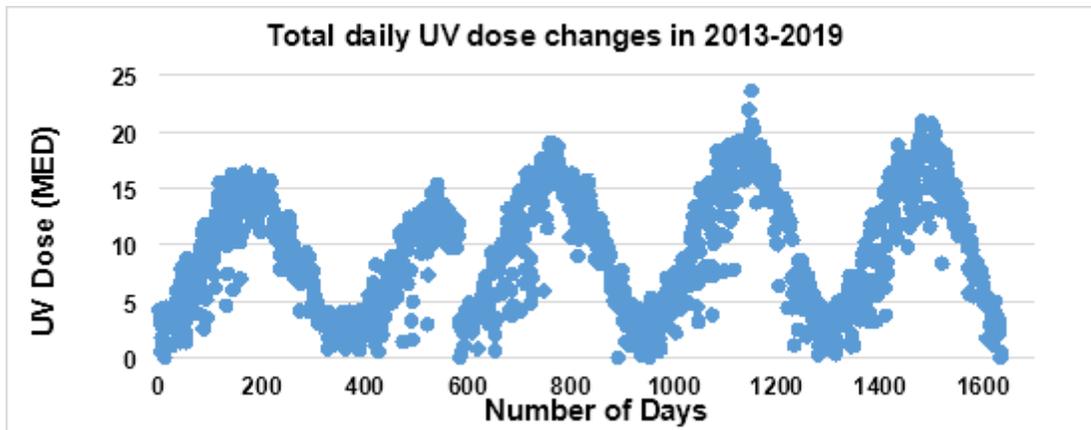


Figure 1

Daily total UV dose change between 2013 and 2019

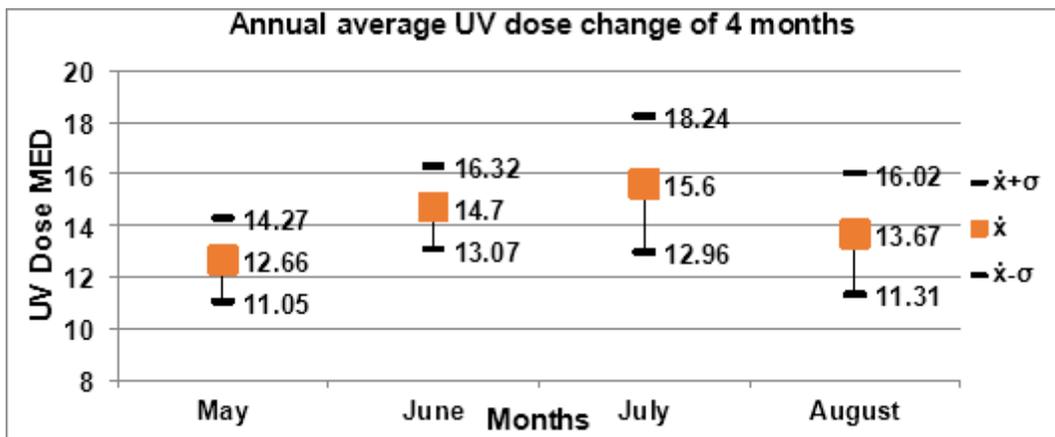


Figure 2

The average UV dose for the months of May-June-July-August between 2013-2019

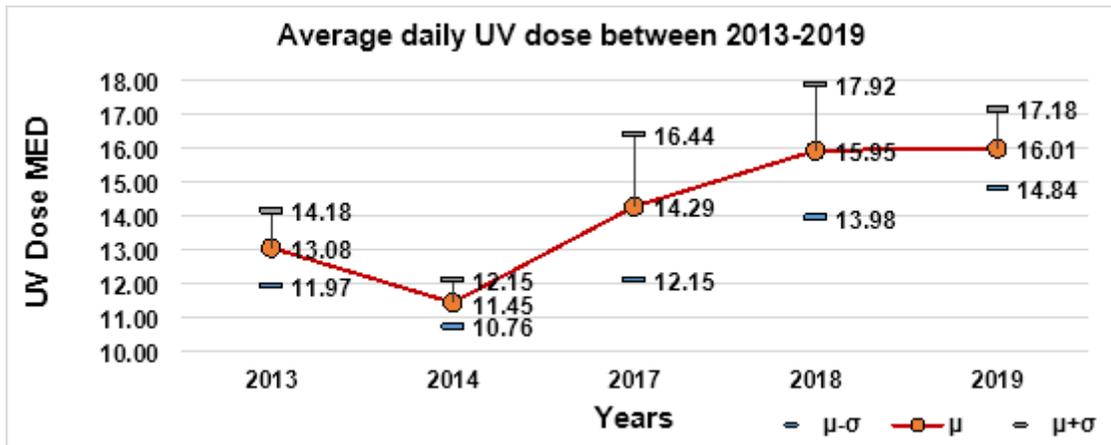


Figure 3

Annual average changes in the average UV dose values for the months of May-June-July-August between 2013-2019. Another finding obtained in this study is the frequency distribution of the UV Dose percentage. The percentile scale of the UV dose is listed as high, very high, and extremely high. Percentage frequency values corresponding to this scale are given in Table 2. The percentage frequency of the total daily irradiance calculated as High+V.High+Extreme between May-August 2017-2019 is between 98% and 100% in total. These results can be regarded as dangerous values for humans and table 2 UV dose values confirm this danger.

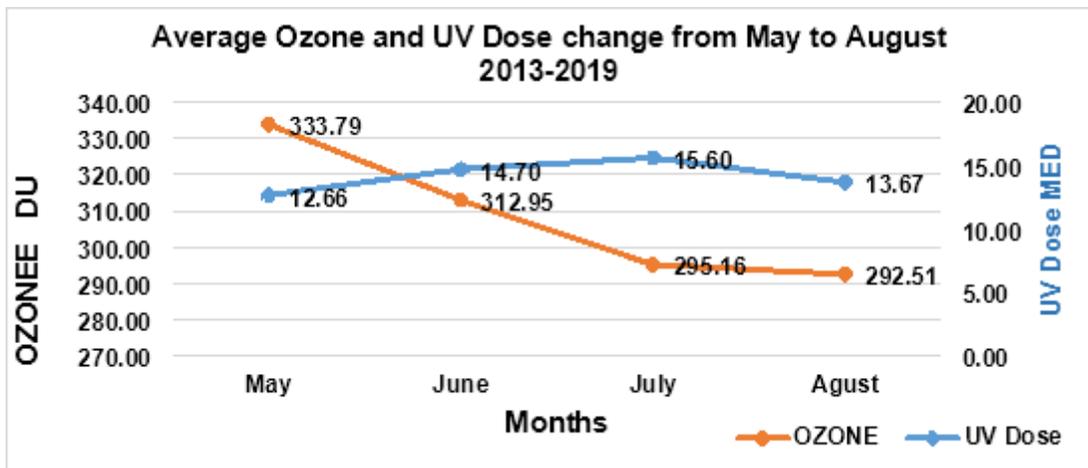


Figure 4

Average Ozone -UV Dose change from May to August during 2013 -2019

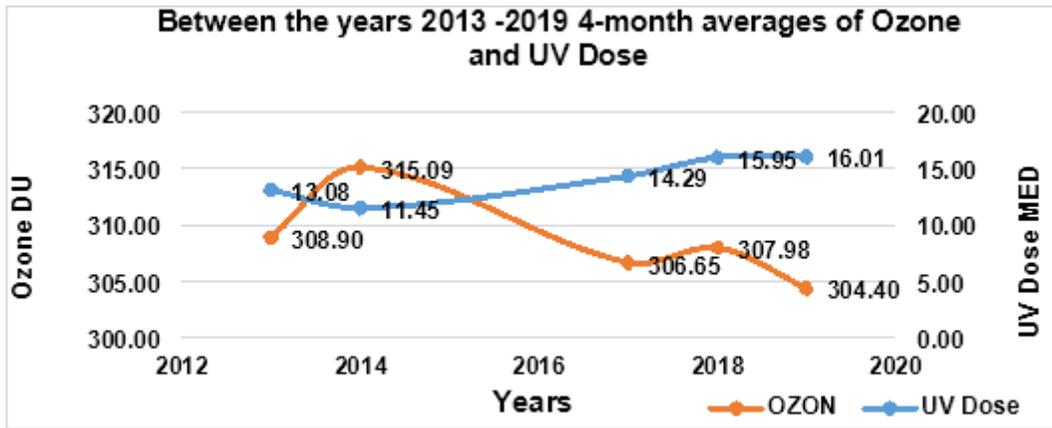


Figure 5

Average Ozone -UV Dose change for 4 months between 2013 and 2019

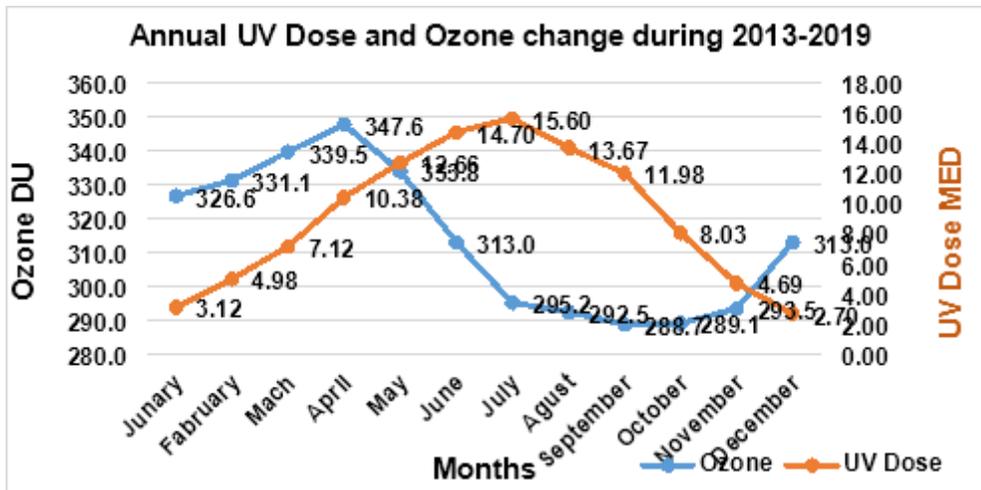


Figure 6

Annual average UV Dose and Ozone change during 2013-2019