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Proposal for a modification of the UVI Risk Scale

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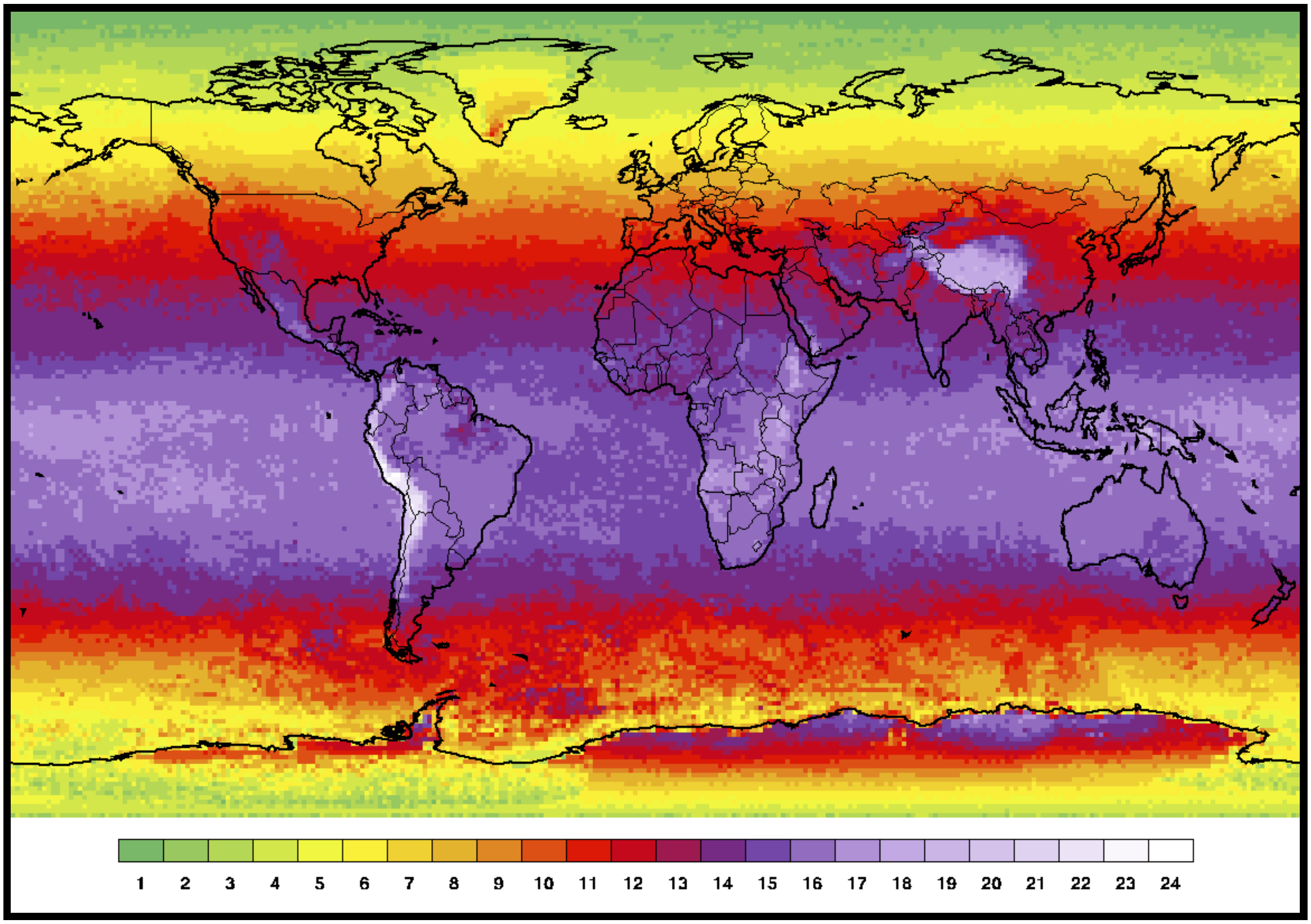

Peak UVI values for the globe using a modified colour scale. With the colour scale for UVI as currently recommended by WHO, more than 78% the globe area – representing 89% of the world's population - would be indistinguishable.

UVI >	Area (%)	Land (%)	Population (%)	Population (millions)
10	78.4	70.4	89.1	5,390
11	74.1	66.6	85.0	5,150
12	66.9	60.6	74.8	4,530
13	61.5	55.2	62.4	3,780
14	51.2	44.8	37.7	2,290
15	41.2	36.0	27.1	1,640
16	21.3	18.5	12.8	770
17	5.5	6.3	4.80	290
18	0.64	2.0	1.39	84
19	0.36	1.1	0.78	47
20	0.22	0.68	0.35	21
21	0.19	0.59	0.28	17
22	0.078	0.250	0.135	8
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Table 1. Calculated percentages of area of the globe, and land area; and millions of population (in year 2000, global population 6.056 billion) living in regions where the peak UVI reaches values greater than that specified in column 1 [6].

Time for 1 MED as a function of UVI & Skin type						
Skin Type	**I**	**II**	**III**	**IV**	**V**	**VI**
Example	Celtic	Pale	Caucasian	Mediterranean	Sth American	Negro
Sensitivity	Always Burns	Easily Burns	May burn	Rarely Burn	Rarely Burn	Rarely Burn
SED/MED *	2.5	3.0	4.0	5.0	8.0	15.0
UVI	**Minutes of unprotected exposure before perceptible skin damage**					
1	167	200	267	334	534	1001
2	83	100	133	167	267	500
3	56	67	89	111	178	334
4	42	50	67	83	133	250
5	33	40	53	67	107	200
6	28	33	44	56	89	167
7	24	29	38	48	76	143
8	21	25	33	42	67	125
9	19	22	30	37	59	111
10	17	20	27	33	53	100
11	15	18	24	30	49	91
12	14	17	22	28	44	83
13	13	15	21	26	41	77
14	12	14	19	24	38	71
15	11	13	18	22	36	67
16	10	13	17	21	33	63
17	10	12	16	20	31	59
18	9	11	15	19	30	56
19	9	11	14	18	28	53
20	8	10	13	17	27	50
21	8	10	13	16	25	48
22	8	9	12	15	24	45
23	7	9	12	15	23	44
24	7	8	11	14	22	42
25	7	8	11	13	21	40

Table 2. Calculated approximate exposure time in minutes before perceptible skin damage occurs (1 MED, Minimum Erythemal Dose) as functions of skin type and UVI. The skin types, and sensitivities to UV exposure are from [13]. Colours associated with the UVI values are a modified and extended version of those suggested by WHO [5]. The shading from lightest to darkest, correspond to exposure times up to 10 minutes, 20 minutes, 30 minutes, 60 minutes, 120 minutes, and greater than 120 minutes respectively.

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Summary: **The standardisation of UV information to the public through the UV Index (UVI) has been hugely beneficial since its endorsement by multiple international agencies more than 10 years ago. It has now gained widespread acceptance, and UVI values are available throughout the world from satellite instruments, ground-based measurements, and from forecasts based on model calculations. These have been useful for atmospheric scientists, health professions (skin and eye specialists), and the general public. But the descriptors and health messages associated with the UVI scale are targeted towards European skin types and UV regimes, and are not directly applicable to population living closer to the equator, especially for those in the high-altitude Altiplano region of South America. This document arose from discussions at the Latin American Society of Photobiology and Photomedicine's Congress, which was held in Arequipa, Peru, in November 2013. A major outcome of the meeting was the Arequipa Accord, which is intended as a unifying document to ensure co-ordination of UV and health research decisions in Latin America [*]. A plank of that agreement was the need to tailor the UVI scale to make it more relevant to the region and its population. Here we make some suggestions to improve the international applicability of the UVI scale.**

The Altiplano area of South America is home to a population of over 30 million people. Inhabitants are exposed to the highest UV levels that occur anywhere on the planet. For example, in La Paz, 16.5°S, 68.1°W, alt: 3420 m a.s.l.(Bolivia), the UVI daily maximum exceeds 8 every clear day of the year, and UVI daily maxima exceed 10 for 68% of the year (over 240 days each year), as shown in Figure 1. In the Cusco area, satellite data show peak values reaching UVI = 25, as shown in Figure 2 [1]. Ground-based broad-band and spectrometer measurements, calibrated to the highest international standards, confirm the occurrence of UVI values of more than 20 at the Earth's surface in this region [2-4].

[*] See ftp://200.7.163.211/LFA/RUV/Documentos/Declaration%20of%20Arequipa%20English.pdf and ftp://200.7.163.211/LFA/RUV/Documentos/Declaracion%20de%20Arequipa%20Espanhol.pdf for the English and Spanish versions respectively.

The UVI scale was originally developed in Canada, where it was defined such that the maximum value in southern Canada was UVI = 10 (see http://www.ec.gc.ca/uv/default.asp?lang=En&n=D4001B75-1). The idea was that it was an easily digestible number, like temperature, for the public to understand. The UVI was later formalised in SI units by defining it such that one UVI unit corresponds to 0.025 Wm^{-2} of erythemally-weighted UV irradiance.

Its Canadian origin is the source of the idea that UVI values greater than 10 are “extreme”, and that values greater than 10 were less relevant. Those ideas were unfortunately perpetuated when the UVI scale was adapted for world-wide use, as described in a document published in 2002. That document was endorsed by WHO, WMO, UNEP, and ICNRP [5].

But in a global context, the messages therein are flawed. The highest values occur at high altitudes within the southern hemisphere tropics, where the dates of overhead sun occur close to the dates of closest approach between the Earth and the Sun. The highest UVI values occur near solar noon during this period when (a) the sun is unobscured by clouds, (b) there are low levels of pollution, and (c) ozone amounts are close to their annual minimum. In the tropical Altiplano this results in UVI values two and half **times** greater. Furthermore, the problem is not confined to just the Altiplano area. Combining the gridded UV data in Figure 2 with gridded population data [6], it can be seen (Table 1) that in fact most of the world, and an even larger proportion of its population, are exposed to UVI values considerably larger than 10. According to these figures, over 5 billion people (89% of the world’s population) live in areas where the peak UVI exceeds 10, and 5 million (all in the Altiplano region) live in areas where the peak UVI exceeds 23.

Even the action spectrum on which the UVI is based may not be appropriate for the general population in Latin America, since it is based only on Caucasian and Japanese skin types [7]. Furthermore, the skin areas considered (torso) were not normally exposed to sunlight. Photo adaptation of skin in exposed areas that receive greater levels of UV radiation has been well documented [8-10]. It may therefore have been more appropriate to use more habitually exposed much thicker skin areas, but then of course the detection of erythema would have been more difficult to detect. However, in the absence of anything better, we accept that the current accepted action spectrum will have to suffice. We therefore recommend the continued use of the current UVI scale, which has the advantage of wide international uptake.

The current UVI scale is quantitatively useful, especially in preference to limited information provided through using only derived products, such as the so-called UV "Alert Period" which has recently been advocated. These are limited by their lack of a uniform "alert" threshold (e.g., UVI = 3 in Australia and NZ, UVI = 6 in USA) which can potentially lead to confusion, and by their lack of any distinction between UVI values ranging from as low as 3 up to as high as to 25. Clearly any UV effects, and behavioural messages should be quite different at those extremes. We suggest, however, that some changes are needed to the UVI descriptors. The ranges of UVI values presented (limited to a max of 11+), their associated colour scales (ending in purple), and the descriptive terms suggested (e.g., "extreme" for UVI > 10) are clearly not appropriate for this region. Similarly, for the dominant population groups, the currently ratified health messages (e.g., cover up when UVI > 3, or "stay at home" if UVI > 10) may not be appropriate.

Similar concerns were raised following a Photobiology and Photomedicine Congress in Santiago (Chile) in 2006. A consensus agreement from that meeting was submitted to the Chilean representative of the WMO in 2006 for consideration by the WMO. However, to date we have seen no response to that request.

The only relevant communication we have seen since then is titled "Validity and use of the UV Index: Report from the UVI Working Group", Germany, 5-7 Dec 2011.)[11].Their terms of reference were: *A working group convened by ICNIRP and WHO met to assess whether modifications of the UVI were warranted, and to discuss ways of improving its effectiveness as a guide to healthy sun-protective behaviour.*

The Santiago Accord request from 5 years previously was not even mentioned in that report, and apparently was not discussed at all. It seems likely that the authors of the report were not aware of the request, which suggests a serious communication issue within WMO/WHO. Furthermore, some of the recommendations ratified in that report (e.g., protection needed when UVI > 3) are difficult to reconcile with the populations living in these extreme UV climates and mainly having a mean phototype greater than of higher latitude Northern Hemisphere inhabitants [12].

The time has come to re-address the issue to a wider group, through this Journal. Even though the future UV climate is uncertain due to complex interactions between UV radiation and climate change, current models predict relatively small changes from the present day situation over the remaining decades of this century. The extreme UV problems of the Altiplano existed prior to the onset of any anthropogenic ozone depletion in this region, and will persist into the future. In fact, the action requested in this region is "photo-education" and a correct use of UVI scale is a major commitment.

Our suggestions, for consideration by future committees involved with UVI decisions, are as follows:

1. Recommend continued use of the numerical UVI scale, but emphasise that it is open ended, rather than "ending" at a value of 11+. For example, at the top of the atmosphere it reaches 300, and the highest solar UV anywhere on Earth is in the Altiplano region where it may reach UVI = 25 (note that artificial sources, such as arc welders and solaria may exceed UVI = 25).
2. Focus on the numerical value, rather than the colours. In time, with education and experience and parental advice, individuals will learn what particular UVI values mean for them (that depends on skin type, amount of time to be spent outdoors, eye protection, etc). Analogy with temperature: for somebody living in Punta Arenas (Chile, 53ºS), 20ºC is hot, but for somebody living in Fortaleza (Brazil, 3ºS) that is cool.
3. Change the wording associated with each UVI value so that the descriptive terms such as "extreme" are used in a statistical sense that is representative for the region (regions to be decided at a national level). So the UVI threshold for "extreme" varies from place to place [†]. These descriptive terms should not be linked to health messages.
4. Recommend an extension of the colours associated with each UVI value, so that UVI values greater than 11+ are distinguishable by colours. For example, the colours could taper from purple to white from UVI = 13 to UVI = 20, This colour scale has already been used by the European Space Agency (ESA) in their

[†] For example:following a suggestion by Piacentini and collaborators (http://www.smn.gov.ar/?mod=ozono&id=2), the Argentinian National Weather Service introduced a modification to the relationship between UV index values and their descriptors. In particular, the "extreme" threshold was changed from11+ to 15+. The corresponding ratio is 15/11 = 1.36, which is rather similar to that between the mean UVB-MED (minimal erythemal dose) for skin types II and the mean of III and IV (45/32.5) = 1.38 [13].

global UVI data products (e.g., http://www.temis.nl/uvradiation/), and has the additional advantage that highest UVI values are in Mountainous regions, where white is intuitively satisfying (e.g., as often used in altitude contours).

5. Apply objective criteria to health messages, as derived for the most at-risk major sub-group of the country or region. For example, they could be based on the calculated UVI value that cannot be exceeded for a person of skin type III to receive 1 MED (Minimal Erythemal Dose) in a short period, such as 30 minutes. Based on that criterion, protection is recommended for skin type III would be needed for UVI > 8 (see Table 1). More stringent criteria (e.g., cover up whenever UVI > 3) may still be required for people who are habitually outdoors, or for more sensitive skin types.
6. Educate the public so that they know what a given UVI value means for them personally. In the same way that we learn what a given temperature means for our comfort, the aim is to learn what a given UVI value means for our health. Unlike temperature, for which the physiological effects are immediate, the physiological effects of UV exposure (e.g., sunburn) are usually delayed, and manifest themselves several hours after the exposure. Consequently, some guidance is needed if damage is to be avoided. For example, the peak UVI expected where they live can be estimated from Figure 2. Then, for any given UVI value (provided by measurement or forecast), the number of minutes of exposure without protection before perceptible skin damage occurs can be estimated using Table 2. Note that these predicted exposure times are for an unshaded, horizontal surface. For skin surfaces facing the sun when it is low in the sky, exposure times can be significantly shorter than those estimated here, but these occurrences are only for relatively low UVI values.[14] Times are generally longer for most aspects of human behaviour in the sun, which involve an upright, ambulance subject,[15, 16] especially if there is partial obscuration of the sky, such as in urban areas.
7. Include representation from the Altiplano region (which has 30 million inhabitants and experiences the world's highest UV) on future committees to discuss the UVI.

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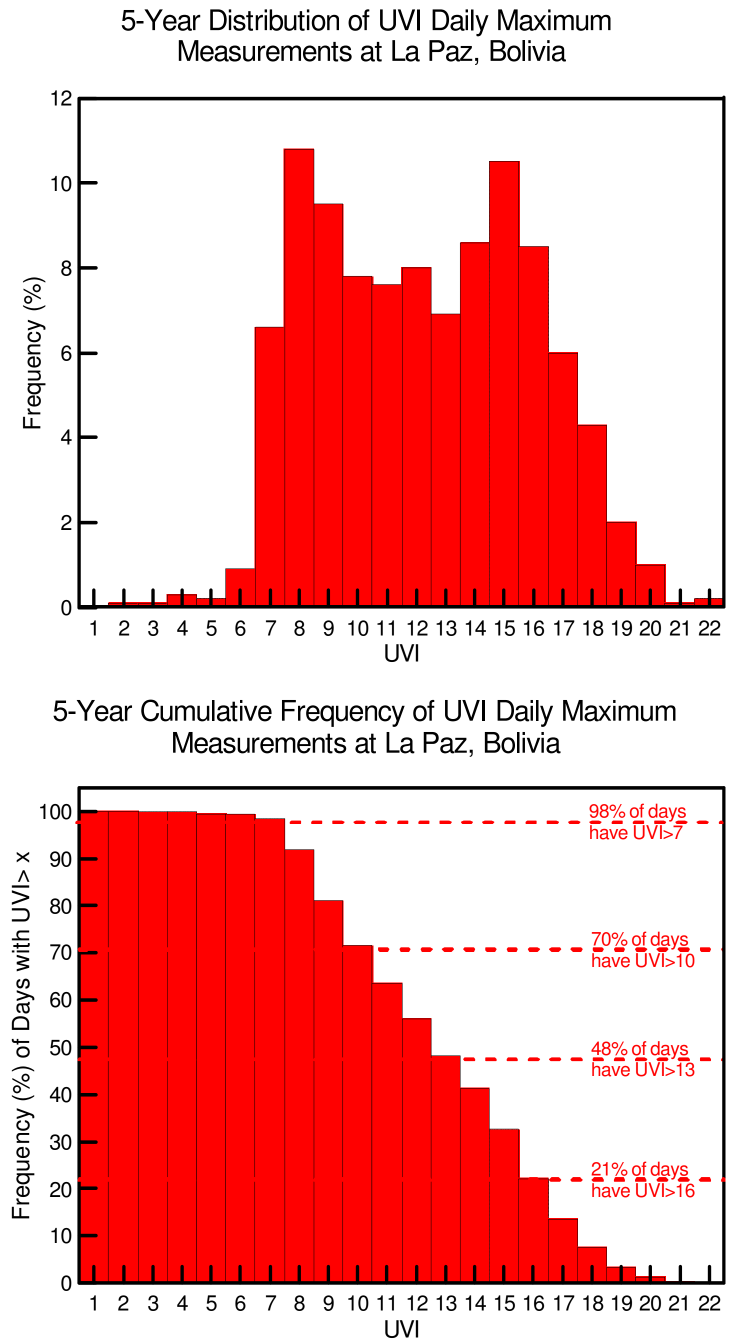

Figure 1. Cumulative distribution of peak daily UVI values measured by Brewer Spectrophotometer at the Laboratory for Atmospheric Physics (LFA-UMSA), La Paz Bolivia (16.5°S, 68.1°W, alt: 3420 m a.s.l) over a five year period (2008 to 2012), showing that UVI daily maximum exceeds 10 on two days out of every three. UVI measurements were available on 95% of the days.

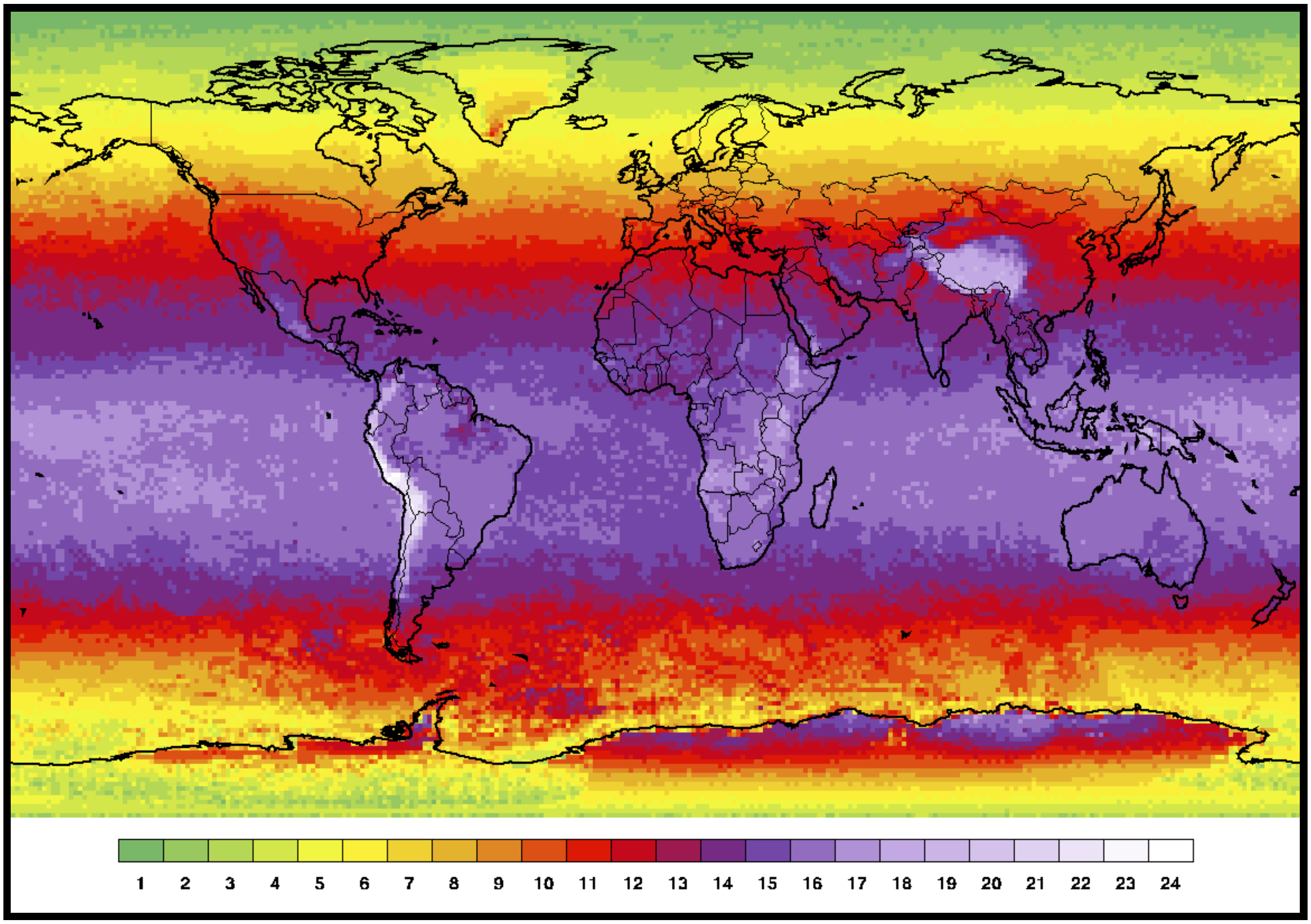

Figure 2. Peak UVI values by location. Shows that for places in the Altiplano region, where peak UVI values are highest, UVI > 20 may be considered "extreme", whereas in the UK, UVI > 8 may be considered "extreme". Adapted from [1]. Note that the colour scale used in this map is a modified and extended version of that recommended by WHO. With the WHO colour scale, the colours for more than 78% the globe area – representing 89% of the world's population [6] - would be indistinguishable (i.e., for regions with UVI > 10, corresponding to colours from red, through purple to white in the map shown).

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7	24	29	38	48	76	143
8	21	25	33	42	67	125
9	19	22	30	37	59	111
10	17	20	27	33	53	100
11	15	18	24	30	49	91
12	14	17	22	28	44	83
13	13	15	21	26	41	77
14	12	14	19	24	38	71
15	11	13	18	22	36	67
16	10	13	17	21	33	63
17	10	12	16	20	31	59
18	9	11	15	19	30	56
19	9	11	14	18	28	53
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these times are for an unobscured horizontal surface, and for realistic skin orientations, they are generally longer.