Package 'photobiologySun'

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Type Package

Title Data for Sunlight Spectra

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Description Data for the extraterrestrial solar spectral irradiance and ground level solar spectral irradiance and irradiance. In addition data for shade light under vegetation and irradiance time series from different broadband sensors. Part of the 'r4photobiology' suite, Aphalo P. J. (2015) <doi:10.19232/uv4pb.2015.1.14>.

License GPL (>= 2)

VignetteBuilder knitr

Depends R (>= 4.1.0), photobiology (>= 0.14.0)

Suggests knitr (>= 1.45), rmarkdown (>= 2.26), photobiologyWavebands (>= 0.5.3), ggspectra (>= 0.3.17), lubridate (>= 1.9.3)

LazyLoad yes

LazyData yes

ByteCompile true

Encoding UTF-8

URL https://docs.r4photobiology.info/photobiologySun/, https://github.com/aphalo/photobiologySun

BugReports https://github.com/aphalo/photobiologySun/issues

RoxygenNote 7.3.3

NeedsCompilation no

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photobiologySun: Data for Sunlight Spectra

Description

Data for the extraterrestrial solar spectral irradiance and ground level solar spectral irradiance and irradiance. In addition data for shade light under vegetation and irradiance time series from different broadband sensors. Part of the 'r4photobiology' suite, Aphalo P. J. (2015) doi:10.19232/uv4pb.2015.1.14.

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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

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

See Also

Useful links:

- https://docs.r4photobiology.info/photobiologySun/
- https://github.com/aphalo/photobiologySun
- Report bugs at https://github.com/aphalo/photobiologySun/issues

Examples

```
library(photobiology)
library(photobiologyWavebands)

q_irrad(sun_may_morning.spct, PAR())
q_ratio(sun_may_morning.spct, Red("Smith10"), Far_red("Smith10"))
```

---

four_days_1min.data *Ground level irradiance for wavelength bands*

Description

Dataset containing mean values for observed terrestrial radiation for PAR, UV-B, UV-A2, UV-A1, blue, red, and far-red photon irradiances and global radiation energy irradiance. Values are summaries of 12 consecutive readings acquired once every 5 s. The data set covers 4 consecutive days with different cloud conditions.

Usage

```
four_days_1min.data
```

Format

A data frame with 24479 rows and 9 variables. variables.

Details

The variables are as follows:

- time_EEST POSIXct Local time according to EET coordinates.
- UTC POSIXct Local time according to UTC.
- solar_time numeric Local solar time (h)
- sun_elevation numeric Sun elevation above the astronomical horizon (degrees)
- PAR_umo numeric (umol m-2 m-2)
- PAR_diff_fr numeric Fraction of total downwelling PAR that is diffuse (/1)
- global_watt numeric Global radiation (W m-2)
- red_umol numeric Red () light (umol m-2 m-2)
- far_red_umol numeric Far red () light (umol m-2 m-2)
- blue_umol numeric blue light () (umol m-2 m-2)
- blue_sellaro_umol numeric blue light () (umol m-2 m-2)
- UVA_umol numeric UV-A radiation (315-400 nm) (umol m-2 m-2)
- UVA1_umol numeric UV-A1 radiation (340-400 nm) (umol m-2 m-2)
- UVA2_umol numeric UV-A2 radiation (315-340 nm) (umol m-2 m-2)
- UVB_umol numeric UV-B radiation (280-315 nm) (umol m-2 m-2)
- solar_disk factor Estimate of whether the solar disk was visible or occluded (visible, occluded)

These data are part of a much larger data set (Aphalo, 2023). height. Data collected with a Campbell Scientific CR6 datalogger, using analogue outputs from the sensors. Location: Viikki campus of the University of Helsinki. Coordinates: 60.226803 N, 25.019205 E. Same data were plotted in Fig. 1 of Sellaro et al. (2024).

References

Aphalo, Pedro J. (2023) High frequency weather data for Viikki, Helsinki, Finland. doi:10.17605/OSF.IO/E4VAU.

Sellaro, Romina; Durand, Maaxime; Aphalo, Pedro J., Casal, Jorge J. (2024) Making the most of canopy light: shade avoidance under a fluctuating spectrum and irradiance. Journal of Experimental Botany, erae334. doi:10.1093/jxb/erae334.

Examples

```
colnames(four_days_1min.data)
nrow(four_days_1min.data)
range(four_days_1min.data$time_EET)
where_measured(four_days_1min.data)
how_measured(four_days_1min.data)
what_measured(four_days_1min.data)
comment(four_days_1min.data)
```

gap.mspct *Solar spectral irradiance in a tree canopy gap (measured)*

Description

A dataset containing a sequence of 72 spectra measured with an Ocean Optics Maya2000 Pro spectrometer and a Bentham DH-7-SM cosine diffuser. Values measured on 30 April 2014, in the late morning, under clear sky conditions. The whole sequence was measured in 39 seconds in a sunfleck under young silver birch trees. Place: University of Helsinki, Viikki Campus, Finland. Coordinates: 60.227162 N, 25.019429 E. Calibration and corrections done with package MayaCalc using bracketing and noise reduction (with filter measurement) and method "sun". Algorithm and calibration data by Lasse Ylianttila (STUK, Helsinki, Finland).

Usage

```
gap.mspct
```

Format

A `source_mspct` object containing a collection of 72 `source_spct` objects.

Details

The variables are as follows:

- w.length (nm), range 293 to 800 nm.
- s.e.irrad (W m-2 nm-1)

Author(s)

T. Matthew Robson and Saara Hartikainen (data).

References

Ylianttila, L.; Visuri, R.; Huurto, L. & Jokela, K. (2005) Evaluation of a single-monochromator diode array spectroradiometer for sunbed UV-radiation measurements. Photochem Photobiol, 81, 333-341

Examples

```
length(gap.mspct)
summary(gap.mspct)
e_irrad(gap.mspct, attr2tb = "when.measured")
```

`irrad_Kipp.data` *Ground level solar irradiance (measured)*

Description

Dataset containing mean, maximum, minimum and standard deviation values for global radiation data expressed as (energy) irradiance. Values are summaries of 12 consecutive readings acquired once every 5 s. The data set covers 17 consecutive days.

Usage

```
irrad_Kipp.data
```

Format

A data frame with 24479 rows and 5 variables. variables.

Details

The variables are as follows:

- time_EEST POSIXct Local time according to EET coordinates.
- UTC POSIXct Local time according to UTC.
- e_irrad_mean numeric (W m-2)
- e_irrad_min numeric (W m-2)
- e_irrad_max numeric (W m-2)
- e_irrad_sd numeric (W m-2)

These data are part of a much larger data set (Aphalo, 2023). Instrument used: Kipp SMP3 smart pyranometer, factory calibrated, mounted on permanent tripod at approximately 2 m height. Data collected with a Campbell Scientific CR6 datalogger. Wavelength sensitivity range of the pyranometer is 300 nm to 2800 nm. Location: Viikki campus of the University of Helsinki. Coordinates: 60.226803 N, 25.019205 E.

References

Aphalo, Pedro J. (2023) High frequency weather data for Viikki, Helsinki, Finland. doi:10.17605/OSF.IO/E4VAU.

https://www.kippzonen.com/

Examples

```
colnames(irrad_Kipp.data)
nrow(irrad_Kipp.data)
range(irrad_Kipp.data$time_EET)
where_measured(irrad_Kipp.data)
how_measured(irrad_Kipp.data)
what_measured(irrad_Kipp.data)
comment(irrad_Kipp.data)
```

---

ppfd_BF.data *Ground level solar PAR photon irradiance, direct and diffuse (measured)*

Description

Dataset containing mean, maximum, minimum and standard deviation values for total, direct and diffuse photosynthetically active radiation expressed as photon irradiance. Values are summaries of 12 consecutive readings acquired once every 5 s. The data set covers 17 consecutive days.

Usage

```
ppfd_BF.data
```

Format

A data frame with 24479 rows and 9 variables.

Details

The variables are as follows:

- time_EEST POSIXct Local time according to EET coordinates.
- UTC POSIXct Local time according to UTC.
- ppfd_tot_mean numeric (umol m-2 m-2)
- ppfd_tot_min numeric (umol m-2 m-2)
- ppfd_tot_max numeric (umol m-2 m-2)
- ppfd_tot_sd numeric (umol m-2 m-2)
- ppfd_diff_mean numeric (umol m-2 m-2)
- ppfd_diff_min numeric (umol m-2 m-2)
- ppfd_diff_max numeric (umol m-2 m-2)
- ppfd_diff_sd numeric (umol m-2 m-2)

These data are part of a much larger data set (Aphalo, 2023). Instrument used: Delta-T BF5 "quantum sensor" , mounted on tripod at approximately 2 m height. Data collected with a Campbell Scientific CR6 datalogger, using analogue outputs from the sensor. Wavelength sensitivity range of the quantum sensor is 400 nm to 700 nm, but response is not proportional to energy quanta across wavelengths. Sensor calibrated in site for sunlight. Location: Viikki campus of the University of Helsinki, Finland. Coordinates: 60.226803 N, 25.019205 E.

References

Aphalo, Pedro J. (2023) High frequency weather data for Viikki, Helsinki, Finland. doi:10.17605/OSF.IO/E4VAU.

https://delta-t.co.uk/ https://www.campbellsci.com/

Examples

```
colnames(ppfd_BF.data)
nrow(ppfd_BF.data)
range(ppfd_BF.data$time_EET)
where_measured(ppfd_BF.data)
how_measured(ppfd_BF.data)
what_measured(ppfd_BF.data)
comment(ppfd_BF.data)
```

---

ppfd_LICOR.data *Ground level solar PAR photon irradiance (measured)*

Description

Dataset containing mean, maximum, minimum and standard deviation values for photosynthetically active radiation expressed as photon irradiance. Values are summaries of 12 consecutive readings acquired once every 5 s. The data set covers 17 consecutive days.

Usage

```
ppfd_LICOR.data
```

Format

A data frame with 24479 rows and 5 variables.

Details

The variables are as follows:

- time_EEST POSIXct Local time according to EET coordinates.
- UTC POSIXct Local time according to UTC.
- ppfd_mean numeric (umol m-2 m-2)

- ppfd_min numeric (umol m-2 m-2)
- ppfd_max numeric (umol m-2 m-2)
- ppfd_sd numeric (umol m-2 m-2)

These data are part of a much larger data set (Aphalo, 2023). Instrument used: LI-COR LI-190 quantum sensor, mounted on permanent tripod at approximately 2 m height. Data collected with a Campbell Scientific CR6 datalogger. Sensor connected through a LI-COR millivolt adaptor (604 ohm). Wavelength sensitivity range of the quantum sensor is 400 nm to 700 nm. Location: Viikki campus of the University of Helsinki. Coordinates: 60.226803 N, 25.019205 E.

References

Aphalo, Pedro J. (2023) High frequency weather data for Viikki, Helsinki, Finland. doi:10.17605/OSF.IO/E4VAU.

https://www.licor.com/env/ https://www.campbellsci.com/

Examples

```
colnames(ppfd_LICOR.data)
nrow(ppfd_LICOR.data)
range(ppfd_LICOR.data$time_EET)
where_measured(ppfd_LICOR.data)
how_measured(ppfd_LICOR.data)
what_measured(ppfd_LICOR.data)
comment(ppfd_LICOR.data)
```

---

sun_elevation.spct *Ground level spectral irradiance and sun elevation*

Description

Datasets containing the wavelengths at 1.0 nm interval and tabulated values of spectral irradiance and its direct and diffuse components at different sun elevation angles under clear sky conditions.

Usage

```
sun_elevation.spct
```

Format

A `source_spct` containing 34 spectra in long form (290.5 nm to 699.5 nm at 1 nm interval) and 6 variables.

Details

The variables are as follows:

- w.length numeric (nm)
- s.e.irrad numeric (W m-2 nm-1)
- s.e.irrad.dir numeric (W m-2 nm-1)
- s.e.irrad.diff.down numeric (W m-2 nm-1)
- s.e.irrad.diff.up numeric (W m-2 nm-1)
- sun.elevation factor with one level per spectrum

Author(s)

Pedro J. Aphalo (radiation transfer modelling with Quick TUV calculator, TUV 5.3)

References

Quick TUV calculator https://www.acom.ucar.edu/Models/TUV/Interactive_TUV/.

Examples

```
e_irrad(sun_elevation.spct)
wl_range(sun_elevation.spct)
getMultipleWl(sun_elevation.spct) # number of spectra
```

---

sun_hourly_august.spct

Ground level spectral irradiance at hourly intervals

Description

Datasets containing the wavelengths at 1.0 nm interval and tabulated values of spectral irradiance for the sun for 21 and 22 August in Helsinki, Finland.

Usage

```
sun_hourly_august.spct
```

Format

A `source_spct` containing 31 spectra in long form (293 nm to 800 nm at 1 nm interval) and 4 variables `w.length`, `s.e.irrad`, `UTC`, and `spct.idx`.

Details

The variables are as follows:

- w.length numeric (nm)
- s.e.irrad numeric (W m-2 nm-1)
- UTC POSIXct (UTC date and time)
- spct.idx factor with one level per spectrum

The data set includes NAs for missing night-time spectral irradiance values.

Note

The simualtion methods has been described in Lindfors et al. (2009).

Author(s)

Anders K. Lindfors (radiation transfer modelling)

References

Lindfors, A.; Heikkilä, A.; Kaurola, J.; Koskela, T. & Lakkala, K. (2009) Reconstruction of Solar Spectral Surface UV Irradiances Using Radiative Transfer Simulations. Photochemistry and Photobiology, 85: 1233-1239

Examples

```
e_irrad(sun_hourly_august.spct)
wl_range(sun_hourly_august.spct)
getMultipleWl(sun_hourly_august.spct) # number of spectra
```

---

sun_hourly_june.spct *Ground level spectral irradiance at hourly intervals*

Description

Datasets containing the wavelengths at 1.0 nm interval and tabulated values of spectral irradiance for the sun for 22 to 24 June 2010 in Helsinki, Finland.

Usage

```
sun_hourly_june.spct
```

Format

A `source_spct` containing 58 spectra in long form (293 nm to 800 nm at 1 nm interval) and 4 variables `w.length`, `s.e.irrad`, `UTC`, and `spct.idx`.

Details

The variables are as follows:

- w.length numeric (nm)
- s.e.irrad numeric (W m-2 nm-1)
- UTC POSIXct (UTC date and time)
- spct.idx factor with one level per spectrum

The data set includes NAs for missing night-time spectral irradiance values.

Note

A summary of these data has been published in the article by Morales et al. (2013). The simulation methods has been described in Lindfors et al. (2009).

Author(s)

Anders K. Lindfors (radiation transfer modelling)

References

Morales, L. O.; Brosché, M.; Vainonen, J.; Jenkins, G. I.; Wargent, J. J.; Sipari, N.; Strid, A.; Lindfors, A. V.; Tegelberg, R. & Aphalo, P. J. (2013) Multiple roles for UV RESISTANCE LOCUS8 in regulating gene expression and metabolite accumulation in Arabidopsis under solar ultraviolet radiation. Plant Physiology, 161, 744-759

Lindfors, A.; Heikkilä, A.; Kaurola, J.; Koskela, T. & Lakkala, K. (2009) Reconstruction of Solar Spectral Surface UV Irradiances Using Radiative Transfer Simulations. Photochemistry and Photobiology, 85: 1233-1239

Examples

```
e_irrad(sun_hourly_june.spct)
wl_range(sun_hourly_june.spct)
getMultipleWl(sun_hourly_june.spct) # number of spectra
```

---

sun_hourly_ozone.spct *Ground level spectral irradiance at hourly intervals*

Description

Datasets containing the wavelengths at 1.0 nm interval and tabulated values of spectral irradiance for the sun for 21 May, at Jokioinen, Finland, under climatology-based mean ozone column and with a 20 'libradtran' assuming clear sky.

Usage

```
sun_hourly_ozone.spct
```

Format

A `source_spct` containing 32 spectra in long form (293 nm to 800 nm at 1 nm interval) and 6 variables.

Details

The variables are as follows:

- w.length numeric (nm).
- s.e.irrad numeric (W m-2 nm-1).
- UTC POSIXct (UTC date and time).
- ozone Factor with two levels.
- sun.elevation Angle above the astronomical horizon (degrees).
- spct.idx factor with one level per spectrum.

The data set includes spectra for day-time, not 24 h.

Note

The simulation methods has been described in Lindfors et al. (2009).

Author(s)

Anders K. Lindfors (radiation transfer modelling).

References

Lindfors, A.; Heikkilä, A.; Kaurola, J.; Koskela, T. & Lakkala, K. (2009) Reconstruction of Solar Spectral Surface UV Irradiances Using Radiative Transfer Simulations. Photochemistry and Photobiology, 85: 1233-1239

Examples

```
e_irrad(sun_hourly_ozone.spct)
wl_range(sun_hourly_ozone.spct)
getMultipleWl(sun_hourly_ozone.spct) # number of spectra
```

`sun_may_morning.spct` *Ground level solar spectral irradiance (measured)*

Description

Datasets containing the wavelengths at a 0.5 nm to 1.0 nm interval and tabulated values of measured spectral irradiance for the sun.

Usage

```
sun_may_morning.spct
```

Format

A `source_spct` object with 1421 rows (250 nm to 899 nm, variable step) and 2 variables.

Details

The variables are as follows:

- w.length numeric (nm)
- s.e.irrad numeric (W m-2 nm-1)

Note

Instrument used: Maya2000Pro scanning double monochromator spectroradiometer with a Bentham cosine corrected input optics. Recently calibrated at STUK. Date and time: 31 May 2013, 11:23 EEST. Place: University of Helsinki, Viikki Campus, Finland. Coordinates: 60.226183 N, 25.018302 E. Measurements done by Pedro J. Aphalo. Calibration and corrections done with package MayaCalc using bracketing and noise reduction (with filter measurement) and method "sun". Algorithm and calibration data by Lasse Ylianttila (STUK, Helsinki, Finland).

References

Ylianttila, L.; Visuri, R.; Huurto, L. & Jokela, K. (2005) Evaluation of a single-monochromator diode array spectroradiometer for sunbed UV-radiation measurements. Photochem Photobiol, 81, 333-341

Examples

```
sun_may_morning.spct
wl_range(sun_may_morning.spct)
e_irrad(sun_may_morning.spct)
```

`sun_reference.mspct` *Reference solar spectra from ASTM G173*

Description

Dataset containing wavelengths and tabulated values for spectral irradiance for the sun both above the terrestrial atmosphere and at ground level under clear sky. The different spectra in this collection are from ASTM G173 standard.

Usage

```
sun_reference.mspct
```

Format

A `"source_mspct"` object containing 51 `"source_spct"` objects.

In each of the member spectra, the variables are as follows:

- w.length (nm)
- s.e.irrad (W m-2 nm-1)

Details

`ASTM.E490.AM0` is the mean extraterrestrial solar spectrum, for air mass zero (AM0).

`Gueymard.AM0` is Gueymard's (2004) extraterrestrial solar spectrum, for air mass zero (AM0). Used as the basis for calculating the terrestrial solar spectra defined by ASTM G173.

`WMO.Wehrli.AM0` is Wehrli's (1985) extraterrestrial solar spectrum, for air mass zero (AM0). Used the World Meteorological Organization (WMO).

`ASTM.G173.global` is global spectral irradiance for air mass 1.5 (AM1.5). Reference Spectrum Derived from SMARTS v. 2.9.2 for AM1.5. (solar zenith angle 48.19)

`ASTM.G173.direct` is direct spectral irradiance for air mass 1.5 (AM1.5). Reference Spectrum Derived from SMARTS v. 2.9.2 for AM1.5. (solar zenith angle 48.19)

Note

Please see the metadata in each spectrum. Metadata is stored in attributes and can accessed with functions `getWhatMeasured` and `comment`.

Source

https://rredc.nrel.gov/solar/spectra/am1.5/ (no longer on-line).

References

ASTM (2012) ASTM G173 Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37 degrees Tilted Surface.

Gueymard, C. A. (2004) The sun's total and spectral irradiance for solar energy applications and solar radiation models. Solar Energy, 76, 423-453. <doi:10.1016/j.solener.2003.08.039>

Wehrli, C. (1985) Extraterrestrial solar spectrum. Pub. No. 615, World Radiation Center, Davos, Switzerland.

Examples

```
names(sun_reference.mspct)
```

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