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Practical application of the UV index

Recommendation by the German Commission on Radiological Protection

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Empfehlung der Strahlenschutzkommission

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For several years, a worrying increase in new cases of skin cancer in the population has been in evidence. This development is primarily attributable to excessive sun exposure in consequence of a change in leisure time behaviour and the resulting increase in UV exposure. In addition, it can be aggravated by a possible increase in solar UV radiation due to a further reduction in the ozone layer, including above the territory of the Federal Republic of Germany.

In order to militate against a further increase in UV-induced conditions, the Commission on Radiological Protection recommends that the population should be suitably enlightened on the risks of solar UV radiation. To this end, the Commission has recommended the introduction of the internationally agreed UV index. This index is derived from the daily peak value of erythema-inducing radiation intensity. In the Federal Republic of Germany, this can generally reach maximum values of 8. It is largely determined by the highest position of the sun and cloud cover, but the ozone content in the stratosphere is also a factor.

For the purposes of practical application, in the following the Commission on Radiological Protection makes some observations on the accuracy requirements which a UV index needs to fulfil and provides some hints on the subject of spatial and temporal dissemination of UV index forecasts. The appendix contains detailed reasons for the introduction and application of the UV index and an informative basis for the suitable enlightenment of the population by government offices, authorities and medical and scientific companies and other organizations (such as private weather services) which address the matter of enlightening the public on the problems which UV radiation entails and from a broad dissemination of the UV index can be expected.

For radiation-hygienic and meteorological reasons, the UV index should be applied in Germany as follows:

1. The primary objective of the dissemination of the UV index is to enhance public awareness of the risks of solar UV radiation. The aim of the UV index is to attain an optimum level of UV protection for outside activities.

2. UV index forecasts should afford consideration to those variables, such as cloud cover, which determine its variations.

3. From the viewpoint of radiation hygiene, in consequence of the large biological fluctuation bands involved, the accuracy requirements which the UV index needs to fulfil should, if anything, be classed as low. For reasons of public impressionability and in view of the four-tier protection recommendations (see table below), the UV index should be cited in whole-figure values.

4. A detailed spatial dissemination of UV index forecasts (more than three regions in a North-South direction and two regions in an East-West direction) is not necessary. Special local circumstances such as cloud density in mountainous areas or coastal effects can be mentioned in the texts accompanying the forecasts.

5. UV index forecasts should appear more frequently during those times of the year involving high levels of UV radiation. Protection measures are appropriate from UV index value 3 upwards. From this value upwards, small children and people with sensitive skin can suffer acute injuries (sunburn) in a short period of time. Making

allowance for the leisure-time behaviour of the adult population, weekend forecasts are particularly important. In order to take into account daily potential UV radiation in holiday areas, the everyday exposure of children and young people, and adults who are exposed to radiation during the performance of their professional duties, from May to August it is also advisable to produce forecasts for the remaining days of the week. These forecasts should indicate the possibly higher level of UV radiation in winter-sport and far-off locations.

6. For the purposes of documenting the radiation which has occurred and enhancing confidence in forecasts, the readings for the previous period should also be conveyed. The documentation of continuous ground-level UV readings also plays a key role in the prompt identification of the effects of anthropogenic changes in the ozone layer on the animate and inanimate human environment.

Table: Protection recommendations for various ranges of the UV index and sunburn periods for skin type II in the case of untanned skin. In the case of people with sensitive skin, sunburn can occur after a brief period of exposure. Infants up to twelve months old should not be directly exposed to insolation at all. The best protection against the sun is achieved by appropriate clothing and good sun glasses. Sunscreen agents should possess an adequate protection factor and be effective in UV ranges B and A. This protection factor should equate to at least double the value of the UV index. For particularly sensitive people and children, a sunscreen agent with a protection factor of at least fifteen is recommended.

UV index	Radiation	Sunburn possible	Protective measures
8 and higher	very high	in less than 20 mins	imperative
7-5	high	from 20 mins onwards	necessary
4-2	average	from 30 mins onwards	recommended
1-0	low	unlikely	not necessary

Appendix*): Informing the population of the health implications/risks of solar UV radiation

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1 Introduction

As an environmental factor, solar radiation, including its ultraviolet components (UV rays[1]), has always had a bearing on life on earth. It is a proven fact that low UV exposure is beneficial to humans and essential for the generation of vitamin D.

However, during the course of the last fifty years the view that tans are handsome and healthy has gained social currency among white-skinned sections of the population. This has issued in excessive UV exposure (sun and solariums) in leisure time and even more so during the holiday season, especially in view of the fact that a large percentage of holidaymakers travel to countries with a high level of solar radiation. There is also a growing trend towards making such journeys during the winter months, in which connection depigmented skin is particularly sensitive to UV radiation.

This change in leisure-time and social behaviour has resulted in a marked increase in incidences of skin cancer among virtually all white-skinned sections of the population. An additional aspect which could increase in importance in the future is an increase in UV radiation in consequence of the reduction in the stratospheric ozone layer. Over a long-year average, the overall level of ozone over Germany has decreased by 0.5% per year [Har 95]. The reduction in the overall level of ozone reveals seasonal differences involving particularly sharp drops in the winter and spring months. Thus, for example, on the Hohenpeissenberg, between 1979 and 1984 the overall level of ozone dropped by 8.4% during March, April and May. It is possible to deduce from model calculations that against the background of otherwise similar atmospheric conditions, such a drop in the level of ozone on a cloudless 21 March generated a 16% increase in the daily erythema dose. UV radiation can also occasion damage to the eyes and accelerate the formation of cataracts (dulling of the eye lens), and possibly also damage the immune system.

For a number of years, the Commission on Radiological Protection (SSK) has been observing with some concern the increase in acute and chronic skin and eye damage, particularly the increase in the incidences of skin cancer. As recently as 1990 and 1993, it submitted information on protecting humans against UV radiation, and in 1995 it also submitted a report on the introduction of an international solar UV index [SSK 90, 93, 95].

The key factor with regard to the influence of UV radiation on the health of humans, on animals, marine organisms and plants are the ground-level values of solar UV radiation. Even if a stratospheric reduction in the ozone level of a region of the earth's surface emerges, other factors such as the position of the sun and the degree of cloud cover generally exercise greater influence on the values of ground-level UV radiation. Current data reveals that the primary risk is linked to personal habits with regard to exposure to the sun [Her 94]. It is therefore important to inform the population of the fact that the effects of exposure to the sun might be injurious to health.

A key aspect of this is informing the population of the values of the solar UV radiation to which they can be exposed. For this purpose, the Commission on Radiological Protection has recommended the application of the simple, universally applicable solar UV index [SSK 95, ICN 95 WMO 94], which reflects the erythema-inducing radiation intensity which can be

[1] Electromagnetic waves of between 100 and 400 nanometers (nm) in length are designated as UV rays; they are subdivided into UV C rays (100 to 280 nm), UV B rays (280 to 315 nm) and UV A rays (315 to 400 nm) [CIE 87]; 1 nm = 10^{-9} m. *Note: Recently, the limit between UV A rays and UV B rays is defined at 320 nm.*

expected at ground level. This supplementary recommendation provides radiation hygienic reasons for introducing the UV index, recommendations for its practical introduction and informative bases for enlightening the public on the subject of the UV index.

2 Ground-level solar UV radiation conditions in the Federal Republic of Germany

2.1 Atmospheric influence parameters

Solar UV radiation occurring at ground level is contingent upon a plurality of influence parameters [Sec 94, Mad 93], of which the key parameters are: the position of the sun, the ozone content in the atmosphere, air particles (aerosols) and cloud cover, albedo (back-scatter and reflection capability), height above mean sea level. These influence parameters induce spatial and temporal variations in UV radiation.

In the event of a largely cloudless sky over Germany, the degree of UV radiation is mainly determined by the position of the sun. In addition to continuous daily and seasonal changes, as a result of the height-dependency of UV radiation intensity, the South-North gradient is additionally modified by the prevailing orography (low mountain range, the Alps). The steep West-East gradient in the distribution of the total level of ozone in the stratosphere can issue in marked regional deviations from the pure South-North gradient with regard to UV radiation intensity at ground level. In addition, purely meteorologically induced fluctuations occur from one day to the next in consequence of changes in the pillar of the total ozone level and cloud cover.

In comparison with cloud cover, the influence of aerosol-induced atmospheric clouding on UV radiation is minimal, though it should still be noted. Fairly high ground albedo values (up to factor 2, particularly given the presence of snow).

2.2 UV monitoring of solar UV radiation

UV radiation is a key environmental parameter. Although initially measured on a discontinuous basis, it is now continuously measured and analysed for the purpose of radiation hygiene. The relevant findings are published regularly. In view of the fact that the expected increase in UV radiation constitutes a global problem, collaboration with other national and international institutions which are active in this field is advisable [Ken 95, Sec 95].

Solar UV radiation measurements have been made for many years [Sec 92]. However, given the fact that such measurements have largely been made during measurement drives, the results which they have hitherto produced have only provided a limited database for evaluating individual exposure to solar UV radiation [Mad 93, Fre 89]. Recently, not least in consequence of the realization of the importance of this question and the enhancement of measuring techniques, numerous measuring activities have been in evidence. These range from individual and a small number of integral or spectrally disseminated measurements using radiometers to fully equipped measuring networks.

For the purpose of evaluating UV radiation in terms of radiation hygiene, its erythema-inducing property is always examined. In the case of radiometers which produce integral measurements, readings are weighted automatically by means of a filter which approximates this effectiveness, meaning that they provide a direct indication of erythema-inducing radiation intensity. Subsequent evaluations of such readings on the basis of different effectiveness spectrums are only possible to a limited extent. This is the only means of determining dosage values weighted on the basis of different biological effects from a single series of measurements. Even given any subsequent changes to the effectiveness functions, it is always possible to fall back on this series of measurements. The requirements which the spectral measuring technique is expected to fulfil are high because the spectral distribution of solar UV radiation is subject to strong natural fluctuations [Gib 91].

Simple measuring instruments have recently become available for the purpose of recording individual UV exposure.

2.3 The UV index

The UV index is defined as the peak daily value of sunburn-inducing radiation intensity in W/m^2, arithmetically averaged over 10 - 30 minutes and multiplied by 40. This definition is internationally accepted [WMO 94]. Sunburn-inducing radiation intensity is the product of the spectral radiation intensity at ground level, measured for a horizontal reference area, and the relative spectral standard erythema-inducing property in accordance with CIE [CIE 87a], integrated over the entire UV range.

The UV index is a parameter for describing the expected peak daily value of sunburn-inducing UV radiation at ground level. For the purpose of easier comprehensibility, it was standardized in such a manner that in practice it can currently accept numerical values between 1 and 12. The maximum value for the Federal Republic of Germany in summer is generally 8. In countries which are located more to the south, higher values are reached.

Calculation programs which forecast the solar UV index take as their point of departure ozone values which can be obtained from ground-based spectroradiometers or from satellites [ICN 95, Vog 95]. The spectral UV radiation at ground level can then be calculated on the basis of the current, temperature and steam fields of the numerical weather-forecasting systems in atmospheric layers up to a height of 30 km.

On the other hand, it is possible to forecast the UV index with a sufficient degree of accuracy for a short period of time on the basis of statistical evaluations of existing UV readings. In addition, necessary parameters such as the degree of cloud cover are obtained from the weather forecast data [BfS 96]. By means of a planned European research programme, the so-called COST action 713 "Effective forecasting of UV radiation on the earth's surface", it is intended to improve and standardize these methods on a concerted European basis.

3 Effects on human health

Human exposure to insolation can result in acute and chronic effects on health [Sch 95, RKI 94]. In the main, the skin, the eyes and the immune system are affected. Acute effects of UV radiation primarily entail erythema (sunburn) of the skin and photokeratitis of the eye.

Benevolent melanocyte anomalies can occur as a result of excessive UV exposure during childhood and adolescence. Chronic UV-induced skin diseases are premature ageing of the skin and skin cancer. Chronic effects on the eyes include cataracts, droplet keratopathies and epithelioma of the conjunctiva.

The primary risks and the problems which are of relevance to health in connection with UV exposure are concentrated on skin cancer and cataracts. A detailed summary and critical evaluation of current knowledge are contained in WHO/UNEP/ICNIRP environmental health document 160 "Ultraviolet radiation" [WHO 94].

3.1 Skin

The most easily recognizable acute effect of excessive UV exposure is erythema, the well-known reddening of the skin, which is termed "sunburn". In addition to erythema, most people also develop bronzing due to UV-stimulated melanogenesis and a thickening of the external dermal layers ("light callosity")which appears within a few days of exposure [Gil 81].

The primary chronic effects are malignant melanoma and the other forms of skin cancer which are jointly termed "non-melanoma skin cancers" (basalcell carsinoma, epithelioma), the so-called NMSC [IARC 92]. In these cases, solar UV radiation is a key causal factor, and the risk is related to the accumulative effect of radiation. The temporal trends of the incidence of NMSC are difficult to determine, primarily due to the fact that as yet there is no reliable system of registering the condition. The incidence of NMSC is contingent upon phenotype and predominates among the white population. The anatomical distribution of NMSC correlates with those party of the body which are most frequently exposed to solar radiation.- In certain countries there is a clear correlation between the increased incidence of NMSC and decreasing geographical latitude.

Although malignant melanomas are far less prevalent than NMSC, they are the main cause of death due to skin cancer and constitute a major health problem for white sections of the population. The risk of developing a malignant melanoma correlates with genetic and personal characteristics, personal behaviour and estimates of exposure to solar radiation [Arm 88, Zan 92]. Risk factors which have been identified to date for the development of malignant melanomas in whites are the presence of more than forty benign naevi (moles) per individual and the appearance of atypical naevi. There is some indication that solar radiation in early childhood may constitute aetiological factor in the development of such naevi. The main risk factors for humans are as follows: a large number of naevi, red or sandy hair and a pale complexion are well-confirmed risk factors in the development of malignant melanomas in humans of European origin. The incidence of malignant melanomas in white sections of the population generally increases as geographical latitude decreases. The highest recorded incidence is in Queensland, Australia, who the annual rates are greater than those obtaining in Europe by a factor of 10 (women) and more than 20 (men).

3.2 Eyes

Unlike the skin, which to some extent can adjust to UV radiation (by means of thickening and bronzing), the eye has no comparable adjustment mechanism. In addition, ground reflection plays the key role in UV radiation of the eyes, as is demonstrated by the phenomenon of snow blindness, an acute reaction of the conjunctiva of the eyeball. Chronic effects are droplet keratopathies, epithelioma of the conjunctiva and cataracts. Cataracts are the most frequent cause of blindness across the globe. Laboratory experiments have demonstrated UV-induced cataractogenic effects, in which connection UV-B radiation proved to produce the strongest effect [Wit 86, Hoc 89].

In spite of the large number of laboratory experiments which demonstrate the UV radiation induces cataracts, epidemiological studies of the relationship between age-induced cataracts and chronic UV radiation have apparently produced contradictory results. This could be attributable to dosimetrical errors. Analysing ocular radiation is complicated by the fact that it is not directly correlated with the global UV values on the earth's surface measured using meteorological instruments. Sensitivity to light in the range of vision is determined by the aperture of the eyelids and the diameter of the pupils. Therefore, the cornea and the lens can be exposed to a higher level of UV radiation on a misty day than on a sunny day.

3.3 Immune system

Inter alia, there are the following observations on the effect of UV radiation on the immune system:

– The protective reactions of the skin are modified by complex biological processes, in which connection urocanic acid values, Langerhans' cells, suppresser and auxiliary T lymphocytes are affected. Even a level of solar radiation as low as 1 MED[1]) can result in a higher risk of infection. There is some indication that solar radiation can have a negative bearing on the development of HIV diseases.

– Experiments on animals have demonstrated that the development and severity of skin cancer can be negatively influenced by UV radiation.

– Among people who have undergone immunosuppressive treatment there is a higher incidence of NMSC than among the normal population.

The quantitative data on UV-induced immunosuppression are provisional, and research needs to be conducted in this field [Kri 90].

4 Radiation hygiene assessment criteria

4.1 Effectiveness spectrums

The effects of UV radiation are heavily wavelength-dependent. Both with regard to the creation of cataracts and skin damage, the short-wave UV range of up to approximately 300 nm is highly effective. Effectiveness declines sharply in the case of fairly long wavelengths. For this reason, the biological effectiveness needs to be established with a high level of spectral dispersal. This relative effectiveness spectrum is standardized at the wavelength of maximum effectiveness. Linking it with the physically measured UV radiation

[1] MED = minimal erythema dose: UV exposure required in order to produce reddening of the skin which is just visible

gives the corresponding biologically effective UV radiation. However, this approach ignores the synergistic effects which are to be expected. It should be noted that too little is still known about the effectiveness spectrums which are required for the purpose of analysing biological UV radiation reactions.

For the purpose of radiation hygiene assessment, the effectiveness spectrums for erythema, premature skin ageing and dermal carcinogenesis are of particular significance. This is due to the fact that owing to fairly high levels of uncontrolled exposure, solar UV radiation constitutes a far greater risk potential for the skin than for the eyes.

Observations indicate that the relative spectral effectiveness of UV radiation for bronzing (melagonesis), "light inflammation" (formation of erythemas), the generation of skin cancer (dermal carcinogenesis) and premature skin ageing (elastosis) is very similar. Therefore, no radiation alone generates a single desired effect without also simultaneously generating the other effects. In view of the fact that, as the most readily recognizable acute effect, erythema assumes a key function with regard to the generation of awareness of the biological effectiveness of solar radiation, erythema-inducing radiation takes centre stage in radiation hygiene analysis and public relations [Kin 87].

4.2 Individual reaction ranges

The sensitivity of human skin to UV radiation differs from individual to individual. In line with the reaction to solar radiation, the following classifications are made:

- Skin type I: Always sunburn, hardly any bronzing even after repeated exposure to radiation
- Skin type II: Nearly always sunburn, moderate bronzing after repeated exposure to radiation
- Skin type III: Moderately frequent sunburn, progressive bronzing after repeated exposure to radiation
- Skin type IV: Seldom sunburn, rapid bronzing.

Skin type III predominates in Central Europe. The "minimal erythema dose" (MED) fluctuates according to person and skin type. In the case of skin used to light, the MED of skin type I is approximately 150 J/m^2, of skin type II 250 J/m^2, of skin type III approximately 350 J/m^2 and of skin type IV up to 450-500 J/m^2.

By means of the thickening of the epidermis and the horny layer of the epidermis (light callosity) and pigmentation (bronzing), within certain limits the skin can protect itself against UV radiation. This thickening reduces the level of UV radiation which penetrates the deeper-lying dermal layers. This protection reaches its highest level of effectiveness after between ten and twelve days' exposure to radiation, in each case below the minimal erythema dose. The adaptability of the skin and the initial erythema threshold fluctuate greatly from person to person. In extreme cases, a light callus can provide up to ten times the level of protection, and pigmentation an additional four times the level of protection.

Age and the genetic predisposition of the individual

In comparison to adults, the skin of children is more sensitive to UV radiation and reacts correspondingly more intensely. Genetic factors, such as the number of naevi, constitute a greater risk factor in the formation of malignant melanomas. In comparison to checks, experimental studies have revealed lower threshold values of the minimal erthema-inducing dose and longer lasting erythema in melanoma patients. In addition, some conditions can result in a higher level of UV sensitivity of the skin.

4.3 Individual exposure

Skin

How high actual exposure is in comparison to ground-level UV radiation is, on the one hand, contingent upon the type of preventive measures which are selected, and, on the other, on which activity an individual is currently performing in the open. In the case of sunbathing, UV radiation is obviously at maximum level, whereas in the case of movement outdoors it is reduced. Depending on the position of the sun, the cutaneous areas which are positioned vertically to the given solar radiation can receive 1.3 times the erythema-inducing dose which falls on horizontally positioned cutaneous areas. Personal dosimetric measurements have revealed that playing tennis, sailing and swimming can produce skin exposure values which amount to up to 80% of natural environmental UV radiation in relation to a horizontal measuring area. In contrast, hiking and gardening when only partially exposed to direct solar radiation produced radiation values of only approximately 30% [Her 94].

By means of suitable protective measures, a person's exposure to UV radiation can be significantly reduced. In view of the fact that diffuse radiation contains a considerable proportion of UV radiation, under certain circumstances a place in the shade might not provide adequate protection against UV radiation. In contrast, suitable clothes can greatly reduce UV radiation. Sunscreen agents currently available on the market achieve light protection factors[1] of more than 30.

With regard to the genesis of malignant melanomas, discussion primarily focuses on the influence which the temporal distribution of radiation exposure (intermittent or continuous) exercises on the disease.

Eye

The geometry of radiation exposure and the composition of the solar spectrum have a bearing on the health risk. For example, looking into a vertically positioned sun can occasion retinitis within ninety seconds, whereas a few hours later a few minutes are required. However, this happens only infrequently. When the sun is high the eyelids provide effective shading. When the sun is low, albeit more than ten degrees over the horizon, the eye naturally reacts by means of reducing the aperture of the pupil or partially closing the eyelid. This behaviour reduces the exposure of the cornea to UV radiation to a maximum of 5% vis-à-vis the top of the head. Disregarding this protective mechanism, the exposure of the eyelids to radiation would reach approximately 20% of that which is related to a horizontal surface [Sli 83]. In

[1] The light protection factor of a sunscreen agent states the factor by which the radiation exposure time until the onset of sunburn is increased when the agent is applied.

winter, even given dose values , due to the low position of the sun, the face and eyes are more heavily exposed than in summer.

4.4 Conclusions

The adaptability of skin and the initial erythema threshold fluctuate greatly from person to person. The individually attainable level of skin protection as a multiple of the erythema threshold ranges from 1 (skin used to light) to 40 (extreme case for well-adapted skin following light callus formation and bronzing). The erythema threshold reveals differences of up to factor 3 for different skin types. Related solely to acute skin reactions, this produces an erythema threshold fluctuation range of up to 100 in the case of one and the same UV radiation. According to initial studies, the different levels of sun exposure occasioned by different leisure-time activities are in the region of approximately 30-130% of those which are related to a horizontal measuring surface. This makes allowance for the fact that the level of radiation exposure is reduced when in the shade. If anything, in consequence of the large biological fluctuation ranges on the one hand, and exposure to the sun deviating from the environmental UV radiation on the other, the accuracy requirements which a UV index needs to fulfil should be classed as low.

5 Informing the public

5.1 Basics

In consequence of the very high and increasing incidence of skin cancer among the population at large, the first information campaign on the prevention of hazards emanating from solar UV exposure was launched in Australia in the 1960s. This subsequently led to similar programmes in a great many other countries.

At several international conferences, agreements were reached which underlined the importance of "enlightening the public" to attaining a reduction in the morbidity and mortality rates of malignant melanomas and NMSC. In particular, the objective was to make people aware of the health risks which excessive exposure to the sun involves. On the basis of sound scientific data, it is therefore imperative that this information is rendered accessible to the population at large.

What is important is the positive conveyance of information which, while enabling people to enjoy the sun, will also enable them to assess the risks of excessive UV radiation and be aware of the necessity of avoiding excessive UV exposure. To this end, the various protective measures which facilitate this must be public knowledge. The feeling of well-being which people derive from outdoor activities should be compared with the potential risks of solar UV radiation. In order to change the leisure-time behaviour of the population at large and the current view that a suntan alone is a sign of health, long-term strategies are required. The cooperation of various social and scientific groups is needed in order to implement far-reaching information strategies. Therefore, in many countries these campaigns will be organized in conjunction with the government, various medical and scientific companies and private institutions, and charitable organizations (such as cancer counselling agencies).

5.2 The task of the UV index

The solar UV index is of key importance to the implementation of programmes aimed at informing the public of the health risks which excessive UV exposure involves.

The solar UV index serves to warn against the possible danger emanating from UV radiation on a given day. It is an instrument of health care and disease prevention, since it makes the public at large aware of the risks of excessive UV radiation. The application of the UV index can considerably reduce health service costs.

The UV index can be employed as a key component of a programme aimed at informing the general public of the health risks which UV radiation involves. This programme is primarily intended to serve the purpose of protecting young people, since the effect of UV radiation during childhood and adolescence can increase the risk of skin cancer, particularly with regard to possibly fatal malignant melanomas. The general public should also be informed of other effects, such as UV-induced skin ageing and eye diseases.

In addition, the UV index can stress the fact that the risk of effects injurious to health emanating from UV exposure is not restricted to exposure to the sun during holidays abroad, but also results from daily exposure at home and at work in Germany.

The solar UV index does not relate to UV radiation emanating from artificial sources of radiation.

5.3 Variations in the UV index in the Federal Republic of Germany

In winter, the UV index accepts values up to a maximum of 3 (in March), and in summer, given a cloudless sky and a total column ozone which equates to the long-year average, values of 6 in northern Germany and between 7 and 8 in southern Germany are obtained. In the event of reduced ozone values in the stratosphere, even higher values can be obtained, particularly at the highest points of the low range of mountains in southern Germany.

Geographical latitude determines the maximum height of the sun and, thus, given the existence of a column ozone and the vertical distribution of the ozone, the UV index. From the standpoint of radiation hygiene, it would seem advisable to split the north-south direction into three regions; meteorologically speaking, additional differences can arise in the west-east direction. In spatial terms, the influence exerted by cloud cover varies greatly, both with regard to the degree of cover which is present and transparency, in which connection influences such as the intensification of cloud cover in mountainous areas or coastal effects can also produce considerable local fluctuations. For this reason, special local features can be mentioned in the text accompanying the forecasts, a practice which will increase their acceptance level.

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