UV Radiation

What is UV Radiation?

The three types of UV radiation are classified according to their wavelength. They differ in their biological activity and the extent to which they can penetrate the skin. The shorter the wavelength, the more harmful the UV radiation. However, shorter wavelength UV radiation is less able to penetrate the skin.[1]

The UV region covers the wavelength range 100-400 nm and is divided into three bands:

- UVA (315-400 nm)
- UVB (280-315 nm)
- UVC (100-280 nm)

Ultraviolet (UV) Radiation[2]

Ultraviolet (UV) "light" is a type of electromagnetic radiation. … Ultraviolet radiation lies between visible light and X-rays along the electromagnetic spectrum. UV "light" spans a range of wavelengths between about 10 and 400 nanometers. The wavelength of violet light is around 400 nanometers (or 4,000 Å). Ultraviolet radiation oscillates at rates between about 800 terahertz (THz or 1012 hertz) and 30,000 THz.

Regions of the UV spectrum

Scientists subdivide the ultraviolet spectrum into regions named near UV, far UV, and extreme UV. These divisions are comparable to the partitions between different colors, and hence different wavelengths, of visible light. The near UV region lies closest to visible light, and includes wavelengths between 200 and 400 nm. The higher energy, shorter wavelength far UV region spans wavelengths between 91 and 200 nm. Extreme UV radiation has the shortest wavelength range and highest energies of the regions of the ultraviolet spectrum and lies on the border between UV and X-ray radiation. Extreme UV radiation spans the 10 to 30 nm wavelength range. Normal air is largely opaque to UV with wavelengths shorter than 200 nm; oxygen absorbs "light" in that part of the UV spectrum. That is good news for us Earthlings, since our atmosphere shields us from the most dangerous, highest energy portions of the UV spectrum that reach our planet from the Sun and other sources in space.

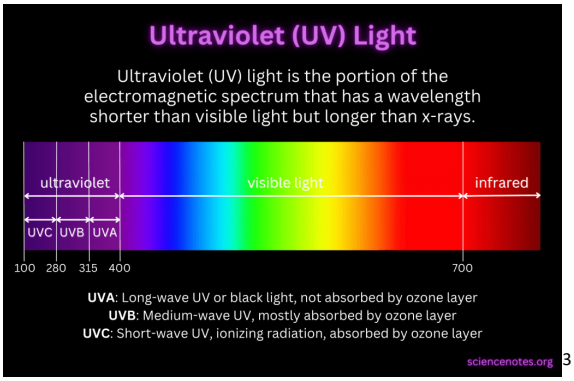
What is the significance of UV Radiation?

When discussing the impact of UV radiation on the environment and human health, scientists subdivide the ultraviolet spectrum in a different way. They speak of the UV-A, UV-B, and UV-C regions of the UV spectrum. You have probably seen UV-A and UV-B mentioned on the labels for sunglasses or sunscreen. UV-A, which is also called "blacklight" or "Long Wave" UV, spans wavelengths between 320 and 400 nm. It is the closest UV radiation to visible light. Almost all of the ultraviolet radiation that makes it through our atmosphere to Earth's surface is UV-A. UV-B waves, with wavelengths between 280 and 320 nm, carry more energy than UV-A waves. UV-B radiation is the main cause of sunburn; the SPF factor listed on sunscreens refers to their ability to reduce the effects of UV-B. The third region of the UV spectrum, UV-C, includes radiation with wavelengths between 100 and 280 nm. These short-wavelength UV

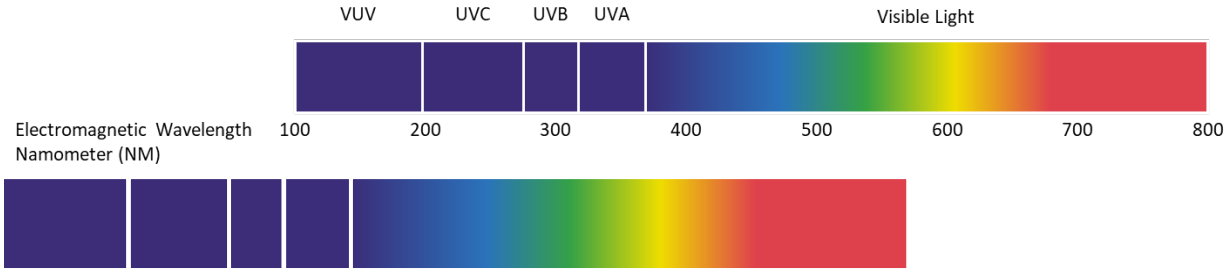
[1] World Health Organization, Radiation: Ultraviolet (UV) radiation, https://www.who.int/news-room/questions-and-answers/item/radiation-ultraviolet-(uv)

[2] University Center for Science Education, Ultraviolet (UV) Radiation, https://scied.ucar.edu/learning-zone/atmosphere/ultraviolet-uv-radiation

photons have high energies and are very damaging to living creatures. UV-C is sometimes called "Short Wave" UV or "germicidal" UV; the latter because it is sometimes used to sterilize laboratory equipment or to purify water by killing microbes.



[3]



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UV Index	0	1	2	3	4	5
Vout(mV)	<50	227	318	408	503	606
Analog Value	<10	46	65	83	103	124
UV Index	6	7	8	9	10	11+
Vout(mV)	696	795	881	976	1079	1170+
Analog Value	142	162	180	200	221	240

GUVA-S12SD UV Sensor, https://www.epa.gov/sunsafety/uv-index-scale-0

How is the UV Index measured and calculated?

UV Index Overview

The UV Index provides a forecast of the expected risk of overexposure to UV radiation from the sun. The National Weather Service calculates the UV index forecast for most ZIP codes across the U.S., and EPA publishes this information. The UV Index is accompanied by recommendations for sun protection and is a useful tool for planning sun-safe outdoor activities.

Ozone depletion, as well as seasonal and weather variations, cause different amounts of UV radiation to reach the Earth at any given time. Taking these factors into account, the UV Index predicts the level of solar UV radiation and indicates the risk of overexposure on a scale from 1 (low) to 11 or more

[3] Science Notes, Ultraviolet Light or UV Radiation,

(extremely high). A special UV Alert may be issued for a particular area, if the UV Index is forecasted to be higher than normal.

Calculating the UV Index

The U.S. National Weather Service calculates the UV Index using a computer model that relates the ground-level strength of solar ultraviolet (UV) radiation to forecasted stratospheric ozone concentration, forecasted cloud amounts, and elevation of the ground.

The calculation done by some other nations also includes ground observations. The calculation starts with measurements of current total ozone amounts over the entire globe, obtained via two satellites operated by the National Oceanic and Atmospheric Administration. These data are used to produce a forecast of stratospheric ozone levels for the next day at many points across the country. A computer model uses the ozone forecast and the incident angle of sunlight at each point to calculate the strength of UV radiation at ground level. Sunlight angle is determined by latitude, day of year, and time of day (solar noon). The strength of UV radiation is calculated for several wavelengths between 280 and 400 nm, the full spectrum of UVB (280-314 nm) and UVA (315-400 nm) radiation.

Ozone in the atmosphere absorbs (attenuates) shorter UV wavelengths more strongly than longer wavelengths. The strength of ground-level UV radiation differs significantly across the UV spectrum. As an example, UV strengths for a point might be calculated as shown in the table below. (These are hypothetical values. A National Weather Service chart shows typical UV irradiance values.)

Wavelength	Strength
290nm	4
320nm	26
400nm	30

The next step in the calculation adjusts for the sensitivity of human skin to UV radiation. Shorter UV wavelengths cause more skin damage than longer UV wavelengths of the same intensity. To account for this response, calculated UV strength is weighted (adjusted) at each wavelength using a function called the McKinlay-Diffey erythema action spectrum.

Continuing with our example, the table below gives skin response weighting factors for the UV wavelengths. (These are hypothetical values for the example, not actual McKinlay-Diffey weighting factors.) We multiply the ground-level UV strength by the weighting factor to calculate the result, the effective strength of the UV radiation, at each wavelength.

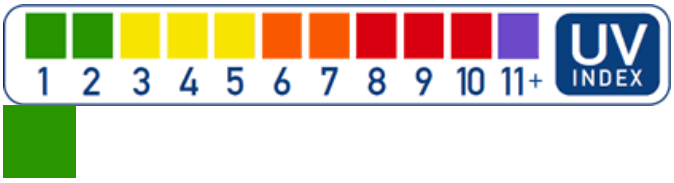
Wavelength	Strength	Weight	Result
290nm	4	15	60
320nm	26	5	130
400nm	30	3	90

Next, the effective UV strength at each wavelength across the 290 to 400 nm spectrum is summed (integrated), giving a value that represents the total effect of UV radiation on skin. In our example, the total UV effect is 280 (60 + 130 + 90).

The next step of the calculation adjusts for the effects of elevation and clouds. UV intensity increases about 6% per kilometer elevation above sea level. Clouds absorb UV radiation, reducing ground-level UV intensity. Clear skies allow virtually 100% of UV to pass through, scattered clouds transmit 89%, broken clouds transmit 73%, and overcast skies transmit 31%.

For our example, let us assume that the elevation is 1 kilometer and there are broken clouds overhead. The total UV effect, adjusted 6% for elevation and 73% for clouds, would be calculated as:
280 x 1.06 x 0.73 = 216.7
The final step of the calculation scales the total UV effect, dividing it by 25 and rounding to the nearest whole number. The result is a number that usually ranges from 0 (darkness or very weak sunlight) to the mid-teens (very strong sunlight). This value is the UV Index.
For our example, the UV Index would be:
216.7 / 25 = 8.7, rounded to 9

UV Index Scale
The UV Index scale used in the United States conforms with international guidelines for UVI reporting established by the World Health Organization. Learn how to read the UV index Scale to help you avoid harmful exposure to UV radiation.



1-2: Low
No protection needed. You can safely stay outside using minimal sun protection.

3-7: Moderate to High
Protection needed. Seek shade during late morning through mid-afternoon. When outside, generously apply broad-spectrum SPF-15 or higher sunscreen on exposed skin, and wear protective clothing, a wide-brimmed hat, and sunglasses.

8+: Very High to Extreme
Extra protection needed. Be careful outside, especially during late morning through mid-afternoon. If your shadow is shorter than you, seek shade and wear protective clothing, a wide-brimmed hat, and sunglasses, and generously apply a minimum of SPF-15, broad-spectrum sunscreen on exposed skin.

The Shadow Rule

An easy way to tell how much UV exposure you are getting is to look for your shadow:

- If your shadow is taller than you are (in the early morning and late afternoon), your UV exposure is likely to be lower.
- If your shadow is shorter than you are (around midday), you are being exposed to higher levels of UV radiation. Seek shade and protect your skin and eyes.

Information from:

- ***UV Index Overview***
- ***Calculating the UV Index***

More information / additional resources

What is the UV Index?
What is the nature of UV radiation?
How does UV radiation vary throughout the day?
How do clouds, elevation, surface type (albedo) and aerosols (haze) affect UV radiation?
How is the UV Index determined?
What cities does the NWS forecast the UV Index for?
How to make use of the UV Index Information.
Is the UV Index validated?
https://www.cpc.ncep.noaa.gov/products/stratosphere/uv_index/uv_information.shtml
https://www.uvindex.app/houston