The Copernicus Atmosphere Monitoring Service UV Index

Background information

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1. What is ultraviolet (UV) radiation?

Ultraviolet (UV) radiation covers the wavelength range of 100–400 nm, which is a higher frequency and lower wavelength than visible light. UV radiation comes naturally from the sun, but it can also be created by artificial sources used in industry, commerce and recreation.

The UV radiation wavelength region is divided into three bands:

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

As sunlight passes through the atmosphere, all UVC and approximately 90% of UVB radiation is absorbed by ozone, water vapour, oxygen and carbon dioxide. UVA radiation is less affected by the atmosphere. Therefore, the UV radiation reaching the Earth's surface is largely composed of UVA, with a small UVB component.

The amount of UV radiation from the sun that comes to the Earth's surface depends on several factors, including the sun's height in the sky, cloud cover, the thickness of the ozone layer, geographical location (latitude, altitude), and ground reflection. Reductions in the ozone layer due to human-created pollution increase the amount of UVA and UVB that reaches the surface. This can impact human health, animals, marine organisms and plant life. In humans, increased UV exposure can cause skin cancers, cataracts and immune system damage (WHO, n.d.).

2. What is the UV index?

The UV index (UVI) is an international standard way of measuring the sunburn-producing UV radiation, adopted by the World Health Organisation in 1994. The UVI is primarily used in forecasts to alert people about the need to use sun protection (WHO, 2017) (see Table 1).

UVI values range from zero upward - the higher the UVI, the greater the potential for damage to the skin and eye, and the less time it takes for harm to occur. The scale is directly proportional to the intensity of UV radiation that causes sunburn on human skin (WHO, 2017).

Copernicus Atmosphere Monitoring Service (CAMS) provides *clear-sky UVI* and *total-sky UVI*. The clear-sky UVI is valid for cloud-free conditions. The total-sky UVI is valid for conditions when the solar radiation reaches the surface of the Earth directly and considers actual or predicted cloud cover.

The level of UV radiation and therefore the UVI value varies substantially throughout the day. Clear-sky UVI is highest in the four-hour period around solar noon. Total-sky UVI can be more variable during the day as it depends on cloud cover.

The map viewer within the European Climate and Health Observatory presents the maximum daily UVI value, calculated based on the CAMS hourly forecast. The hourly variability is presented in pop-up boxes for specific locations.

Table 1. Understanding the UV index values

UV Index	Exposure category	Sun protection needed
1 - 2	**Low**	**No protection required** Being outside is safe
3 - 5	**Moderate**	**Protection required** Shirt, sunscreen, and sunglasses recommended in the sun.
6 - 7	**High**	**Protection required** During midday hours, staying in shade advised. In the sunshine, shirt, sunscreen, hat and sunglasses recommended
8 – 10	**Very high**	**Extra protection required** Staying inside recommended between 11 - 16. During those hours, even in shade, long-sleeve shirt, long trousers, sunscreen, wide-brimmed hat and sunglasses are recommended.
11+	**Extreme**	**Extra protection required** Staying inside between 11 – 16 and seeking shade beyond those hours is recommended. Even in shade, long-sleeve shirt, long trousers, sunscreen, wide-brimmed hat and sunglasses are essential.

Source: WHO et al., 2002 and DWD (n.d.)

3. How is the UV Index calculated?

The CAMS model computes solar irradiance at 5 nm spectral resolution. The UVI is then computed by integrating the spectral data over the bandwidth of sunlight wavelengths that can cause erythema (i.e. sunburn) (280 to 400 nm), thus accounting for both UVA and UVB radiation. To reflect the effect of these different wavelengths on sunburn, the UV power spectrum is weighted by a curve known as the erythemal action spectrum (see Figure 1). The result is the UV biologically effective dose rate, which is the amount of UV radiation at a specific moment in time for a given biological effect.

CAMS produces data on the UV biologically effective dose rate (in Wm^{-2}) used in the calculation of the total-sky and the clear-sky UVI. This dose rate is divided by 0.025 Wm^{-2} (i.e. multiplied by 40) to derive the UVI, as one unit of the index corresponds with 25 mW/m^2 of UVA and UVB radiation. This results in the UVI values depicted in Table 1, representing the amount of radiation absorbed by the human skin in a simplified way.

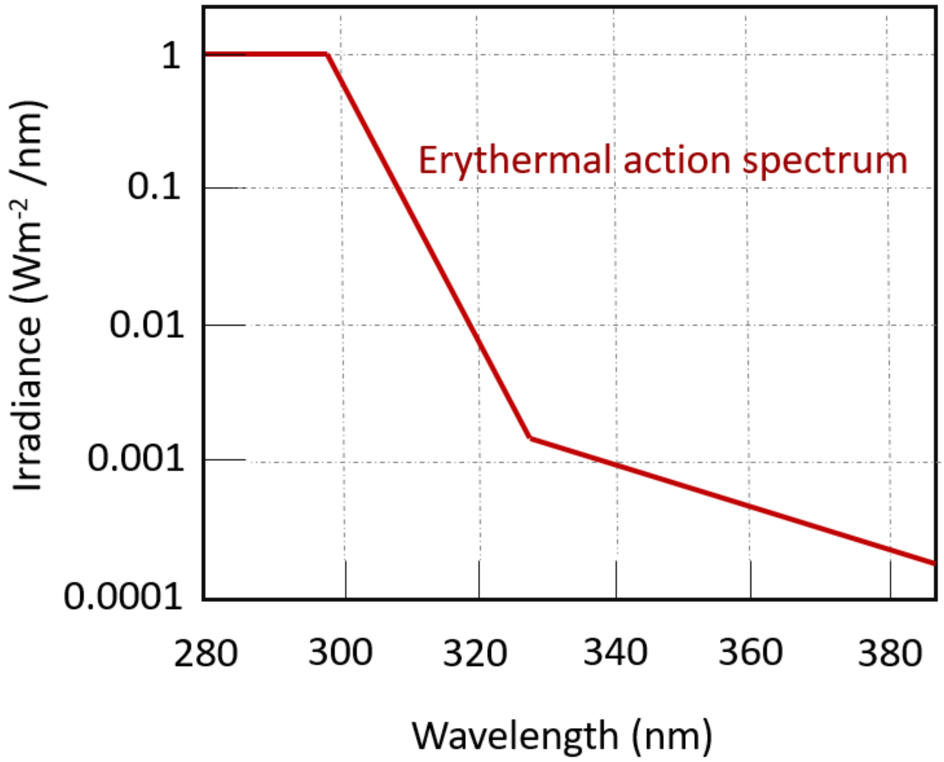

Figure 1 The UV biologically effective dose for erythemal action spectrum (adapted from [KNMI / TEMIS]())

4. How are the Copernicus Atmosphere Monitoring Service UV forecasts developed?

The UV processor is part of the Copernicus Atmosphere Monitoring Service (CAMS) Integrated Forecasting System (IFS). The IFS is a global numerical weather prediction system that has been run by the European Centre for Medium-Range Weather Forecasts (ECMWF) since the early 1990s. This IFS model is used for both ECMWF's operational weather forecasts and CAMS forecasts (ECMWF, 2021).

CAMS produces global forecasts for atmospheric composition twice a day. The initial conditions of each forecast are obtained by combining a previous forecast with current satellite observations through a process called data assimilation. This best estimate of the state of the atmosphere at the initial forecast time step, called the analysis, provides a globally complete and consistent dataset allowing for estimates at locations where observation data coverage is low or for atmospheric pollutants for which no direct observations are available.

The forecast itself uses a model of the atmosphere based on the laws of physics and chemistry to determine the evolution of the conditions over time for the next five days. Apart from the required initial state, it also uses inventory-based or observation-based emission estimates as a boundary condition at the surface.

The CAMS global forecasting system is upgraded about once a year resulting in technical and scientific changes. Updates may involve changes in the horizontal or vertical resolution, addition of new chemical species, and other improvements in the accuracy of the forecasts (CAMS, 2021).

5. What are the limitations of the CAMS UV Index Viewer?

With the current spatial resolution of the forecast model, the values are not representative for single locations. Instead, they provide a regional estimate, as the modelling is based on around 40 km grids.

The CAMS UV Index Viewer provides the daily maximum value based on hourly forecasts. This differs from the 30-minute time interval recommended by the WHO for UVI reporting (WHO et al. 2002). However, any short-term variations in radiation parameters (in particular due to cloud cover) would not be captured in the CAMS model due to the large-scale spatial grid used (one value of the cloudiness parameter is provided for every 40km model grid point). The short-term variability of cloudiness is the weak point of all meteorological models.

6. What other CAMS data and information on UV radiation is available?

CAMS provides a global solar UVI forecast, available through the Atmospheric Data Store (ADS).

The UV biologically effective dose rate (used to calculate UV Index data) is available for both total-sky and clear-sky conditions (Wm^{-2}).

UVI plots for the past five days are available for both total UV index and clear sky UV index at https://atmosphere.copernicus.eu/charts/cams/uvindex-forecasts.

References

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