photobiologyInOut Version 0.4.3.9002 User Guide

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Contents

1 Introduction

```
# this may be needed in some geographic locations as some Windows TZ strings are
# not recognized by all versions of R
Sys.setenv(TZ = 'UTC')
library(photobiology)
library(photobiologyWavebands)
library(photobiologyInOut)
library(lubridate)
library(ggplot2)
library(ggmap)
library(ggspectra)
```

```
options(dplyr.print_max = 5)
options(dplyr.print_min = 3)
```

This package defines functions for importing spectral data from different instruments (Table 1) and simulation models (Table 3).

R function	Instrument	Program
read_ooss_file()	Ocean Optics spectrometers	SpectraSuite
read_oo_jazirrad()	Ocean Optics Jaz	*instrument*
read_oo_jazdata()	Ocean Optics Jaz	*instrument*
read_avaspec_csv()	Avantes spectrometers	*instrument*
read_macam_file()	Macam	*instrument*
read_licor_file()	LI-COR LI-1800	PC1800 (MS-DOS)

Table 1: Functions for importing measured spectral emission data

R function	Simulation model	version
read_tuv_file()	TUV (Sasha Madronich)	version 5.0 (modified)
read_tuv_file()	TUV (Sasha Madronich)	edited output
read_fmi_cum()	(Anders Lindfors)	daily cumulated

Table 2: Functions for importing simulated spectral data from models

R function	R package	function
hyperSpec2mspct()	hyperSpec	import
mspct2hyperSpec()	hyperSpec	export
rspec2mspct()	pavo	import

Table 3: Functions for exchange of data in 'foreign' formats.

2 Examples

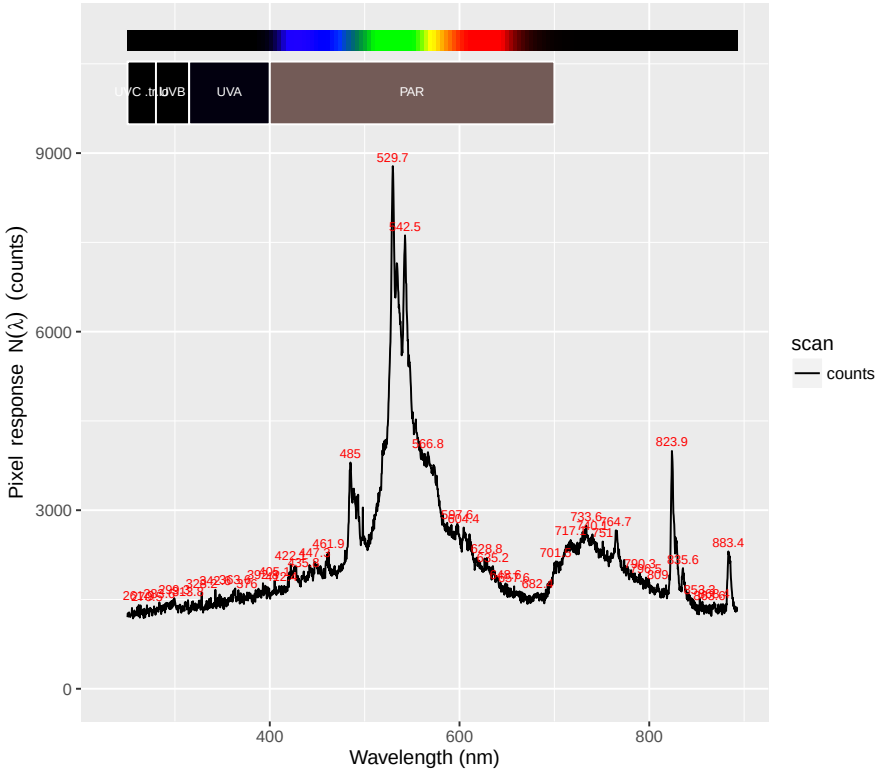
2.1 Ocean Optics Jaz

Reading a raw data file generated by Ocean Optics' Jaz spectrometer. The light source was the Jaz PX pulsed Xenon light module.

```
jazraw.spct <- read_oo_jazdata(file = "data-vignettes/spectrum.jaz")
jazraw.spct <- trim_wl(jazraw.spct, range = c(250, 900))
```

Plotting the spectrum.

```
plot(jazraw.spct)
```

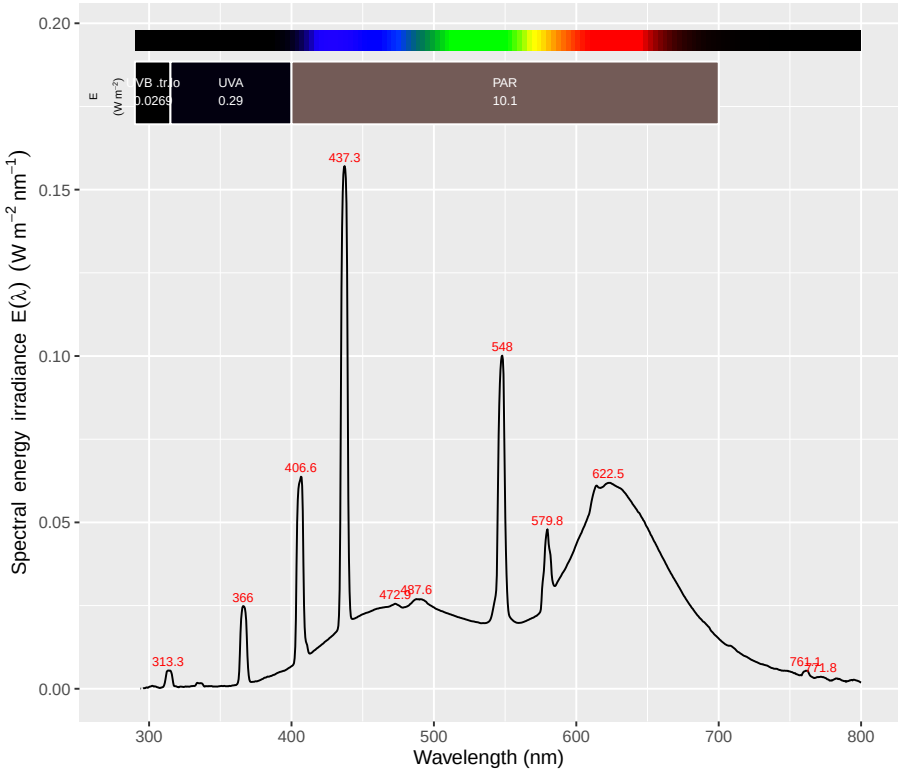


Reading an irradiance file generated by Ocean Optics' Jaz spectrometer. The light source was a 'white' fluorescent tube.

```
jaz.spct <- read_oo_jazirrad(file = "data-vignettes/spectrum.JazIrrad")

## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032

jaz0.spct <- jaz.spct
jaz.spct <- trim_wl(jaz.spct, range = c(290, 800))

## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032
```

Plotting the spectrum.

```
plot(jaz.spct)

## Warning:  Removed 9 rows containing non-finite values
## (stat_peaks).
## Warning:  Removed 9 rows containing non-finite values
## (stat_wb_irrad).
## Warning:  Removed 2 rows containing missing values (geom_path).
```

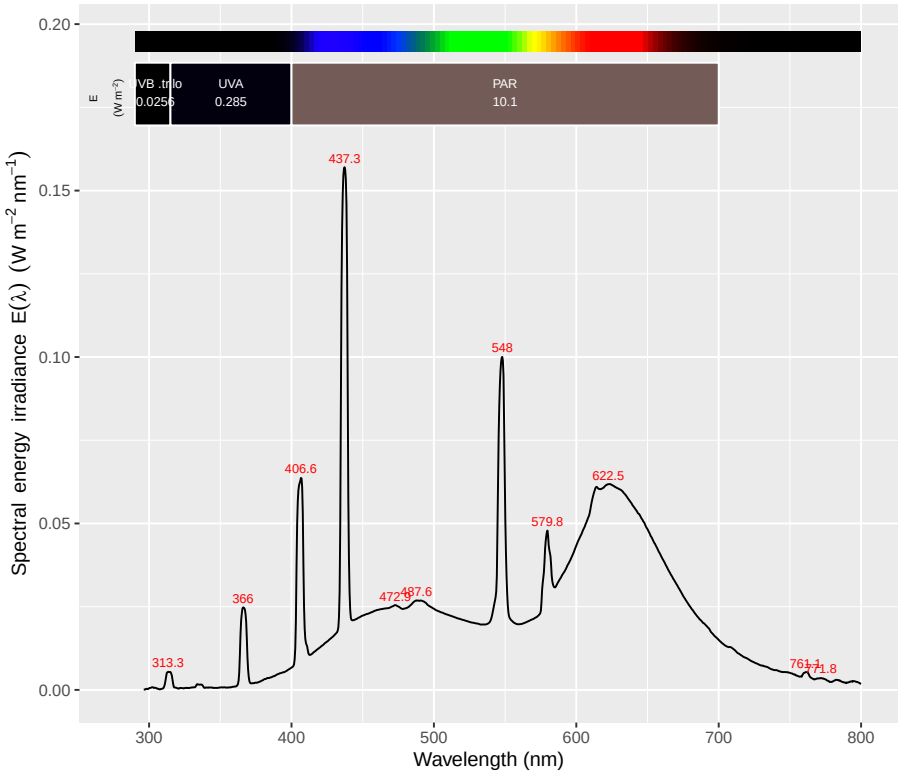


We can see that the data have problems. We get a warning because the data contains negative values for spectral irradiance. We will use some methods from package photobiology to correct the problem. As the data are noisy we cannot just shift the scale so that the most negative value becomes zero. Neither can we replace all negative values with zeros, as this would create bias.

In the following code chunk we will use a region of the spectrum in which spectral irradiance is known to be equal to zero as reference to shift the scale zero.

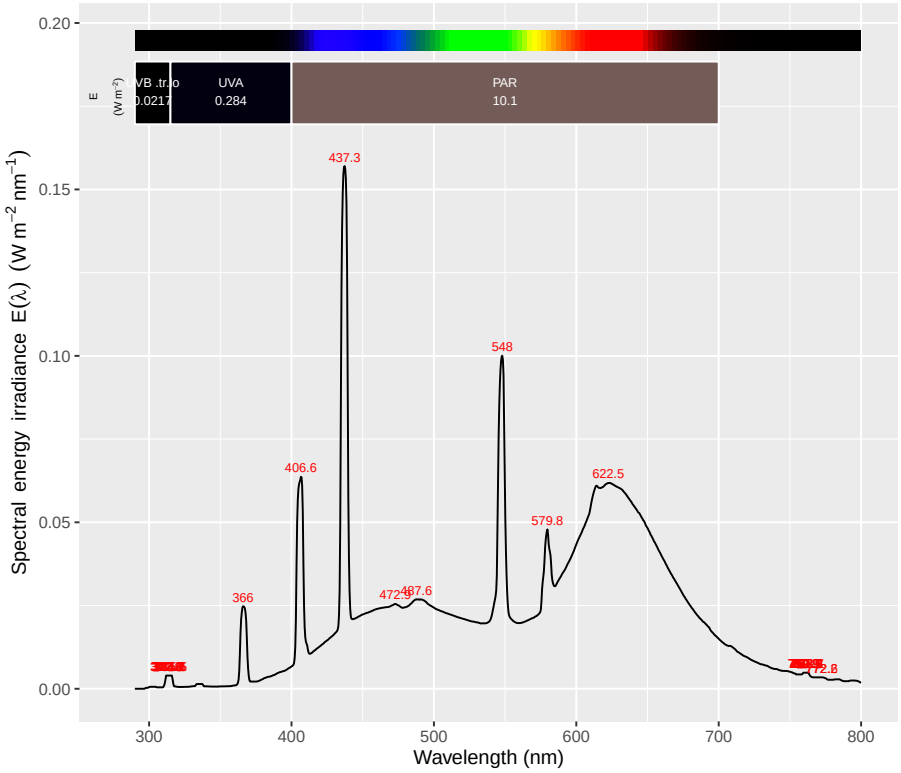
```
jaz.spct <- fshift(jaz0.spct, range = c(255, 290), f = "mean")

## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032
## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.00035
## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.00035

jaz.spct <- trim_wl(jaz.spct, range = c(290, 800))

## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032

plot(jaz.spct)
```

```
## Warning:  Removed 13 rows containing non-finite values
## (stat_peaks).
## Warning:  Removed 13 rows containing non-finite values
## (stat_wb_irrad).
## Warning:  Removed 9 rows containing missing values (geom_path).
```



We can next try to smooth the spectrum as it is very noisy outside the visible region.

```
jaz.spct <- smooth_spct(jaz.spct)
plot(jaz.spct)
```

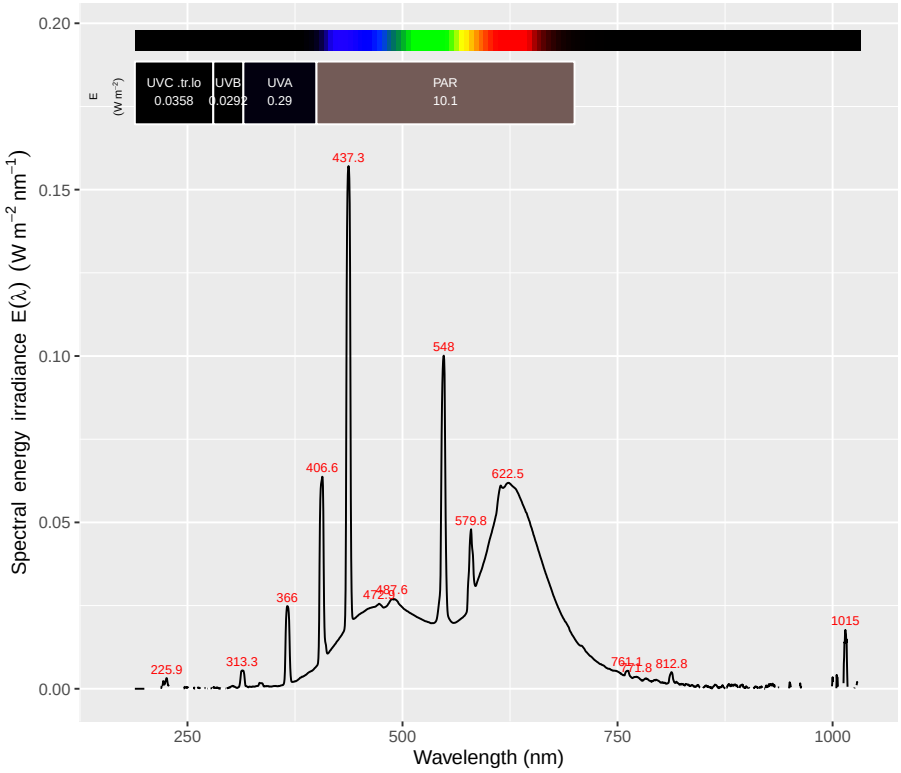


Photon and energy irradiances.

```
e_irrad(jaz.spct, PAR())       # W m-2

##      PAR
## 10.10459
## attr(,"time.unit")
## [1] "second"
## attr(,"radiation.unit")
## [1] "energy irradiance total"
```

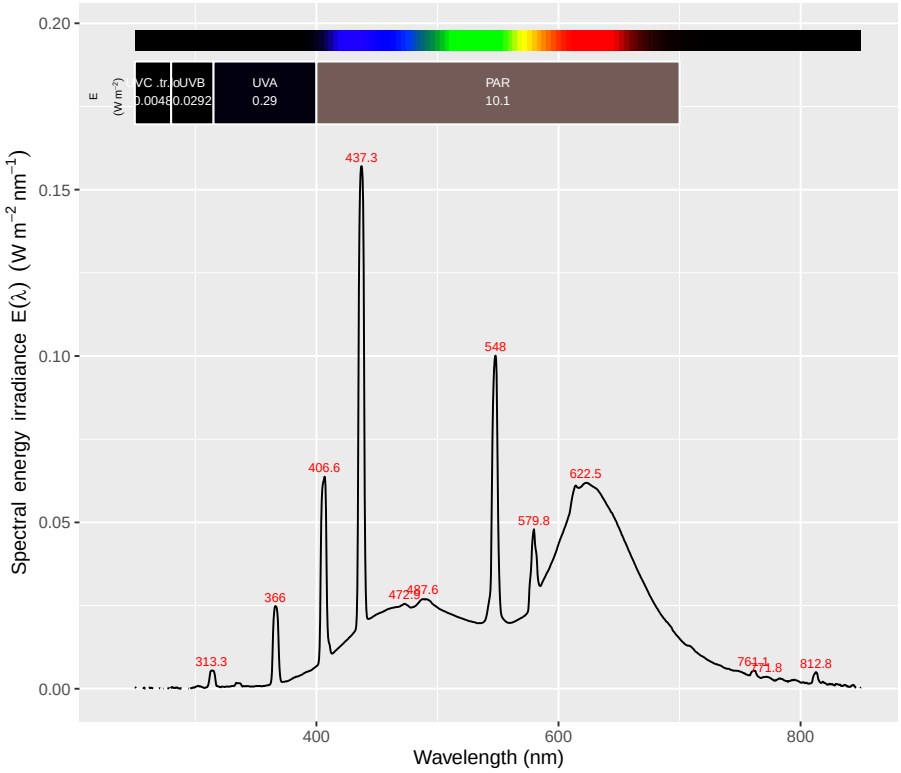
All in one statement.

```
plot(read_oo_jazirrad(file = "data-vignettes/spectrum.JazIrrad"))

## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032
## Warning:  Removed 378 rows containing non-finite values
## (stat_peaks).
## Warning:  Removed 378 rows containing non-finite values
## (stat_wb_irrad).
## Warning:  Removed 1 rows containing missing values (geom_path).
```



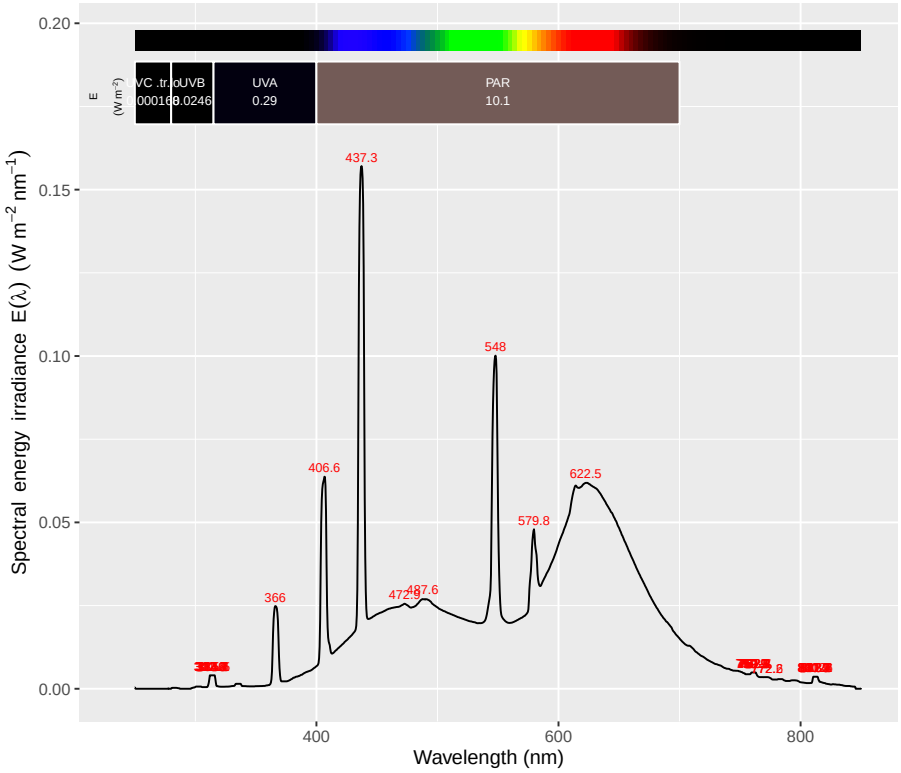
As above but limiting the wavelength range plotted.

```
plot(read_oo_jazirrad(file = "data-vignettes/spectrum.JazIrrad"),
     range = c(250,850))

## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032
## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032
## Warning:  Removed 52 rows containing non-finite values
## (stat_peaks).
## Warning:  Removed 52 rows containing non-finite values
## (stat_wb_irrad).
```



Adding our custom "adaptive" smoothing.

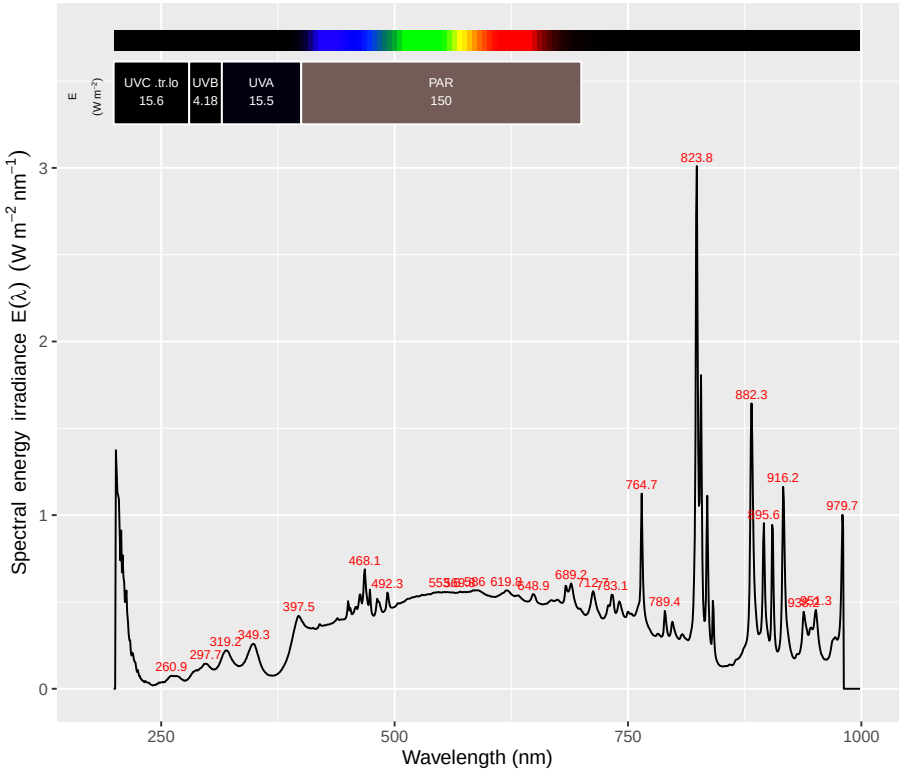
```
plot(smooth_spct(read_oo_jazirrad(file = "data-vignettes/spectrum.JazIrrad")),
     range = c(250,850))

## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032
## Warning in smooth_spct.source_spct(read_oo_jazirrad(file = "data-vignettes/spectrum.JazIrrad")):
89 'bad' estimates in spectral irradiance
## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.027
## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.027
```



2.2 Other modular spectrometers from Ocean Optics

Now a file from an Ocean Optics' Q6500? spectrometer.

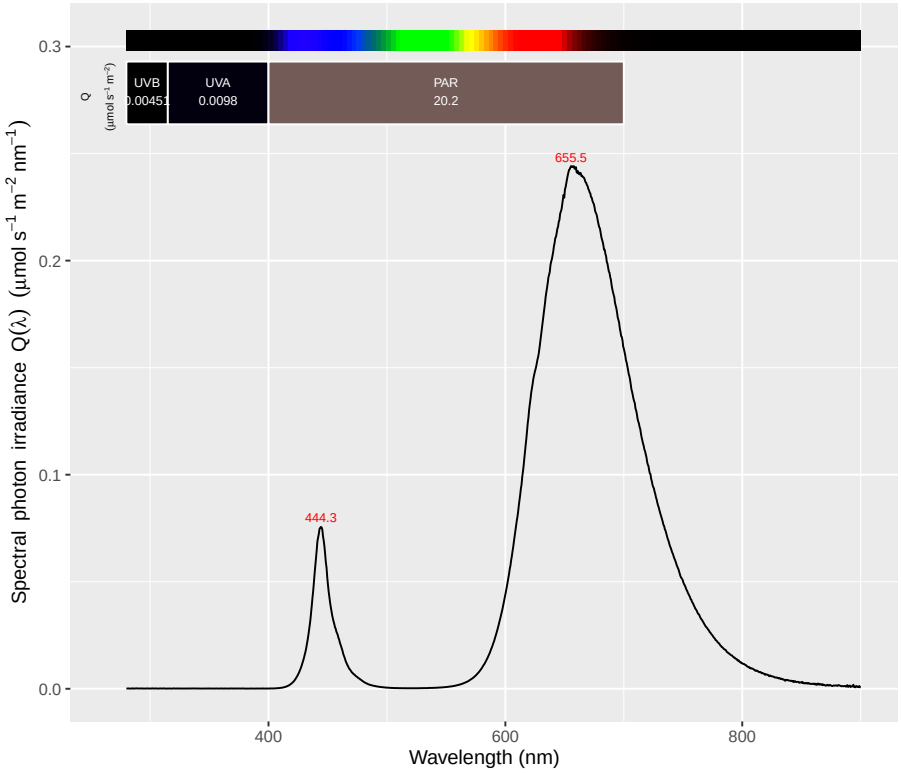
```
plot(read_oo_ssirrad(file = "data-vignettes/spectrum.SSIrrad"))
```



2.3 Modular spectrometers from Avantes

Avantes' two column .csv files can also be imported.

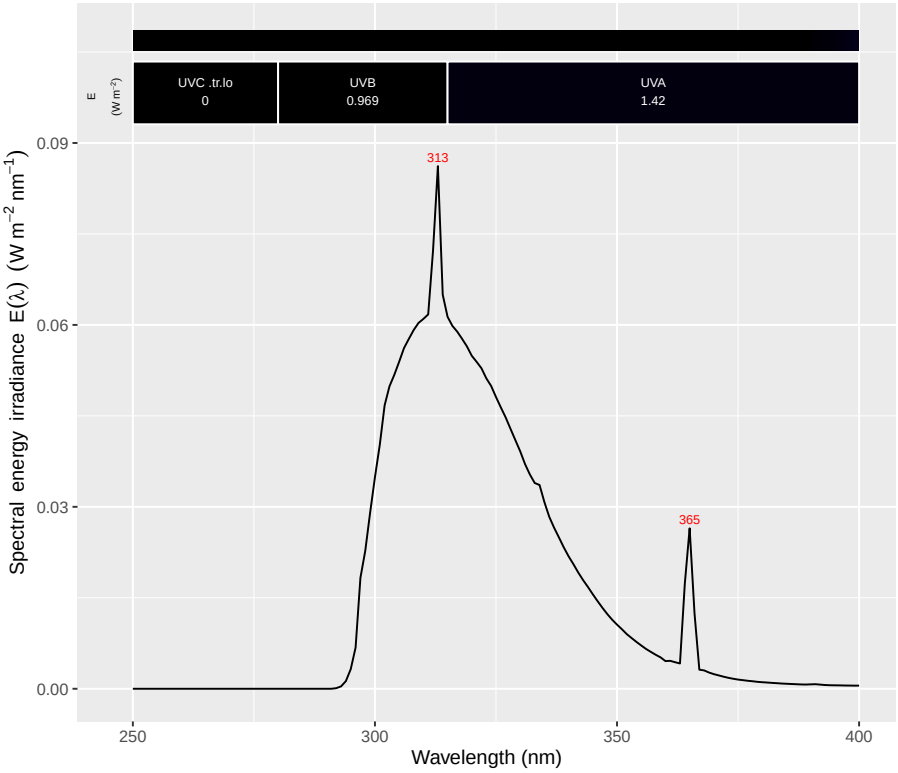
```
plot(read_avaspec_csv(file = "data-vignettes/spectrum-avaspec.csv"),
     range = c(280, 900), unit.out = "photon")

## Warning in range_check(x, strict.range = strict.range):  Negative spectral photon
irradiance values; minimun s.q.irrad = -1.5e-08
```



2.4 Scanning spectrometer from Macam

Macam's single column DTA files can also be imported.

```
plot(read_macam_dta(file = "data-vignettes/spectrum.DTA"))
```



2.5 LI-1800 scanning spectrometer from LI-COR

And a file generated by LI-COR's PC1800 program for the LI-1800 spectroradiometer.

```
licor.spct <- read_licor_prn(file = "data-vignettes/spectrum.PRN")
```

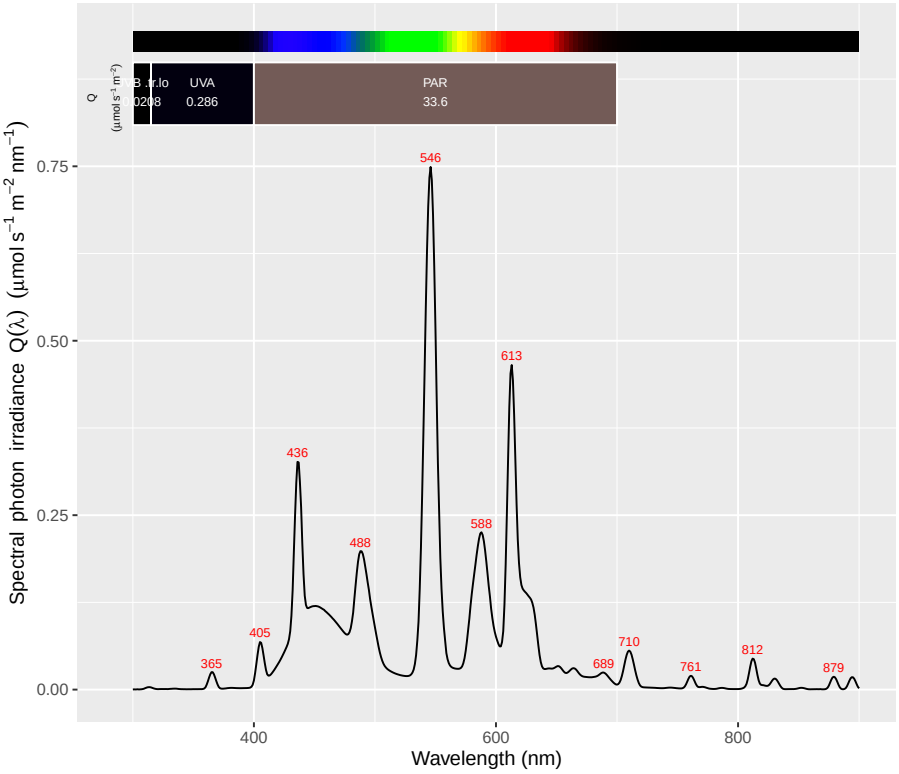
In all cases as much information as possible is decoded, and the data file headers are preserved as comments in the source.spct objects.

```
licor.spct

## Object: source_spct [601 x 2]
## Wavelength (nm): range 300 to 900, step 1
## Measured on: 0000-08-23 16:32:00 UTC
## Time unit: 1s
##
##    w.length s.q.irrad
##       (dbl)     (dbl)
## 1       300 1.518e-10
## 2       301 3.355e-10
## 3       302 2.197e-10
## ..      ...       ...
```

```
cat(comment(licor.spct))
```

```
## LICOR LI-1800 file 'data-vignettes/spectrum.PRN' imported on 2016-05-14 15:12:07 UTC
## "FILE:FL2"
## "REM: TLD 36W/865       (QNTM)"
## "LIMS: 300- 900NM"
## "INT:  1NM"
## "DATE:08/23 16:32"
## "MIN:  300NM  1.518E-04"
## "MAX:  546NM  7.491E-01"
```

```
plot(licor.spct, unit.out = "photon")
```



2.6 Overriding default metadata

A variable with the user supplied date and time data, or the date read from the header (the text itself) not the file date as the file date may not reflect the creation date and time.

```
jaz1.spct <- read_oo_jazirrad(file = "data-vignettes/spectrum.JazIrrad", date = NULL)
```

```
## Warning in range_check(x, strict.range = strict.range): Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032
```

```
jaz1.spct
```

```
## Object: source_spct [2,048 x 2]
## Wavelength (nm): range 188.82523 to 1033.1483, step 0.357056 to 0.459625
## Measured on: 2015-02-03 09:44:41 UTC
## Time unit: 1s
##
##    w.length s.e.irrad
##       (dbl)     (dbl)
## 1  188.8252         0
## 2  189.2849         0
## 3  189.7444         0
## ..      ...       ...
```

```
jaz.spct <- read_oo_jazirrad(file = "data-vignettes/spectrum.JazIrrad",
                             date = ymd_hms("2015-11-15 12:00:00"))
```

```
## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032
```

```
jaz.spct
```

```
## Object: source_spct [2,048 x 2]
## Wavelength (nm): range 188.82523 to 1033.1483, step 0.357056 to 0.459625
## Measured on: 2015-11-15 12:00:00 UTC
## Time unit: 1s
##
##    w.length s.e.irrad
##       (dbl)     (dbl)
## 1  188.8252         0
## 2  189.2849         0
## 3  189.7444         0
## ..      ...       ...
```

```
jaz.spct <- read_oo_jazirrad(file = "data-vignettes/spectrum.JazIrrad",
                             date = now())
```

```
## Warning in range_check(x, strict.range = strict.range):  Negative spectral energy
irradiance values; minimun s.e.irrad = -0.032
```

```
jaz.spct
```

```
## Object: source_spct [2,048 x 2]
## Wavelength (nm): range 188.82523 to 1033.1483, step 0.357056 to 0.459625
## Measured on: 2016-05-14 15:12:08 UTC
## Time unit: 1s
##
##    w.length s.e.irrad
##       (dbl)     (dbl)
## 1  188.8252         0
## 2  189.2849         0
## 3  189.7444         0
## ..      ...       ...
```

3 Output from simulation models

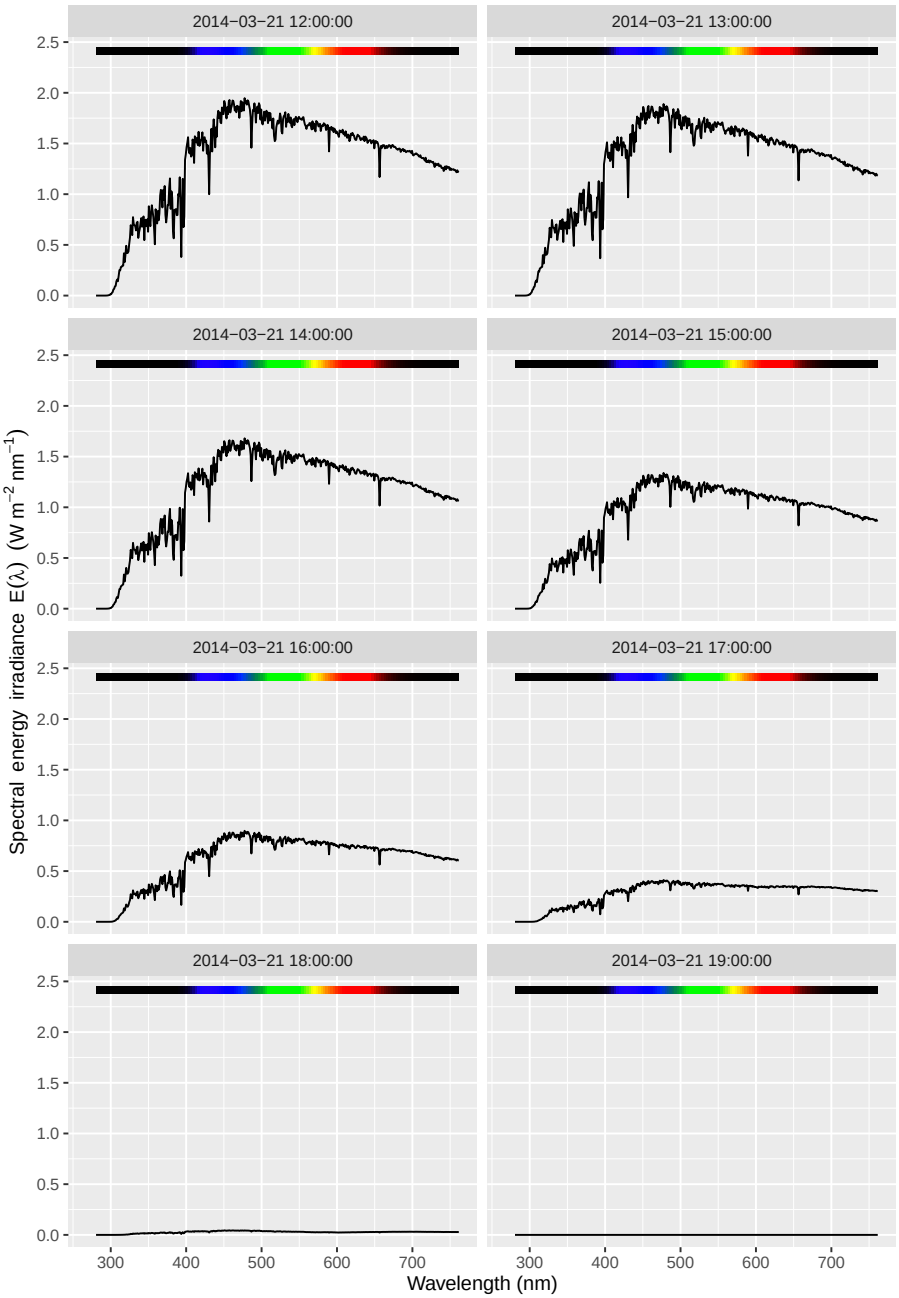
3.1 TUV

The output from the TUV model can be imported either by editing it before import, or by making a simple edit to the output routine of TUV. This function is known to work with TUV version 5.0 output. The output from TUV can contain a variable number of spectra in "parallel" columns, which are *melted* into a single column, with a factor with letter as levels, a numeric variable with the zenith angle and a POSIXct column with times. A date needs to be always supplied as the output file from TUV has only time of day information.

```
tuv.spct <- read_tuv_usrout(file = "data-vignettes/usrout.txt",
                            date = ymd("2014-03-21"))
summary(subset(tuv.spct, spct.idx == "A"))

## Summary of object: source_spct [482 x 5]
## Wavelength (nm): range 280.5 to 761.5, step 1
## Time unit: 1s
##
##     w.length        spct.idx     s.e.irrad
##  Min.   :280.5   A      :482   Min.   :0.000
##  1st Qu.:400.8   B      :  0   1st Qu.:1.216
##  Median :521.0   C      :  0   Median :1.483
##  Mean   :521.0   D      :  0   Mean   :1.322
##  3rd Qu.:641.2   E      :  0   3rd Qu.:1.680
##  Max.   :761.5   F      :  0   Max.   :1.947
##                  (Other):  0
##      angle            date
##  Min.   :1.829   Min.   :2014-03-21 12:00:00
##  1st Qu.:1.829   1st Qu.:2014-03-21 12:00:00
##  Median :1.829   Median :2014-03-21 12:00:00
##  Mean   :1.829   Mean   :2014-03-21 12:00:00
##  3rd Qu.:1.829   3rd Qu.:2014-03-21 12:00:00
##  Max.   :1.829   Max.   :2014-03-21 12:00:00
##

tuv.spct

## Object: source_spct [3,856 x 5]
## Containing:  8  spectra in long form
## Wavelength (nm): range 280.5 to 761.5, step 1
## Measured between: 2014-03-21 12:00:00 and 2014-03-21 19:00:00 UTC
## Time unit: 1s
##
##    w.length spct.idx s.e.irrad angle
##       (dbl)   (fctr)     (dbl) (dbl)
## 1     280.5        A 3.041e-15 1.829
## 2     281.5        A 1.164e-13 1.829
## 3     282.5        A 1.824e-12 1.829
## ..      ...      ...       ...   ...
## Variables not shown: date (time)
```

It is possible to extract individual spectra with subset, or as done here plot them in different panels.

```
plot(tuv.spct, annotations = c("colour.guide")) +
  facet_wrap(~date, ncol = 2)
```



The output is a single `source_spct` object that can be easily converted into a `source_mspct` object containing the individual spectra as members of the

collection.

```
tuv.mspct <- subset2mspct(tuv.spct)
tuv.mspct

## Object: source_mspct [8 x 1]
## --- Member: A ---
## Object: source_spct [482 x 4]
## Wavelength (nm): range 280.5 to 761.5, step 1
## Time unit: 1s
##
##    w.length s.e.irrad angle               date
##       (dbl)     (dbl) (dbl)             (time)
## 1     280.5 3.041e-15 1.829 2014-03-21 12:00:00
## 2     281.5 1.164e-13 1.829 2014-03-21 12:00:00
## 3     282.5 1.824e-12 1.829 2014-03-21 12:00:00
## ..      ...       ...   ...                 ...
## --- Member: B ---
## Object: source_spct [482 x 4]
## Wavelength (nm): range 280.5 to 761.5, step 1
## Time unit: 1s
##
##    w.length s.e.irrad  angle               date
##       (dbl)     (dbl)  (dbl)             (time)
## 1     280.5 1.314e-15 13.198 2014-03-21 13:00:00
## 2     281.5 5.415e-14 13.198 2014-03-21 13:00:00
## 3     282.5 9.039e-13 13.198 2014-03-21 13:00:00
## ..      ...       ...    ...                 ...
## --- Member: C ---
## Object: source_spct [482 x 4]
## Wavelength (nm): range 280.5 to 761.5, step 1
## Time unit: 1s
##
##    w.length s.e.irrad angle               date
##       (dbl)     (dbl) (dbl)             (time)
## 1     280.5 4.521e-17  28.2 2014-03-21 14:00:00
## 2     281.5 2.510e-15  28.2 2014-03-21 14:00:00
## 3     282.5 5.413e-14  28.2 2014-03-21 14:00:00
## ..      ...       ...   ...                 ...
## --- Member: D ---
## Object: source_spct [482 x 4]
## Wavelength (nm): range 280.5 to 761.5, step 1
## Time unit: 1s
##
##    w.length s.e.irrad  angle               date
##       (dbl)     (dbl)  (dbl)             (time)
## 1     280.5 3.075e-20 43.202 2014-03-21 15:00:00
## 2     281.5 3.273e-18 43.202 2014-03-21 15:00:00
## 3     282.5 1.234e-16 43.202 2014-03-21 15:00:00
## ..      ...       ...    ...                 ...
## --- Member: E ---
## Object: source_spct [482 x 4]
## Wavelength (nm): range 280.5 to 761.5, step 1
## Time unit: 1s
##
##    w.length s.e.irrad  angle               date
##       (dbl)     (dbl)  (dbl)             (time)
```

```
## 1     280.5 2.253e-26 58.205 2014-03-21 16:00:00
## 2     281.5 7.751e-24 58.205 2014-03-21 16:00:00
## 3     282.5 8.148e-22 58.205 2014-03-21 16:00:00
## ..      ...       ...    ...                 ...
## --- Member: F ---
## Object: source_spct [482 x 4]
## Wavelength (nm): range 280.5 to 761.5, step 1
## Time unit: 1s
##
##    w.length s.e.irrad  angle               date
##       (dbl)     (dbl)  (dbl)             (time)
## 1     280.5 1.929e-27 73.208 2014-03-21 17:00:00
## 2     281.5 5.710e-25 73.208 2014-03-21 17:00:00
## 3     282.5 5.202e-23 73.208 2014-03-21 17:00:00
## ..      ...       ...    ...                 ...
## --- Member: G ---
## Object: source_spct [482 x 4]
## Wavelength (nm): range 280.5 to 761.5, step 1
## Time unit: 1s
##
##    w.length s.e.irrad  angle               date
##       (dbl)     (dbl)  (dbl)             (time)
## 1     280.5 4.721e-28 88.211 2014-03-21 18:00:00
## 2     281.5 1.385e-25 88.211 2014-03-21 18:00:00
## 3     282.5 1.250e-23 88.211 2014-03-21 18:00:00
## ..      ...       ...    ...                 ...
## --- Member: H ---
## Object: source_spct [482 x 4]
## Wavelength (nm): range 280.5 to 761.5, step 1
## Time unit: 1s
##
##    w.length s.e.irrad   angle               date
##       (dbl)     (dbl)   (dbl)             (time)
## 1     280.5         0 103.213 2014-03-21 19:00:00
## 2     281.5         0 103.213 2014-03-21 19:00:00
## 3     282.5         0 103.213 2014-03-21 19:00:00
## ..      ...       ...     ...                 ...
## --- END ---
```

With the default of `lubridate::today()` for date times are 'mapped' to the current local date using the time zone of the computer as visible to R.

```
tuv_nd.spct <- read_tuv_usrout(file = "data-vignettes/usrout.txt")
tuv_nd.spct

## Object: source_spct [3,856 x 5]
## Containing:  8  spectra in long form
## Wavelength (nm): range 280.5 to 761.5, step 1
## Measured between: 2016-05-14 12:00:00 and 2016-05-14 19:00:00 UTC
## Time unit: 1s
##
##    w.length spct.idx s.e.irrad angle
##       (dbl)   (fctr)     (dbl) (dbl)
## 1     280.5        A 3.041e-15 1.829
## 2     281.5        A 1.164e-13 1.829
## 3     282.5        A 1.824e-12 1.829
## ..      ...      ...       ...   ...
```

```
## Variables not shown: date (time)
```

3.2 Models developed by Anders Lindfors

Functions `read_fmi_cum` and `read_m_fmi_cum` can be used to read text files output by a simulation model of solar spectral irradiance. The model was developed at the Finnish Meteorological Institute (FMI) by Dr. Anders Lindfors and collaborators.

We can read an individual file into a `source_spct` object while adding some metadata.

```
z.spct <- read_fmi_cum("data-vignettes/2014-08-21_cum.hel")
class_spct(z.spct)

## [1] "source_spct"  "generic_spct"

getWhenMeasured(z.spct)

## [1] "2014-08-21 UTC"

z.spct

## Object: source_spct [511 x 2]
## Wavelength (nm): range 290 to 800, step 1
## Measured on: 2014-08-21 UTC
## Time unit: 86400s (~1 days)
##
##    w.length    s.e.irrad
##       (dbl)        (dbl)
## 1       290 0.000000e+00
## 2       291 2.931322e-05
## 3       292 7.235264e-04
## ..      ...          ...
```

```
z.mspct <- read_m_fmi_cum("data-vignettes/2014-08-21_cum.hel")
class(z.mspct)

## [1] "source_mspct"  "generic_mspct" "list"

getWhenMeasured(z.mspct)

## Source: local data frame [1 x 2]
##
##             spct.idx when.measured
##               (fctr)        (time)
## 1 2014_08_21_cum.hel    2014-08-21

z.mspct

## Object: source_mspct [1 x 1]
## --- Member: 2014_08_21_cum.hel ---
## Object: source_spct [511 x 2]
```

```
## Wavelength (nm): range 290 to 800, step 1
## Measured on: 2014-08-21 UTC
## Time unit: 86400s (~1 days)
##
##    w.length    s.e.irrad
##       (dbl)        (dbl)
## 1       290 0.000000e+00
## 2       291 2.931322e-05
## 3       292 7.235264e-04
## ..      ...          ...
## --- END ---
```

```
z.mspct <- read_m_fmi_cum(c("data-vignettes/2014-08-21_cum.hel",
                            "data-vignettes/2014-08-22_cum.hel"))
class(z.mspct)

## [1] "source_mspct"  "generic_mspct" "list"

getWhenMeasured(z.mspct)

## Source: local data frame [2 x 2]
##
##             spct.idx when.measured
##               (fctr)        (time)
## 1 2014_08_21_cum.hel    2014-08-21
## 2 2014_08_22_cum.hel    2014-08-22

z.mspct

## Object: source_mspct [2 x 1]
## --- Member: 2014_08_21_cum.hel ---
## Object: source_spct [511 x 2]
## Wavelength (nm): range 290 to 800, step 1
## Measured on: 2014-08-21 UTC
## Time unit: 86400s (~1 days)
##
##    w.length    s.e.irrad
##       (dbl)        (dbl)
## 1       290 0.000000e+00
## 2       291 2.931322e-05
## 3       292 7.235264e-04
## ..      ...          ...
## --- Member: 2014_08_22_cum.hel ---
## Object: source_spct [511 x 2]
## Wavelength (nm): range 290 to 800, step 1
## Measured on: 2014-08-22 UTC
## Time unit: 86400s (~1 days)
##
##    w.length    s.e.irrad
##       (dbl)        (dbl)
## 1       290 0.000000e+00
## 2       291 2.926634e-05
## 3       292 7.213022e-04
## ..      ...          ...
## --- END ---
```

```
files <- system("ls ./data-vignettes/*cum.hel", intern = TRUE)
z1.mspct <- read_m_fmi_cum(files)
class(z1.mspct)

## [1] "source_mspct"  "generic_mspct" "list"

getWhenMeasured(z1.mspct)

## Source: local data frame [2 x 2]
##
##             spct.idx when.measured
##               (fctr)        (time)
## 1 2014_08_21_cum.hel    2014-08-21
## 2 2014_08_22_cum.hel    2014-08-22

z1.mspct

## Object: source_mspct [2 x 1]
## --- Member: 2014_08_21_cum.hel ---
## Object: source_spct [511 x 2]
## Wavelength (nm): range 290 to 800, step 1
## Measured on: 2014-08-21 UTC
## Time unit: 86400s (~1 days)
##
##    w.length    s.e.irrad
##       (dbl)        (dbl)
## 1       290 0.000000e+00
## 2       291 2.931322e-05
## 3       292 7.235264e-04
## ..      ...          ...
## --- Member: 2014_08_22_cum.hel ---
## Object: source_spct [511 x 2]
## Wavelength (nm): range 290 to 800, step 1
## Measured on: 2014-08-22 UTC
## Time unit: 86400s (~1 days)
##
##    w.length    s.e.irrad
##       (dbl)        (dbl)
## 1       290 0.000000e+00
## 2       291 2.926634e-05
## 3       292 7.213022e-04
## ..      ...          ...
## --- END ---
```

```
z2.mspct <-
  read_m_fmi_cum(files,
                 geocode = geocode("Kumpula, Helsinki, Finland",
                                   source = "google"))
class(z2.mspct)

## [1] "source_mspct"  "generic_mspct" "list"

getWhenMeasured(z2.mspct)

## Source: local data frame [2 x 2]
##
```

```
##             spct.idx when.measured
##               (fctr)        (time)
## 1 2014_08_21_cum.hel    2014-08-21
## 2 2014_08_22_cum.hel    2014-08-22

getWhereMeasured(z2.mspct)

## Source: local data frame [2 x 3]
##
##             spct.idx      lon      lat
##               (fctr)    (dbl)    (dbl)
## 1 2014_08_21_cum.hel 24.96474 60.20911
## 2 2014_08_22_cum.hel 24.96474 60.20911

z2.mspct

## Object: source_mspct [2 x 1]
## --- Member: 2014_08_21_cum.hel ---
## Object: source_spct [511 x 2]
## Wavelength (nm): range 290 to 800, step 1
## Measured on: 2014-08-21 UTC
## Measured at: 60.20911 N, 24.96474 E
## Time unit: 86400s (~1 days)
##
##    w.length    s.e.irrad
##       (dbl)        (dbl)
## 1       290 0.000000e+00
## 2       291 2.931322e-05
## 3       292 7.235264e-04
## ..      ...          ...
## --- Member: 2014_08_22_cum.hel ---
## Object: source_spct [511 x 2]
## Wavelength (nm): range 290 to 800, step 1
## Measured on: 2014-08-22 UTC
## Measured at: 60.20911 N, 24.96474 E
## Time unit: 86400s (~1 days)
##
##    w.length    s.e.irrad
##       (dbl)        (dbl)
## 1       290 0.000000e+00
## 2       291 2.926634e-05
## 3       292 7.213022e-04
## ..      ...          ...
## --- END ---
```

4 Other R packages

Coming soon.