Shade evaluation method against ultraviolet radiation

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Abstract. Ultraviolet radiation UV-B can cause serious health problems, such as cataracts, loss of skin immunity, and skin cancer. For this reason, it is important to discover **how** to protect the human body from ultraviolet radiation. Shades are very effective in reducing exposure to UV radiation. The author measured the sky erythema radiance distribution. UV Sky Charts are plotted using the distribution of the erythema action ultraviolet radiation. These charts are useful for evaluation and designing shades.

Outline of Measurement Equipment

A form of AlGaN (i.e., UVPD-300T046BS-AlGaN manufactured by ALGAN, http://www.algan.jp/jp/) is used as a sensor. The sensor response is in excellent agreement with the human skin's sensitivity to erythema. Figure 1 shows the erythema ultraviolet radiance measurement equipment, where 145 sensors are buried on the surface of the hemisphere of the equipment. These sensors are calibrated under a xenon source for cross reference. The dimensions of the equipment's main body are 37 cm in length and width, the height is 20 cm, the leg portion is 5.5 cm diameter and height of the base and sphere portions are 40 cm and 20 cm respectively. The aperture angle of each tube where the sensor is buried is 11 degrees. The altitudes and directions of 145 area of the sky elements are determined by CIE. Based upon the radiance of 145th zenith element as a standard, a radiance ratio is obtained by the radiance of the number of each sky element being divided by the zenith radiance.
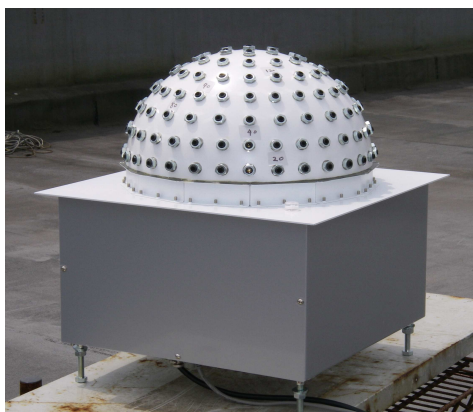

Figure1. Measurement equipment of erythema ultraviolet radiance distribution 145 sensors on the semi sphere.

Radiance distribution and direction

The UV Sky Chart as shown in Figure 2 was developed expressing sky erythema radiance as point density (Toshimasa et al., 2007, 2009). The sun angle on the circumference indicates the solar azimuth. About 50% of the dots were at and near the sun and about 50% in other sky areas.
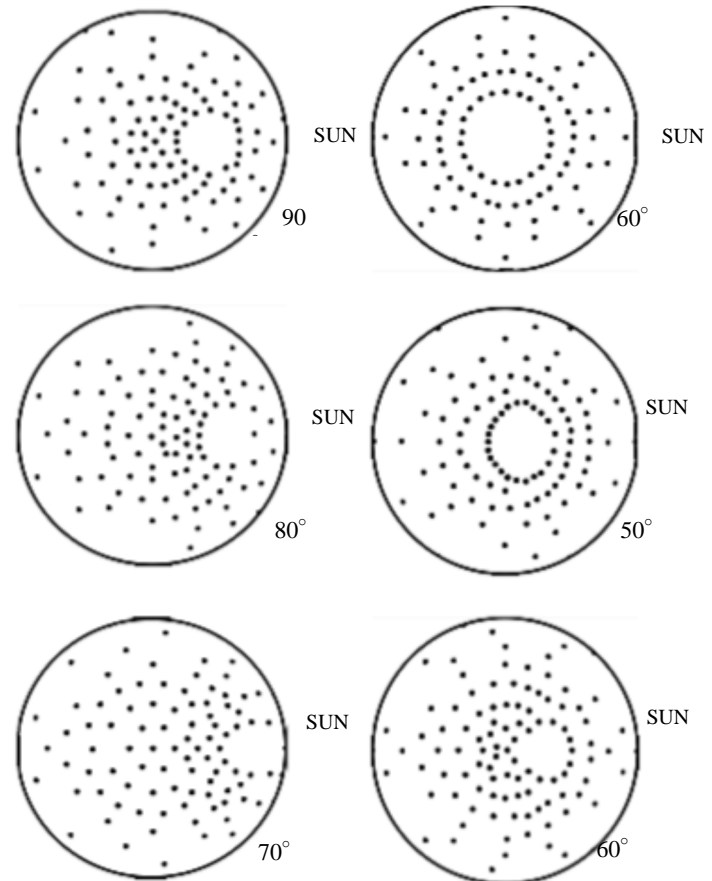

Figure2. UV Sky Chart   Sun elevation (°)

Following the development of the UV Sky Chart, a photograph is taken under a shade under test using a fisheye lens and superposed on the UV Sky Chart as in Figure 3. The number of dots in the visible sky area is counted, and the total number of dots divided by the number of dots in the sky area is defined as the architectural sun protection factor (ASPF). The ASPF can be obtained by the UVIndex outside of the shade divided by the UVIndex measured under the shade. The ASPF shows the shade protection factor in comparison with the case where there is no shade.

ASPF
= UVIndex out of shade ÷ UVIndex under shade
= Total points ÷ Points of sky part
(1)

For the shade evaluation as shown in Table1, ASPF=1 and 2 are Bad. ASPF=3-5 is good. ASPF=6-9 is good protection. ASPF equals above 10 is excellent protection.

Fukuda estimated the time for skin damage to be 20 minutes for fair-skinned Japanese (Fukuda, 1981). Thus, if a shade has an ASPF of 6, it is possible for such a person to stay under it for 6×20 minutes = 2 hours without developing erythema.
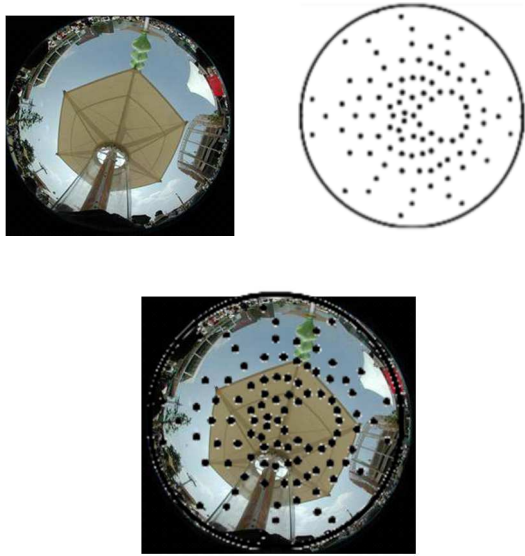
Figure 3. Upper left: Fisheye photograph of shade, Upper right: UV sky chart. Lower Superposition of photograph and UV Sky Chart

UV Sky Charts can be used to estimate the exposure to ultraviolet radiation in an outdoor space or under a shade

Table 1 ASPF & Evaluation

ASPF	Subrun Time (hour)	Evaluation	contents
1〜2	0.3	Bad	
3〜5	1	Good	Lunch,Tea
6〜9	2	Good Protection	Sports
10〜	3	Excellent Protection	Work

that designed to be block ultraviolet radiation. Figure 4 shows for various kinds of shade, the ASPF and evaluation.
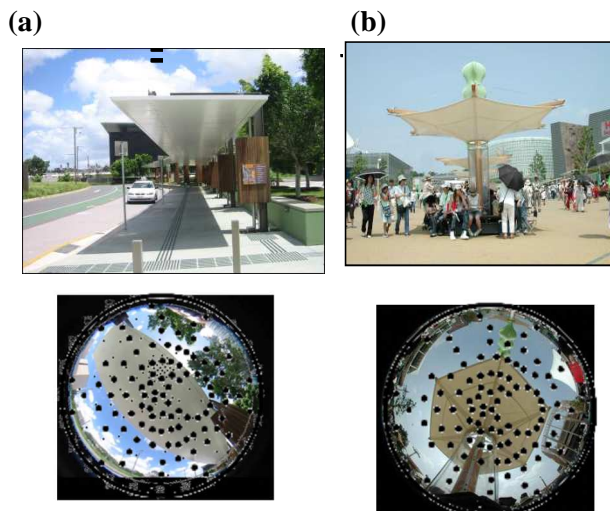
(a)　　　　　**(b)**

Figure 4 ASPF of various shades:
(a)Bus stop: ASPF=10   (b) Umbrella: ASPF= 5
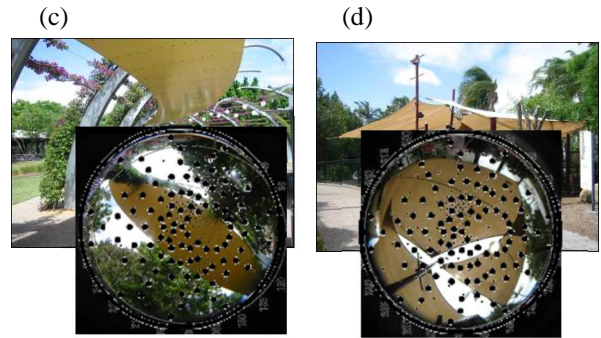
(c)　　　　　　(d)

Figure 4 (continued). ASPF of various shades.
 (c)Path roof: ASPF=16 (d) Play ground: ASPF=14

Conclusion

(1) UV Sky Chart was developed expressing sky erythema radiance as point density.

(2) ASPFs were calculated using these charts. The method proposed in this study makes it possible to design and evaluate the effectiveness of shades in protecting people from ultraviolet radiation.

References

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