Package 'photobiologyWavebands'

August 15, 2022

Type Package

Title Waveband Definitions for UV, VIS, and IR Radiation

Version 0.5.0

Date 2022-08-13

Maintainer Pedro J. Aphalo <pedro.aphalo@helsinki.fi>

Description Constructors of waveband objects for commonly used biological spectral weighting functions (BSWFs) and for different wavebands describing named ranges of wavelengths in the ultraviolet (UV), visible (VIS) and infrared (IR) regions of the electromagnetic spectrum. Part of the 'r4photobiology' suite, Aphalo P. J. (2015) <doi:10.19232/uv4pb.2015.1.14>.

License GPL (>= 2)

VignetteBuilder knitr

Depends R (>= 3.6.0), photobiology (>= 0.10.8)

Suggests knitr (>= 1.37), rmarkdown (>= 2.11)

LazyLoad yes

LazyData yes

ByteCompile true

Encoding UTF-8

URL https://docs.r4photobiology.info/photobiologyWavebands/, https://bitbucket.org/aphalo/photobiologywavebands

BugReports https://bitbucket.org/aphalo/photobiologywavebands/issues

RoxygenNote 7.2.1

NeedsCompilation no

Author Pedro J. Aphalo [aut, cre] (<https://orcid.org/0000-0003-3385-972X>), Titta K. Kotilainen [ctb] (<https://orcid.org/0000-0002-2822-9734>)

Repository CRAN

Date/Publication 2022-08-15 07:20:15 UTC

R topics documented:

`photobiologyWavebands-package`
photobiologyWavebands: Waveband Definitions for UV, VIS, and IR Radiation

---

Description

Constructors of waveband objects for commonly used biological spectral weighting functions (BSWFs) and for different wavebands describing named ranges of wavelengths in the ultraviolet (UV), visible (VIS) and infrared (IR) regions of the electromagnetic spectrum. Part of the 'r4photobiology' suite, Aphalo P. J. (2015) doi:10.19232/uv4pb.2015.1.14.

Details

This package provides constructors for objects of class `waveband` from package 'photobiology'. These contructors are based on standard definitions and frequently used non-standardized definitions. When different definitions are in common use for a given named waveband the constructors accept an argument to chose among them. Whenever an ISO standard provides a definition, this is used by default. In the infrared (IR) there are many different definitions and waveband names in use. We have tried to include most of the commonly used names and definitions.

Definitions "matching" the different bands of Landsat imagers are included. These are simple wavelength ranges for wavelengths at half-maximun response as given in the NASA literature, which in some cases presents small inconsistencies. These definitions cannot exactly reproduce instrument responses as they do not describe the real spectral responisveness of the satellite imagers.

By necesity we cover only a subset of all definitions in use. These should be thought as convenience functions, as waveband objects according to any arbitrary definition can be constructed with the functions provided by package `photobiology-package`

Author(s)

Maintainer: Pedro J. Aphalo <pedro.aphalo@helsinki.fi> (ORCID)

Other contributors:

- Titta K. Kotilainen <titta.kotilainen@helsinki.fi> (ORCID) [contributor]

References

Aphalo, Pedro J. (2015) The r4photobiology suite. UV4Plants Bulletin, 2015:1, 21-29. doi:10.19232/uv4pb.2015.1.14.

Aphalo, P. J., Albert, A., Björn, L. O., McLeod, A. R., Robson, T. M., Rosenqvist, E. (Eds.). (2012). Beyond the Visible: A handbook of best practice in plant UV photobiology (1st ed., p. xxx + 174). Helsinki: University of Helsinki, Department of Biosciences, Division of Plant Biology. ISBN 978-952-10-8363-1 (PDF), 978-952-10-8362-4 (paperback). Open access PDF download available at https://hdl.handle.net/10138/37558

Caldwell, M. M. (1971) Solar UV irradiation and the growth and development of higher plants. In Giese, A. C. (Ed.) Photophysiology, Academic Press, 1971, 6, 131-177

Diffey, B. L. 1991. Solar ultraviolet radiation effects on biological systems. Review in Physics in Medicine and Biology 36 (3): 299-328.

Green, A. E. S., Miller, J. H. (1975) Measures of biologically active radiation in the 280-340 nm region. Impacts of climate change on the environment. CIAP Monograph, 5, Part 1, Chapter 2.2.4

Green, A. E. S.; Sawada, T. & Shettle, E. P. (1974) The middle ultraviolet reaching the ground Photochemistry and Photobiology, 1974, 19, 251-259

Ibdah, M., Krins, A., Seidlitz, H. K., Heller, W., Strack, D. & Vogt, T. (2002) Spectral dependence of flavonol and betacyanin accumulation in Mesembryanthemum crystallinum under enhanced ultraviolet radiation. Plant, Cell & Environment, 25, 1145-1154

International Commission on Non-Ionizing Radiation Protection (2004) ICNIRP Guidelines on Limits of Exposure to Ultraviolet Radiation of Wavelengths Between 180 nm And 400 nm (Incoherent Optical Radiation). Health Physics 87(2):171-186. https://www.icnirp.org/cms/upload/publications/ICNIRPUV2004.pdf

ISO (2007) Optics and photonics - Spectral bands. ISO Standard 20473:2007. ISO, Geneva.

ISO (2007) Space environment (natural and artificial) - Process for determining solar irradiances. ISO Standard 21348. ISO, Geneva.

Quaite, F. E., Sutherland, B. M., Sutherland, J. C. Action spectrum for DNA damage in alfalfa lowers predicted impact of ozone depletion. Nature, 1992, 358, 576-578

Leutner, B. and Horning, N. (2016). RStoolbox: Tools for Remote Sensing Data Analysis. R package version 0.1.6. https://CRAN.R-project.org/package=RStoolbox

Micheletti, M. I.; Piacentini, R. D. & Madronich, S. (2003) Sensitivity of Biologically Active UV Radiation to Stratospheric Ozone Changes: Effects of Action Spectrum Shape and Wavelength Range Photochemistry and Photobiology, 78, 456-461

Musil, C. F. (1995) Differential effects of elevated ultraviolet-B radiation on the photochemical and reproductive performances of dicotyledonous and monocotyledonous arid-environment ephemerals Plant, Cell and Environment, 18, 844-854

Murakami, K., Aiga I. (1994) Red/Far-red photon flux ratio used as an index number for morphological control of plant growth under artificial lighting conditions. Proc. Int. Symp. Artificial Lighting, Acta Horticulturae, 418, ISHS 1997.

NASA (nd) Landsat 7 Science Data Users Handbook. https://landsat.gsfc.nasa.gov/wp-content/uploads/2016/08/Landsat7_Handbook.pdf Visited on 2016-12-26.

Sellaro, R., Crepy, M., Trupkin, S. A., Karayekov, E., Buchovsky, A. S., Rossi, C., & Casal, J. J. (2010). Cryptochrome as a sensor of the blue/green ratio of natural radiation in Arabidopsis. Plant physiology, 154(1), 401-409. doi:10.1104/pp.110.160820

Setlow, R. B. (1974) The Wavelengths in Sunlight Effective in Producing Skin Cancer: A Theoretical Analysis. Proceedings of the National Academy of Sciences, 71, 3363-3366

Smith, H. (1982) Light quality, photoperception and plant strategy. Annual Review of Plant Physiology, 33:481-518.

USGS (nd) Landsat 8 Science Data Users Handbook. https://www.usgs.gov/media/files/landsat-8-data-users-handbook. Visited on 2020-04-28.

Webb, A. R.; Slaper, H.; Koepke, P. & Schmalwieser, A. W. Know your standard: clarifying the CIE erythema action spectrum. Photochemistry and photobiology, 2011, 87, 483-486

See Also

Useful links:

- https://docs.r4photobiology.info/photobiologyWavebands/
- https://bitbucket.org/aphalo/photobiologywavebands
- Report bugs at https://bitbucket.org/aphalo/photobiologywavebands/issues

Examples

```
q_irrad(sun.spct, PAR())  # PAR photon irradiance
q_irrad(sun.spct, Blue("ISO")) # blue photon irradiance, ISO definition
q_irrad(sun.spct, Blue("Sellaro")) # blue photon irradiance, Sellaro et al.'s definition
e_irrad(sun.spct, VIS()) # VIS irradiance, ISO definition
q_irrad(sun.spct, VIS()) # VIS photon, ISO definition
```

Blue *Constructor of blue waveband*

Description

Default defined according to "ISO".

Usage

```
Blue(std = "ISO")
```

Arguments

std	a character string "ISO", "Sellaro" (plant biology), or "RS" (remote sensing), or Landsat imagers, "LandsatTM", "LandsatETM", or "LandsatOLI".

Value

a waveband object wavelength defining a wavelength range.

See Also

new_waveband waveband

Other unweighted wavebands: Far_red(), Green(), IR(), Orange(), Purple(), Red(), UVA(), UVB(), UVC(), UV(), VIS(), Yellow()

Examples

```
Blue()
Blue("ISO")
Blue("Sellaro")
```

CH4 *Constructor of CH4 production from pectin weighted waveband*

Description

Methane production from pectin BSWF

Usage

```
CH4(norm = 300, w.low = 275, w.high = 400)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

See Also

waveband

Other BSWF weighted wavebands: CIE(), DNA_GM(), DNA_N(), DNA_P(), FLAV(), GEN_G(), GEN_M(), GEN_T(), ICNIRP(), PG()

Examples

```
CIE()
CIE(300)
```

CH4_e_fun *Gives values for the CH4 production from pectin BSWF as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. The returned values are on quantum based effectiveness relative units.

Usage

```
CH4_e_fun(w.length)
```

Arguments

w.length	numeric array of wavelengths (nm)

Value

a numeric array of the same length as `w.length` with values for the BSWF normalized as in the original source (300 nm) and based on energy effectiveness.

References

Bloom, A. A.; Lee-Taylor, J.; Madronich, S.; Messenger, D. J.; Palmer, P. I.; Reay, D. S. & McLeod, A. R. (2010) Global methane emission estimates from ultraviolet irradiation of terrestrial plant foliage. New Phytologist, Blackwell Publishing Ltd, 187, 417–425 .

See Also

Other BSWF functions: `CH4_q_fun()`, `CIE_e_fun()`, `CIE_q_fun()`, `DNA_GM_q_fun()`, `DNA_P_q_fun()`, `FLAV_q_fun()`, `GEN_G_q_fun()`, `GEN_M_q_fun()`, `GEN_T_q_fun()`, `ICNIRP_e_fun()`, `PG_q_fun()`

Examples

```
CH4_e_fun(293:400)
```

CH4_q_fun *Gives values for the CH4 production from pectin BSWF as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. The returned values are on quantum based effectiveness relative units.

Usage

```
CH4_q_fun(w.length)
```

Arguments

w.length	numeric array of wavelengths (nm)

Value

a numeric array of the same length as `w.length` with values for the BSWF normalized as in the original source (300 nm) but based on quantum effectiveness.

See Also

Other BSWF functions: `CH4_e_fun()`, `CIE_e_fun()`, `CIE_q_fun()`, `DNA_GM_q_fun()`, `DNA_P_q_fun()`, `FLAV_q_fun()`, `GEN_G_q_fun()`, `GEN_M_q_fun()`, `GEN_T_q_fun()`, `ICNIRP_e_fun()`, `PG_q_fun()`

Examples

```
CH4_q_fun(293:400)
```

CIE *Constructor of CIE weighted waveband*

Description

Erythema BSWF

Usage

```
CIE(norm = 298, w.low = 250, w.high = 400)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

References

Webb, A. (20XX)

See Also

waveband

Other BSWF weighted wavebands: CH4(), DNA_GM(), DNA_N(), DNA_P(), FLAV(), GEN_G(), GEN_M(), GEN_T(), ICNIRP(), PG()

Examples

```
CIE()
CIE(300)
```

CIE1924_lef.spct *CIE1924 luminous efficiency function (photopic human vision)*

Description

A dataset containing the wavelengths at a 1 nm interval. Tabulated values for quantum luminous efficiency according to CIE1924.

Format

A response.spct object with 471 rows and 2 variables

Details

The variables are as follows:

- w.length (nm)
- s.q.response

Note

This luminous efficiency function understimates the renponse to short wavelengths.

References

http://www.cvrl.org/ downloaded on 2015-01-24

`CIE1951_scotopic_lef.spct` *Luminous efficiency function (scotopic human vision)*

Description

A dataset containing the wavelengths at a 1 nm interval. Tabulated values for quantum luminous efficiency at low light levels according to CIE1951.

Format

A response.spct object with 401 rows and 2 variables

Details

The variables are as follows:

- w.length (nm)
- s.q.response

References

http://www.cvrl.org/ downloaded on 2015-01-24

`CIE2008_lef2deg.spct` *CIE2008 luminous efficiency function (2-deg) (photopic human vision)*

Description

A dataset containing the wavelengths at a 1 nm interval. Tabulated values for quantum luminous efficiency according to CIE2008 for 2 degrees.

Format

A response.spct object with 441 rows and 2 variables

Details

The variables are as follows:

- w.length (nm)
- s.q.response

References

http://www.cvrl.org/ downloaded on 2015-01-24

CIE_e_fun *Gives values for the erythemal BSWF as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. The returned values are on quantum based effectiveness relative units.

Usage

```
CIE_e_fun(w.length)
```

Arguments

w.length	numeric array of wavelengths (nm)

Value

a numeric array of the same length as `w.length` with values for the BSWF normalized as in the original source (298 nm) and based on energy effectiveness.

See Also

Other BSWF functions: `CH4_e_fun()`, `CH4_q_fun()`, `CIE_q_fun()`, `DNA_GM_q_fun()`, `DNA_P_q_fun()`, `FLAV_q_fun()`, `GEN_G_q_fun()`, `GEN_M_q_fun()`, `GEN_T_q_fun()`, `ICNIRP_e_fun()`, `PG_q_fun()`

Examples

```
CIE_e_fun(293:400)
```

CIE_q_fun *Gives values for the erythemal BSWF as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. The returned values are on quantum based effectiveness relative units.

Usage

```
CIE_q_fun(w.length)
```

Arguments

w.length	numeric array of wavelengths (nm)

Value

a numeric array of the same length as w.length with values for the BSWF normalized as in the original source (298 nm) and based on quantum effectiveness.

See Also

Other BSWF functions: CH4_e_fun(), CH4_q_fun(), CIE_e_fun(), DNA_GM_q_fun(), DNA_P_q_fun(), FLAV_q_fun(), GEN_G_q_fun(), GEN_M_q_fun(), GEN_T_q_fun(), ICNIRP_e_fun(), PG_q_fun()

Examples

```
CIE_q_fun(293:400)
```

DNA_GM *Constructor of DNA damage (SETLOW) weighted waveband*

Description

Naked DNA damage BSWF, Green and Miller's formulation.

Usage

```
DNA_GM(norm = 300, w.low = 275, w.high = 400)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

See Also

new_waveband waveband

Other BSWF weighted wavebands: CH4(), CIE(), DNA_N(), DNA_P(), FLAV(), GEN_G(), GEN_M(), GEN_T(), ICNIRP(), PG()

Examples

```
DNA_GM()
DNA_GM(300)
```

`DNA_GM_q_fun` *Gives values for naked DNA BSWF (SETLOW) as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. It uses the seldom used Green and Miller formulation.

Usage

```
DNA_GM_q_fun(w.length)
```

Arguments

`w.length`	numeric array of w.length (nm)

Value

a numeric array of the same length as `w.length` with values for the BSWF normalized as in the original source. The returned values are based on quantum effectiveness units.

See Also

Other BSWF functions: `CH4_e_fun()`, `CH4_q_fun()`, `CIE_e_fun()`, `CIE_q_fun()`, `DNA_P_q_fun()`, `FLAV_q_fun()`, `GEN_G_q_fun()`, `GEN_M_q_fun()`, `GEN_T_q_fun()`, `ICNIRP_e_fun()`, `PG_q_fun()`

Examples

```
DNA_GM_q_fun(293:400)
```

DNA_N *Constructor of DNA damage (SETLOW) weighted waveband*

Description

Naked DNA damage BSWF

Usage

```
DNA_N(norm = 300, w.low = 275, w.high = 400)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

See Also

new_waveband waveband

Other BSWF weighted wavebands: CH4(), CIE(), DNA_GM(), DNA_P(), FLAV(), GEN_G(), GEN_M(), GEN_T(), ICNIRP(), PG()

Examples

```
DNA_N()
DNA_N(300)
```

DNA_N_q_fun *Gives values for naked DNA BSWF (SETLOW) as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances.

Usage

```
DNA_N_q_fun(w.length)
```

Arguments

w.length	numeric array of w.length (nm)

Value

a numeric array of the same length as w.length with values for the BSWF normalized as in the original source. The returned values are based on quantum effectiveness units.

Note

The digitized data as used in the TUV model covers the wavelength range from 256 nm to 364 nm. For longer wavelengths we set the value to zero, and for shorter wavelengths we extrapolate the value for 256 nm.

Examples

```
DNA_N_q_fun(293:400)
```

DNA_P *Constructor of DNA damage (Quaite) weighted waveband*

Description

Plant DNA damage BSWF as formulated by Musil.

Usage

```
DNA_P(norm = 300, w.low = 275, w.high = 400)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

See Also

new_waveband waveband

Other BSWF weighted wavebands: CH4(), CIE(), DNA_GM(), DNA_N(), FLAV(), GEN_G(), GEN_M(), GEN_T(), ICNIRP(), PG()

Examples

```
DNA_P()
DNA_P(300)
```

DNA_P_q_fun *Gives values for plant DNA BSWF (Quaite) as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. It uses the formulation proposed by Musil.

Usage

```
DNA_P_q_fun(w.length)
```

Arguments

w.length	numeric array of w.length (nm)

Value

a numeric array of the same length as `w.length` with values for the BSWF normalized as in the original source. The returned values are based on quantum effectiveness units.

See Also

Other BSWF functions: `CH4_e_fun()`, `CH4_q_fun()`, `CIE_e_fun()`, `CIE_q_fun()`, `DNA_GM_q_fun()`, `FLAV_q_fun()`, `GEN_G_q_fun()`, `GEN_M_q_fun()`, `GEN_T_q_fun()`, `ICNIRP_e_fun()`, `PG_q_fun()`

Examples

```
DNA_P_q_fun(293:400)
```

Far_red *Constructor of far-red waveband*

Description

Far-red radiation has no standardized definitions. Far-red is important in photobiology of plants mainly in relation to the phytochrome photoreceptors. The definitions proposed by Prof. Harry Smith are the most widely used, specially to compute a red to far-red photon ratio. However, other authors have used different definitions in their publications. These other definitions are preferred in situations where phytochromes are not the target of study. For example the "red edge" is is used in remote sensing to detect the condition of vegetation. plant photobiology, "Smith10" (725-735 nm), "Smith20" (720-740 nm), "Inada" (700-800 nm), "Warrington" (700-850 nm), and "Sellaro" (700-750 nm). The red-edge used in remote sensing of vegetation is centred at the reflectance transition in the far-red band (725 nm), we define "RedEdge40" (705-745 nm) and "RedEdge20" (715-735 nm).

Usage

```
Far_red(std = "ISO")
```

Arguments

std	a character string, defaults to "ISO", as for other colour definitions, which in this case returns NA.

Value

An object of class waveband, a class defined in package 'photobiology'.

Note

The bands are defined as square windows, these can be applied to spectral data to obtain the "true" values, but they do not simulate the sensitivity of broad-band sensors or the spectral transmittance of ionic filters. Some band-pass interference filters may have very sharp cut-in and cut-off, and their effect can be approximated by a square window, but filters based on light absorption will show gradual tails and bell-shaped wavelength-windows. The Landsat instruments have very steep cut-in anf cut-off slopes and are well approximated.

See Also

NIR for wavebands close to the boundary between red and infrared regions.

waveband

Other unweighted wavebands: Blue(), Green(), IR(), Orange(), Purple(), Red(), UVA(), UVB(), UVC(), UV(), VIS(), Yellow()

Examples

```
Far_red() # no ISO definition exists
Far_red("ISO") # no ISO definition exists
Far_red("Smith10") # 10 nm wide
Far_red("Smith20") # 20 nm wide
Far_red("Inada")
Far_red("Warrington")
Far_red("Sellaro")
Far_red("RedEdge40")
Far_red("RedEdge20")
```

FLAV *Constructor of FLAV BSWF flavonoids*

Description

Mesembryanthin accumulation BSWF, data and formulation from Ibdah et al.

Usage

```
FLAV(norm = 300, w.low = 275, w.high = 346)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

See Also

waveband

Other BSWF weighted wavebands: CH4(), CIE(), DNA_GM(), DNA_N(), DNA_P(), GEN_G(), GEN_M(), GEN_T(), ICNIRP(), PG()

Examples

```
FLAV()
FLAV(300)
```

FLAV_q_fun *Gives values for FLAV BSWF (flavonoid) as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. It is the action spectrum for the accumulation of mesembryanthin.

Usage

```
FLAV_q_fun(w.length)
```

Arguments

w.length	numeric array of w.length (nm)

Value

a numeric array of the same length as `w.length` with values for the BSWF normalized as in the original source. The returned values are based on quantum effectiveness units.

See Also

Other BSWF functions: CH4_e_fun(), CH4_q_fun(), CIE_e_fun(), CIE_q_fun(), DNA_GM_q_fun(), DNA_P_q_fun(), GEN_G_q_fun(), GEN_M_q_fun(), GEN_T_q_fun(), ICNIRP_e_fun(), PG_q_fun()

Examples

```
FLAV_q_fun(293:400)
```

GEN_G *Constructor of GPAS (Green) weighted waveband*

Description

Generalized Plant Action BSWF of Caldwell as formulated by Green et al.

Usage

```
GEN_G(norm = 300, w.low = 275, w.high = 313.3)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

Note

In the original publication [2] describing the formulation, the long-end wavelength boundary is specified as 313.3 nm. This is the default used here. However, in some cases it is of interest to vary this limit in sensitivity analyses. The effect on the RAF and doses of changing this boundary is substantial, and has been analysed by Micheletti et al. [3].

References

[1]Caldwell, M. M. (1971) Solar UV irradiation and the growth and development of higher plants. In Giese, A. C. (Ed.) Photophysiology, Academic Press, 1971, 6, 131-177

[2] Green, A. E. S.; Sawada, T. & Shettle, E. P. (1974) The middle ultraviolet reaching the ground Photochemistry and Photobiology, 1974, 19, 251-259

[3] Micheletti, M. I.; Piacentini, R. D. & Madronich, S. (2003) Sensitivity of Biologically Active UV Radiation to Stratospheric Ozone Changes: Effects of Action Spectrum Shape and Wavelength Range Photochemistry and Photobiology, 78, 456-461

See Also

waveband

Other BSWF weighted wavebands: CH4(), CIE(), DNA_GM(), DNA_N(), DNA_P(), FLAV(), GEN_M(), GEN_T(), ICNIRP(), PG()

Examples

```
GEN_G()
GEN_G(300)
```

GEN_G_q_fun *Gives values for GPAS BSWF (Green's formulation) as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. The BSWF is normalized at 280 nm.

Usage

```
GEN_G_q_fun(w.length)
```

Arguments

w.length	numeric array of w.length (nm)

Value

a numeric array of the same length as w.length with values for the BSWF normalized as in the original source. The returned values are based on quantum effectiveness units.

Note

In the original publication [2] describing the formulation, the long-end wavelength boundary is specified as 313.3 nm. The equation is coded here with no such limit so that any limit can be set when defining the waveband. We do so because in some cases it is of interest to vary this limit in sensitivity analyses. The effect on the RAF and doses of changing this boundary is substantial, and has been analysed by Micheletti et al. [3].

References

[1] Caldwell, M. M. (1971) Solar UV irradiation and the growth and development of higher plants. In Giese, A. C. (Ed.) Photophysiology, Academic Press, 1971, 6, 131-177

[2] Green, A. E. S.; Sawada, T. & Shettle, E. P. (1974) The middle ultraviolet reaching the ground Photochemistry and Photobiology, 1974, 19, 251-259

[3] Micheletti, M. I.; Piacentini, R. D. & Madronich, S. (2003) Sensitivity of Biologically Active UV Radiation to Stratospheric Ozone Changes: Effects of Action Spectrum Shape and Wavelength Range Photochemistry and Photobiology, 78, 456-461

See Also

Other BSWF functions: CH4_e_fun(), CH4_q_fun(), CIE_e_fun(), CIE_q_fun(), DNA_GM_q_fun(), DNA_P_q_fun(), FLAV_q_fun(), GEN_M_q_fun(), GEN_T_q_fun(), ICNIRP_e_fun(), PG_q_fun()

Examples

```
GEN_G_q_fun(293:400)
```

GEN_M *Constructor of GPAS (Micheletti) weighted waveband*

Description

Generalized Plant Action BSWF of Caldwell [1] as formulated by Micheletti et al. [2]

Usage

```
GEN_M(norm = 300, w.low = 275, w.high = 313.3)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

Note

In the original publication [2] describing the formulation, the long-end wavelength boundary is specified as 313.3 nm. This is the default used here. However, in some cases it is of interest to vary this limit in sensitivity analyses. The effect on the RAF and doses of changing this boundary is substantial, and has been analysed by Micheletti et al. [3].

References

[1]Caldwell, M. M. (1971) Solar UV irradiation and the growth and development of higher plants. In Giese, A. C. (Ed.) Photophysiology, Academic Press, 1971, 6, 131-177

[2] Micheletti, M. I.; Piacentini, R. D. & Madronich, S. (2003) Sensitivity of Biologically Active UV Radiation to Stratospheric Ozone Changes: Effects of Action Spectrum Shape and Wavelength Range Photochemistry and Photobiology, 78, 456-461

See Also

new_waveband and waveband

Other BSWF weighted wavebands: CH4(), CIE(), DNA_GM(), DNA_N(), DNA_P(), FLAV(), GEN_G(), GEN_T(), ICNIRP(), PG()

Examples

```
GEN_M()
GEN_M(300)
```

GEN_M_q_fun *Gives values for GPAS BSWF (Micheletti's formulation) as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. The BSWF is normalized at 300 nm.

Usage

```
GEN_M_q_fun(w.length)
```

Arguments

`w.length`	numeric array of w.length (nm)

Value

a numeric array of the same length as `w.length` with values for the BSWF normalized as in the original source. The returned values are based on quantum effectiveness units.

Note

In the original publication [2] describing the formulation, the long-end wavelength boundary is not specified, but 313.3 nm is usually used. The equation is coded here with the limit at 342 nm as at longer wavelengths the values increase with increasing wavelength. The effect on the RAF and doses of changing this boundary ican be substantial, and has been analysed by Micheletti et al. [3].

References

[1]Caldwell, M. M. (1971) Solar UV irradiation and the growth and development of higher plants. In Giese, A. C. (Ed.) Photophysiology, Academic Press, 1971, 6, 131-177

[2] Micheletti, M. I. and R. D. Piacentini (2002) Irradiancia espetral solar UV-B y su relación con la efectividad de daño biológico a las plantas. ANALES AFA, 13, 242-248

[3] Micheletti, M. I.; Piacentini, R. D. & Madronich, S. (2003) Sensitivity of Biologically Active UV Radiation to Stratospheric Ozone Changes: Effects of Action Spectrum Shape and Wavelength Range Photochemistry and Photobiology, 78, 456-461

See Also

Other BSWF functions: `CH4_e_fun()`, `CH4_q_fun()`, `CIE_e_fun()`, `CIE_q_fun()`, `DNA_GM_q_fun()`, `DNA_P_q_fun()`, `FLAV_q_fun()`, `GEN_G_q_fun()`, `GEN_T_q_fun()`, `ICNIRP_e_fun()`, `PG_q_fun()`

Examples

```
GEN_M_q_fun(293:400)
```

GEN_T *Constructor of GPAS (Timijan) weighted waveband*

Description

Generalized Plant Action BSWF of Caldwell [1] as formulated by Timijan et al. [2]

Usage

```
GEN_T(norm = 300, w.low = 275, w.high = 345)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

References

[1] Caldwell, M. M. (1971) Solar UV irradiation and the growth and development of higher plants. In Giese, A. C. (Ed.) Photophysiology, Academic Press, 1971, 6, 131-177

[2] Thimijan RW, Cams HR, Campbell L. (1978) Radiation sources and related environmental control for biological and climatic eflFects of UV research. Final report EPA-IAG-D6-0168. Washington: Environmental Protection Agency.

See Also

GEN.G GEN.M PG and waveband

Other BSWF weighted wavebands: CH4(), CIE(), DNA_GM(), DNA_N(), DNA_P(), FLAV(), GEN_G(), GEN_M(), ICNIRP(), PG()

Examples

```
GEN_T()
GEN_T(300)
```

GEN_T_q_fun *Gives values for GPAS BSWF (Timijan's formulation) as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances.

Usage

```
GEN_T_q_fun(w.length)
```

Arguments

w.length	numeric array of w.length (nm)

Value

a numeric array of the same length as `w.length` with values for the BSWF normalized as in the original source. The returned values are based on quantum effectiveness units.

Note

For wavelengths shorter than 256 nm the value returned by the equation starts decreasing, but we instead extrapolate this maximum value, obtained at 256 nm, to shorter wavelengths. For wavelengths longer than 345 nm we return zero, as is usual parctice.

See Also

Other BSWF functions: `CH4_e_fun()`, `CH4_q_fun()`, `CIE_e_fun()`, `CIE_q_fun()`, `DNA_GM_q_fun()`, `DNA_P_q_fun()`, `FLAV_q_fun()`, `GEN_G_q_fun()`, `GEN_M_q_fun()`, `ICNIRP_e_fun()`, `PG_q_fun()`

Examples

```
GEN_T_q_fun(293:400)
```

Green *Constructor of green waveband*

Description

Green radiation according to ISO or as commonly defined in plant photobiology, no weighting applied.

Usage

```
Green(std = "ISO")
```

Arguments

std	a character string "ISO", "Sellaro" or "LandsatRBV", and equivalent names for Landsat imagers.

Value

a waveband object wavelength defining a wavelength range.

Note

When released, this package will replace the package UVcalc.

See Also

waveband

Other unweighted wavebands: Blue(), Far_red(), IR(), Orange(), Purple(), Red(), UVA(), UVB(), UVC(), UV(), VIS(), Yellow()

Examples

```
Green()
Green("ISO") # 500 to 570
Green("Sellaro") # 500 to 570 nm
```

ICNIRP *Constructor of ICNIRP 2004 weighted waveband*

Description

ICNIRP 2004 BSWF waveband constructor. This BSWF is used for the determination of exposure limits (EL) for workers, and includes a safety margin as it is based on eye and the non-pathologic response of the most sensitive human skin types when not tanned.

Usage

```
ICNIRP(norm = 270, w.low = 210, w.high = 400)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object defining wavelength range, weighting function and normalization wavelength.

References

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION (2004) ICNIRP GUIDELINES ON LIMITS OF EXPOSURE TO ULTRAVIOLET RADIATION OF WAVELENGTHS BETWEEN 180 nm AND 400 nm (INCOHERENT OPTICAL RADIATION). HEALTH PHYSICS 87(2):171-186. https://www.icnirp.org/cms/upload/publications/ICNIRPUV2004.pdf

See Also

new_waveband waveband

Other BSWF weighted wavebands: CH4(), CIE(), DNA_GM(), DNA_N(), DNA_P(), FLAV(), GEN_G(), GEN_M(), GEN_T(), PG()

Examples

```
ICNIRP()
```

ICNIRP_e_fun *Values for the ICNIRP BSWF as a function of wavelength*

Description

This function returns a vector of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. The returned values are on energy based effectiveness relative units. The BSWF is defined for the range 210 nm to 400 nm.

Usage

```
ICNIRP_e_fun(w.length)
```

Arguments

w.length	numeric array of wavelengths (nm)

Value

a numeric array of the same length as `w.length` with values for the BSWF normalized as in the original source (270 nm) and based on energy effectiveness.

See Also

Other BSWF functions: `CH4_e_fun()`, `CH4_q_fun()`, `CIE_e_fun()`, `CIE_q_fun()`, `DNA_GM_q_fun()`, `DNA_P_q_fun()`, `FLAV_q_fun()`, `GEN_G_q_fun()`, `GEN_M_q_fun()`, `GEN_T_q_fun()`, `PG_q_fun()`

Examples

```
ICNIRP_e_fun(210:400)
```

IR *Constructors of infra-red wavebands*

Description

The wavelength limits for `std = "RS"` and Landsat imagers have been taken from R package RStools and NASA and USGS documentation. They are defined simply as wavelength ranges without considering the spectral sensitivity of satellite intruments/cameras based on which remote sensing based indexes are usually calculated. The values for `std = "ISO"` are according to ISO 20473. The values for `std = "CIE"` are suggested values according to Wikipedia, and need verification.

Usage

```
IR(std = "ISO")

NIR(std = "ISO")

IRA(std = "CIE")

SWIR(std = "CIE")

IRB(std = "CIE")

SWIR1(std = "RS")

SWIR2(std = "RS")

MIR(std = "ISO")

IRC(std = "CIE")

FIR(std = "ISO")

TIR1(std = "RS")

TIR2(std = "RS")
```

Arguments

std	character string, "ISO", "CIE", or Landsat imagers named "LandsatRBV", "LandsatMSS", etc., or "RS", for remote sensing wavebands as defined in the documentation of package 'RStoolbox'.

Details

The names NIR, SWIR and TIR are abbreviations of near infra-red, short-wave infra-red and thermal infra-red, respectively.

Value

a waveband object wavelength defining a wavelength range.

See Also

Far_red for wavebands close to the boundary between red and infrared regions.

new_waveband waveband

Other unweighted wavebands: Blue(), Far_red(), Green(), Orange(), Purple(), Red(), UVA(), UVB(), UVC(), UV(), VIS(), Yellow()

Examples

```
SWIR1()
SWIR1("RS")
```

IR_bands *Constructor of lists of infrared wavebands*

Description

Defined according to "ISO" or "CIE".

Usage

```
IR_bands(std = "ISO")
```

Arguments

std	a character string "ISO" or "CIE".

Value

a list of wavebands

See Also

waveband

Other lists of unweighted wavebands: Landsat_bands(), Plant_bands(), UV_bands(), VIS_bands()

Examples

```
IR_bands()
IR_bands("ISO")
IR_bands("CIE")
```

`Landsat_bands` *Constructor of lists of wavebands matching Landsat imagers*

Description

Defined according as ranges of wavelengths according to NASA and USGS manuals. The definitions are as *rectangular* windows, while the true response functions deviate to some extent from these ideal definitions.

Usage

```
Landsat_bands(std = "L8")

RBV_bands(std = "LandsatRBV")

MSS_bands(std = "LandsatMSS")

OLI_bands(std = "LandsatOLI")

TIRS_bands(std = "LandsatTIRS")

ETM_bands(std = "LandsatETM")
```

Arguments

`std`	a character string "L1"..."L9", for missions, "LandsarRBV", "LandsatMSS", etc. for imagers.

Details

See https://landsat.usgs.gov/spectral-characteristics-viewer for detailed sensitivity spectra for the different bands of the imaginers.

Value

a list of wavebands

See Also

`waveband`

Other lists of unweighted wavebands: `IR_bands()`, `Plant_bands()`, `UV_bands()`, `VIS_bands()`

Examples

```
Landsat_bands("L1")
Landsat_bands("L8")
OLI_bands()
TIRS_bands()
```

NDVI *Normalized Vegetation Index*

Description

Compute the NDVI from spectral reflectance according to waveband definitions from standards or corresponding to satellite imagers.

Usage

```
NDVI(spct, imager = "LandsatOLI", wb.trim = FALSE)
```

Arguments

spct	reflectance_spct or reflectance_mspct object.
imager	character Name of the imager or standard to be used.
wb.trim	logical Flag telling if wavebands crossing spectral data boundaries are trimmed or ignored.

Details

NDVI is used in remote sensing to the diagnose the condition of vegetation, including crops. It is used for Landsat imagery but also at the farm or plot scale using cameras on drones. It is computed as:

NDVI = (NIR - Red) / (NIR + Red)

The waveband ranges used to compute reflectance vary. Even the imagers in the different Landsat satellites 1 to 8 have had somehow different wavelength sensitivities. The `NDVI()` function uses the waveband constructors `Red` and `NIR` defined in this package. Reflectance is averaged over the wavebands using function `reflectance`.

Value

A numeric vector. When the wavelength range of `spct` does not fully overlap with both wavebands `NA` is silently returned.

Note

The value passed as argument to `imager` must be a valid argument for both `Red` and `NIR`. If the desired return value is a data frame, function `NDxI` can be used to flexibly compute NDVI and any similar index.

Orange *Constructor of orange waveband*

Description

Orange radiation (591...610 nm), no weighting applied.

Usage

```
Orange(std = "ISO")
```

Arguments

std	a character string "ISO"

Value

a waveband object wavelength defining a wavelength range.

See Also

Other unweighted wavebands: Blue(), Far_red(), Green(), IR(), Purple(), Red(), UVA(), UVB(), UVC(), UV(), VIS(), Yellow()

Examples

```
Orange()
Orange("ISO")
```

PAR *Constructor of PAR waveband*

Description

Photosythetically active radiation (400-700 nm), no weighting applied.

Usage

```
PAR(std = "Plant")
```

Arguments

std	a character string "Plant" or "McCree"

Value

a waveband object wavelength defining a wavelength range.

References

McCree, K. J. (1972) The action spectrum, absorptance and quantum yield of photosynthesis in crop plants. Agricultural Meteorology, 9, 191-216

See Also

waveband

Examples

```
PAR()
PAR("Plant")
```

PG *Constructor of PG weighted waveband*

Description

Plant growth BSWF

Usage

```
PG(norm = 300, w.low = 275, w.high = 390)
```

Arguments

norm	normalization wavelength (nm)
w.low	short-end boundary wavelength (nm)
w.high	long-end boundary wavelength (nm)

Value

a waveband object wavelength defining wavelength range, weighting function and normalization wavelength.

Note

In the original publication [1], the long-end wavelength boundary is not specified. the longest wavelength at which the plant response was measured is 366 nm. From the data there is no evidence that action would immediately drop to zero at longer wavelengths. We have used in earlier versions the same value as used by the 'NSF Polar Programs UV Monitoring Network' as described in http://uv.biospherical.com/Version2/description-Version2-Database3.html. Now we keep 390 nm as our default value, but make if possible for the user to set a different wavelength. To reproduce the output of the TUV simulation model [3] version 5.0 set `w.high = 366`.

In contrast to the NSF Network, for example, the programme TUV uses 366 nm as the limit, so for comparing results one may need to adjust the value of this parameter. The effect on the RAF and doses of changing this wavelength boundary is substantial, as discussed by Micheletti et al. [2].

References

[1] Flint, S. and Caldwell M. M. (2003) A biological spectral weighting function for ozone depletion research with higher plants Physiologia Plantarum, 2003, 117, 137-144

[2] Micheletti, M. I.; Piacentini, R. D. & Madronich, S. (2003) Sensitivity of Biologically Active UV Radiation to Stratospheric Ozone Changes: Effects of Action Spectrum Shape and Wavelength Range Photochemistry and Photobiology, 78, 456-461

[3] https://www2.acom.ucar.edu/modeling/tropospheric-ultraviolet-and-visible-tuv-radiation-model

See Also

GEN_G GEN_T GEN_M and waveband

Other BSWF weighted wavebands: CH4(), CIE(), DNA_GM(), DNA_N(), DNA_P(), FLAV(), GEN_G(), GEN_M(), GEN_T(), ICNIRP()

Examples

```
PG()
PG(300)
```

PG_q_fun *Gives values for the Plant Growth BSWF as a function of wavelength*

Description

This function gives a set of numeric multipliers that can be used as a weight to calculate effective doses and irradiances. The returned values are on quantum based effectiveness relative units.

Usage

```
PG_q_fun(w.length)
```

Arguments

w.length	numeric array of wavelengths (nm)

Value

a numeric array of the same length as w.length with values for the BSWF normalized as in the original source (300 nm)

Note

We follow the original defition here for the equation, with no limtation to the wavelength range. However, be aware that in practice it is not used for long wavelengths (different limits between 366 nm and 400 nm have been used by different authors).

See Also

Other BSWF functions: CH4_e_fun(), CH4_q_fun(), CIE_e_fun(), CIE_q_fun(), DNA_GM_q_fun(), DNA_P_q_fun(), FLAV_q_fun(), GEN_G_q_fun(), GEN_M_q_fun(), GEN_T_q_fun(), ICNIRP_e_fun()

Examples

```
PG_q_fun(293:400)
```

---

photopic_sensitivity *Photopic sensitivity of the human eye*

Description

Constant value used in the definition of Lumen 1 Lumen is equal to 683 W at 555 nm

Usage

```
photopic_sensitivity
```

Format

A single numeric value

Details

A single numeric value

Plant_bands *Constructor of lists of wavebands used in plant biology*

Description

Defined according to different authors.

Usage

```
Plant_bands(std = "sensory20")
```

Arguments

std	a character string "sensory", "sensory10", "sensory20", "ISO", "CIE", "none" or "", where "ISO", "CIE" and "none" affect only the UV bands.

Value

a list of wavebands

See Also

waveband

Other lists of unweighted wavebands: IR_bands(), Landsat_bands(), UV_bands(), VIS_bands()

Examples

```
Plant_bands()
Plant_bands("sensory")
Plant_bands("sensory10")
Plant_bands("sensory20")
Plant_bands("ISO")
Plant_bands("CIE")
```

Purple *Constructor of purple waveband*

Description

Purple radiation (360...450 nm), no weighting applied.

Usage

```
Purple(std = "ISO")
```

Arguments

std	a character string "ISO", or Landsat imager "LandsatOLI".

Value

A waveband object wavelength defining a wavelength range.

See Also

new_waveband waveband

Other unweighted wavebands: Blue(), Far_red(), Green(), IR(), Orange(), Red(), UVA(), UVB(), UVC(), UV(), VIS(), Yellow()

Examples

```
Purple()
Purple("ISO")
```

Red *Constructor of red waveband*

Description

Red radiation according to "ISO" (610-760 nm) or as commonly defined in plant photobiology, "Smith10" (655-665 nm), "Smith20" (650-670 nm), "Inada" (600-700 nm), "Warrington" (625-675 nm), and "Sellaro" (620-680 nm). No weighting applied.

Usage

```
Red(std = "ISO")
```

Arguments

std	a character string, "ISO", "Smith10", "Smith20", "Inada", "Warrington", "Sellaro", "RS", or for Landsat imagers "LandsatRBV", etc.

Value

a waveband object wavelength defining a wavelength range.

References

Aphalo, P. J., Albert, A., Björn, L. O., McLeod, A. R., Robson, T. M., Rosenqvist, E. (Eds.). (2012). Beyond the Visible: A handbook of best practice in plant UV photobiology (1st ed., p. xxx + 174). Helsinki: University of Helsinki, Department of Biosciences, Division of Plant Biology. ISBN 978-952-10-8363-1 (PDF), 978-952-10-8362-4 (paperback). Open access PDF download available at https://hdl.handle.net/10138/37558

ISO (2007) Space environment (natural and artificial) - Process for determining solar irradiances. ISO Standard 21348. ISO, Geneva.

Murakami, K., Aiga I. (1994) Red/Far-red photon flux ratio used as an index number for morphological control of plant growth under artificial lighting conditions. Proc. Int. Symp. Artificial Lighting, Acta Horticulturae, 418, ISHS 1997.

Sellaro, R., Crepy, M., Trupkin, S. A., Karayekov, E., Buchovsky, A. S., Rossi, C., & Casal, J. J. (2010). Cryptochrome as a sensor of the blue/green ratio of natural radiation in Arabidopsis. Plant physiology, 154(1), 401-409. doi:10.1104/pp.110.160820

Smith, H. (1982) Light quality, photoperception and plant strategy. Annual Review of Plant Physiology, 33:481-518.

See Also

waveband

Other unweighted wavebands: Blue(), Far_red(), Green(), IR(), Orange(), Purple(), UVA(), UVB(), UVC(), UV(), VIS(), Yellow()

Examples

```
Red()
Red("ISO")
Red("Smith")
Red("Sellaro")
```

---

scotopic_sensitivity *Scotopic sensitivity of the human eye*

Description

Constant value for human vision under very weak illumination 1 Lumen is equal to 1699 W at 507 nm

Usage

```
scotopic_sensitivity
```

Format

A single numeric value

Details

A single numeric value

`SetlowTUV.spct` *Setlow's action spectrum for DNA damage*

Description

A dataset containing the wavelengths at a 0.1 nm interval. Tabulated values for Setlow's naked DNA damage action spectrum as used in the TUV model.

Format

A response.spct object with 1082 rows and 2 variables

Details

The variables are as follows:

- w.length (nm)
- s.e.response

References

http://uv.biospherical.com/Version2/description-Version2-Database3.html downloaded 2015-02-07

`UV` *Constructor of UV waveband*

Description

UV: 100–400 nm.

Usage

```
UV(std = "ISO")
```

Arguments

`std`	"ISO" or "CIE"

Value

a waveband object wavelength defining a wavelength range.

References

ISO and CIE standards

See Also

new_waveband waveband

Other unweighted wavebands: Blue(), Far_red(), Green(), IR(), Orange(), Purple(), Red(), UVA(), UVB(), UVC(), VIS(), Yellow()

Examples

```
UV()
UV("ISO")
```

UVA *Constructor of UV-A waveband*

Description

UV-A according to CIE and ISO standards: 315-400 nm. UV-A according to common non-standard practice: 320-400 nm. UV-A2 according to CIE report 134/1: 315-340 nm. UV-A1 according to CIE report 134/1: 340-400 nm. UV-Asw according to non-standard use possibly suitable for plants: 315-350 nm. UV-Alw according to non-standard use possibly suitable for plants: 350-400 nm.

Usage

```
UVA(std = "ISO")

UVA1(std = "CIE")

UVA2(std = "CIE")

UVAsw(std = "plants")

UVAlw(std = "plants")

UVAsw(std = "plants")
```

Arguments

std	a character string "CIE", "ISO" or "none".

Value

A waveband object wavelength defining a wavelength range.

Note

The non-standard definitions of UV-A and UV-A2 using 320 nm as limit should not be used in any new publications or work as they deviate from the internationally recommended practice. Their continued use leads to confusion. Their inclusion in this package is to allow calculations needed to compare new results and methods against old publications. UV-A1 and UV-A2 definitions are in use in medicine, but not yet standardised. Recent research on the plant photoreceptor UVR8 suggests that UV-A1 and UV-A2 bands are also relevant to plants (Rai et al., 2021). UV-Alw and UV-Asw have been used for plants, but UV-A1 and UV-A2 seem now preferable.

References

CIE (1999) 134/1 TC 6-26 report: Standardization of the Terms UV-A1, UV-A2 and UV-B. https://cie.co.at/publications/cie-collection-photobiology-photochemistry-1999

Rai N, Morales LO, Aphalo PJ (2021) Perception of solar UV radiation by plants: photoreceptors and mechanisms. Plant Physiology 186: 1382–1396. doi:10.1093/plphys/kiab162

See Also

waveband

Other unweighted wavebands: Blue(), Far_red(), Green(), IR(), Orange(), Purple(), Red(), UVB(), UVC(), UV(), VIS(), Yellow()

Examples

```
UVA()
UVA("none")
UVA("ISO")
UVA("CIE")
UVA1()
UVA1("CIE")
UVA2()
UVA2("CIE")
```

UVB *Constructor of UV-B waveband*

Description

UV-B according to CIE and ISO standrads: 280–315 nm. UV-B according to common non-standard practice: 280–320 nm. UV-B according to medical or dermatological non-standard practice: 280–320 nm.

Usage

```
UVB(std = "ISO")
```

Arguments

std	a character string "CIE", "ISO", "medical" or "none"

Value

a waveband object wavelength defining a wavelength range.

Note

The non-standard definition of UV-B using 320 nm as limit should not be used in any new publications or work as it deviates from the internationally accepted standards and its use leads to confusion. Its inclusion in this package is to allow calculations needed to compare new results and methods against old publications.

See Also

waveband

Other unweighted wavebands: Blue(), Far_red(), Green(), IR(), Orange(), Purple(), Red(), UVA(), UVC(), UV(), VIS(), Yellow()

Examples

```
UVB()
UVB("ISO")
UVB("CIE")
UVB("none")
UVB("medical")
```

UVC *Constructor of UV-C waveband*

Description

UV-C according to CIE and ISO standrads: 100–280 nm. UV-c according to common non-standard practice: 200–280 nm. UV-C according to medical or dermatological non-standard practice, e.g. Diffey (1991): 200–290 nm.

Usage

```
UVC(std = "ISO")
```

Arguments

std	a character string "CIE", "ISO", "none", or "medical".

Value

a waveband object wavelength defining a wavelength range.

See Also

new_waveband waveband

Other unweighted wavebands: Blue(), Far_red(), Green(), IR(), Orange(), Purple(), Red(), UVA(), UVB(), UV(), VIS(), Yellow()

Examples

```
UVC()
UVC("CIE")
UVC("ISO")
UVC("none")
UVC("medical")
```

UVI *Calculate UVI from spectral irradiance*

Description

UVI (UV Index) is a unitless quantity based on erythema BSWF, that gives an easy to interpret UV measure, mainly meant for informing general public about sunburn risk.

Usage

```
UVI(spct, std = "NOAA")
```

Arguments

spct	a source.spct object
std	"WWO" (250 nm to 400 nm), "NOAA" (286.5 nm to 400 nm)

Details

Two different definitions of UV Index are implemented in this package. Setting std="NOAA" follows the definition in Kiedron et al. (2007) but using CIE98 as SWF. NOAA definition discards wavelengths shorter than 286.5 nm as when calculated based on spectral data from Brewer instruments. "WMO" uses the internationally accepted lower limit at 250 nm (see WHO, 2002). "NOAA" is the default as this is safer with noisy data for solar radiation measured at ground level, and in this case the value of UVI should be correct, and almost identical except for errors caused by noise at shorter wavelengths. However, when calculating UVI from radiation spectra from UV lamps, "WMO" should be used, as most UV lamps do emit some radiation between 250 nm and 286.5 nm.

Value

a numeric value for the unitless UVI (This is a value on a continuous scale, rather than the discrete scale normally used.)

References

WHO (2002) Global Solar UV Index: A Practical Guide. ISBN 92 4 159007 6, WHO, Geneva. https://apps.who.int/iris/handle/10665/42459.

P. Kiedron, S. Stierle and K. Lantz (2007) Instantaneous UV Index and Daily UV Dose Calculations. NOAA-EPA Brewer Network. https://www.esrl.noaa.gov/gmd/grad/neubrew/docs/UVindex.pdf

Examples

```
UVI(sun.spct)
UVI(sun.spct, "WMO")
round(UVI(sun.spct), 0)
```

UV_bands *Constructor of lists of UV wavebands*

Description

Defined according to "ISO" by default, but other definitions also supported.

Usage

```
UV_bands(std = "ISO")
```

Arguments

std	a character string "ISO", "CIE", "medical", "plants" or "none".

Value

a list of wavebands

See Also

waveband

Other lists of unweighted wavebands: IR_bands(), Landsat_bands(), Plant_bands(), VIS_bands()

Examples

```
UV_bands()
UV_bands("ISO")
UV_bands("CIE")
UV_bands("medical")
UV_bands("plants")
UV_bands("none")
```

`VIS` *Constructor of VIS waveband*

Description

Visible (to humnas) radiation (380...760 nm) according to ISO standard definition, no weighting applied. For `std = "RS"` the returned range is the same as for `PAR()`. The panchromatic bands of Landsat missions are also supported.

Usage

```
VIS(std = "ISO")
```

Arguments

`std`	a character string "ISO" or "RS" (remote sensing).

Value

A waveband object wavelength defining a wavelength range.

See Also

`waveband`

Other unweighted wavebands: `Blue()`, `Far_red()`, `Green()`, `IR()`, `Orange()`, `Purple()`, `Red()`, `UVA()`, `UVB()`, `UVC()`, `UV()`, `Yellow()`

Examples

```
VIS()
VIS("ISO")
VIS("LandsatOLI")
VIS("Landsat7")
VIS("Pan.RBV.Landsat3")
```

VIS_bands *Contructor of lists of VIS wavebands*

Description

Defined according to "ISO".

Usage

```
VIS_bands(std = "ISO")
```

Arguments

std	a character string "ISO".

Value

a list of wavebands

See Also

Other lists of unweighted wavebands: IR_bands(), Landsat_bands(), Plant_bands(), UV_bands()

Examples

```
VIS_bands()
VIS_bands("ISO")
```

Yellow *Constructor of yellow waveband*

Description

Yellow radiation (570...591 nm), no weighting applied.

Usage

```
Yellow(std = "ISO")
```

Arguments

std	a character string "ISO"

Value

a waveband object wavelength defining a wavelength range.

See Also

waveband

Other unweighted wavebands: Blue(), Far_red(), Green(), IR(), Orange(), Purple(), Red(), UVA(), UVB(), UVC(), UV(), VIS()

Examples

```
Yellow()
Yellow("ISO")
```

Index