

# Package ‘MetFns’

October 14, 2018

**Type** Package

**Title** Analysis of Visual Meteor Data

**Version** 3.2.2

**Date** 2018-10-13

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**Depends** astroFns, lubridate, plotrix, pracma, R (>= 3.4.0)

**Imports** graphics, stats, utils

**Description**

Functions for selection of visual meteor data, calculations of Zenithal Hourly Rate (ZHR) and population index, graphics of population index, ZHR and magnitude distribution.

**License** GPL-2 | GPL-3

**LazyData** true

**NeedsCompilation** no

**Repository** CRAN

**Date/Publication** 2018-10-13 22:50:12 UTC

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MetFns-package	<i>Analysis of Visual Meteor Data</i>
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## Description

Functions for selection of visual meteor data, calculations of Zenithal Hourly Rate (ZHR) and population index, graphics of population index, ZHR and magnitude distribution.

## Details

Package: MetFns  
 Type: Package  
 Version: 3.2.2  
 Date: 2018-10-13  
 License: GPL-2 | GPL-3

## Author(s)

Kristina Veljkovic  
 Maintainer: Kristina Veljkovic <mackikac@gmail.com>

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date_sol.table	<i>Calculation of table of solar longitudes</i>
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**Description**

Calculates table of solar longitudes for given dates and step.

**Usage**

```
date_sol.table(date.begin, date.end, step)
```

**Arguments**

date.begin	character vector specifying beginning date, given in "YYYY-mm-dd" format (UTC timezone).
date.end	character vector specifying ending date, given in "YYYY-mm-dd" format (UTC timezone).
step	numeric vector specifying step in minutes. Possible values are 5,10,15,20,30,60,120 minutes.

**Details**

The function `date_sol.table` calculates table of solar longitudes using function `solar.long` with days as row names and time in hours and minutes as column names. Solar longitude values correspond to beginning date at midnight to ending date at midnight-step.

**Value**

`date_sol.table` returns dataframe of solar longitudes rounded to three decimals.

**Author(s)**

Kristina Veljkovic

**See Also**

[solar.long](#)

**Examples**

```
## calculate table of solar longitudes for 10-14 December 2015, step 120 minutes
date_sol.table("2015-12-10", "2015-12-14", 120)
```

---

date_sollong	<i>Calculation of solar longitude</i>
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---

**Description**

Calculates solar longitude with respect to the equinox of 2000.0 for given date.

**Usage**

```
date_sollong(date, prec=4)
```

**Arguments**

date	character vector or factor of length one specifying date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
prec	numeric vector specifying number of decimals of calculated solar longitude (between 2 and 5 decimals). By default, it is equal to 4.

**Details**

Solar longitude is calculated applying VSOP87 theory, using coefficients from data EarthVSOP87B.

**Value**

sollong returns solar longitude, numeric vector of length one.

**Note**

User can specify date without time (i.e. date at midnight) or date with hours and minutes (without seconds).

**Author(s)**

Kristina Veljkovic

**References**

Meeus, J. (1998). *Astronomical algorithms* (Second Edition). Willmann-Bell, Inc., Richmond, Virginia, p. 219.

<http://neoprogrammics.com/vsop87>

**See Also**

[solar.long](#), [sollong\\_date](#)

**Examples**

```
## calculate solar longitude corresponding to March 7, 2016, at 02:41 UTC
date_sollong(date="2016-03-07 02:41")
```

---

EarthVSOP87B	<i>Computation of Heliocentric Spherical Longitude and Latitude for the Earth</i>
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---

**Description**

The data contains coefficients used in computation of heliocentric spherical longitude and latitude for the Earth, with reference to the standard equinox J2000.0 (VSOP87 Series B).

**Usage**

EarthVSOP87B

**Format**

A data frame with the following four variables.

A numeric Amplitude

B numeric Phase

C numeric Frequency

Subseries factor VSOP87B L and B sub-series

**Source**

<ftp://ftp.imcce.fr/pub/ephem/planets/vsop87/VSOP87B.ear>

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filter	<i>Global filter</i>
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**Description**

Various data selections for a given visual meteor data. Wrapper function for filters by shower code, date, time period, IMO observer code, observer's name, geographical coordinates, site, country, limiting magnitude, correction factor for field-of-view obstruction, solar longitude, radiant elevation and total correction factor.

**Usage**

```
filter(data,date.start=NULL,date.end=NULL,shw=NULL,lat.low=-90,lat.up=90,
long.low=-180,long.up=180,fname=NULL,lname=NULL,site=NULL,country=NULL,
mag.low=1,mag.up=8,P.low=0,P.up=90,sol.low=NULL,sol.up=NULL,
h.low=0,h.up=90,r=NULL,C=NULL)
```

**Arguments**

<code>data</code>	data frame consisting of visual meteor data (rate or magnitude data).
<code>date.start</code>	character vector or factor specifying start date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
<code>date.end</code>	character vector or factor specifying end date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
<code>shw</code>	character string consisting of three capital letters which represent meteor shower code.
<code>lat.low</code>	numeric vector taking a value between -90 (default) and 90, specifying lower boundary of latitude in degrees.
<code>lat.up</code>	numeric vector taking a value between -90 and 90 (default), specifying upper boundary of latitude in degrees.
<code>long.low</code>	numeric vector taking a value between -180(default) and 180, specifying lower boundary of longitude in degrees.
<code>long.up</code>	numeric vector taking a value between -180 and 180(default), specifying upper boundary of longitude in degrees.
<code>fname</code>	character string specifying observer's first name.
<code>lname</code>	character string specifying observer's last name.
<code>site</code>	character string specifying name of the observing site.
<code>country</code>	character string specifying name of the observing country.
<code>mag.low</code>	numeric vector with value between 1(default) and 8, specifying lower boundary of limiting magnitude.
<code>mag.up</code>	numeric vector with value between 1 and 8(default), specifying upper boundary of limiting magnitude.
<code>P.low</code>	numeric vector with value between 0 (default) and 90, specifying lower boundary of percentage of field-of-view obstruction.
<code>P.up</code>	numeric vector with value between 0 and 90(default), specifying upper boundary of percentage of field-of-view obstruction.
<code>sol.low</code>	numeric vector with value between 0 and 360, specifying lower boundary of solar longitude in degrees.
<code>sol.up</code>	numeric vector with value between 0 and 360, specifying upper boundary of solar longitude in degrees.
<code>h.low</code>	numeric vector with value between 0(default) and 90, specifying lower boundary of radiant elevation in degrees.
<code>h.up</code>	numeric vector with value between 0 and 90(default), specifying upper boundary of radiant elevation in degrees.
<code>r</code>	numeric vector specifying population index of a meteor shower.
<code>C</code>	numeric vector specifying total correction factor.

**Details**

Depending on the given arguments, the function `filter` calls one or more particular filters for selection of visual meteor data.

**Author(s)**

Kristina Veljkovic

**References**

Rendtel J. and Arlt R., editors (2014). *Handbook For Meteor Observers*. IMO, Potsdam.

**See Also**

`filter.shw`, `filter.date`, `filter.obsname`, `filter.site`, `filter.country`, `filter.gc`, `filter.mag`,  
`filter.P`, `filter.sol`, `filter.h`, `filter.totcor`

**Examples**

```
## select rate data for Orionids activity from 10th to 25th October,  
## limiting magnitudes above 5, radiant elevation above 20 degrees, percentage of clouds below 20  
filter(rate2015,date.start="2015-10-10",date.end="2015-10-25",shw="ORI",P.up=20,mag.low=5,h.low=20)
```

---

`filter.country`                      *Selection of visual meteor data by country*

---

**Description**

Selects data for a given visual meteor dataset and specified country.

**Usage**

```
filter.country(data, country)
```

**Arguments**

`data`                      data frame consisting of visual meteor data (rate or magnitude data).  
`country`                      character string specifying the name of the observing country.

**Value**

`filter.country` returns data frame with the same number of columns as argument `data`, containing observations corresponding to the specified country.

**Note**

Argument `data` has to consist of the column named "Country".

**Author(s)**

Kristina Veljkovic

**See Also**[filter](#)**Examples**

```
## select 2015 rate and magnitude data from Serbia
filter.country(rate2015, country="Serbia")

filter.country(magn2015, country="Serbia")
```

---

`filter.date`*Selection of visual meteor data by date(s)*

---

**Description**

Selects data for a given visual meteor dataset and specified dates.

**Usage**

```
filter.date(data, date.start, date.end)
```

**Arguments**

<code>data</code>	data frame consisting of visual meteor data (rate or magnitude data).
<code>date.start</code>	character vector or factor specifying start date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
<code>date.end</code>	character vector or factor specifying end date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).

**Details**

The function `filter.date` selects data for a time period, bounded by `date.start` and `date.end`. In selection of the data, date corresponding to the middle of the observing time period is used.

**Value**

`filter.date` returns data frame with the same number of columns as the argument `data`, containing observations which correspond to the specified dates.

**Note**

User can specify date without time (i.e. date at midnight) or date with hours and minutes (without seconds).

Argument `data` has to consist of the columns named "Start.Date" and "End.Date".

**Author(s)**

Kristina Veljkovic



**See Also**[filter](#)**Examples**

```
## select rate and magnitude data for the period from 10-25th October 2015
filter.date(rate2015,date.start="2015-10-10",date.end="2015-10-25")
filter.date(magn2015,date.start="2015-10-10",date.end="2015-10-25")
```

---

`filter.gc`*Selection of visual meteor data by geographical coordinates*

---

**Description**

Selects data for a given visual meteor dataset and specified geographical coordinates of the observing site or interval of geographical coordinates.

**Usage**

```
filter.gc(data,lat.low =-90,lat.up = 90,long.low =-180,long.up = 180)
```

**Arguments**

<code>data</code>	data frame consisting of visual meteor data (rate or magnitude data).
<code>lat.low</code>	numeric vector taking a value between -90 (default) and 90, specifying lower boundary of latitude in degrees.
<code>lat.up</code>	numeric vector taking a value between -90 and 90 (default), specifying upper boundary of latitude in degrees.
<code>long.low</code>	numeric vector taking a value between -180 (default) and 180, specifying lower boundary of longitude in degrees.
<code>long.up</code>	numeric vector taking a value between -180 and 180 (default), specifying upper boundary of longitude in degrees.

**Details**

If values of arguments `lat.low` and `lat.up`, as well as `long.low` and `long.up`, are the same, `filter.gc` selects data for particular observing site.

`filter.gc` enables one to select data only by latitude or longitude, with geographical coordinates being between given boundaries, less, greater or equal to a boundary.

**Value**

`filter.gc` returns data frame with the same number of columns as the argument `data`, containing observations corresponding to geographical coordinates with latitude between `lat.low` and `lat.up` and longitude between `long.low` and `long.up`.

**Note**

Argument data has to consist of the columns named "Latitude" and "Longitude".

**Author(s)**

Kristina Veljkovic

**See Also**

[filter](#)

**Examples**

```
## select 2015 rate and magnitude data for observing site with latitude 44.1583N
## and longitude 19.6869E
filter.gc(rate2015,lat.low=44.1583,lat.up=44.1583,long.low=19.6869,long.up=19.6869)
filter.gc(magn2015,lat.low=44.1583,lat.up=44.1583,long.low=19.6869,long.up=19.6869)

## select 2015 rate and magnitude data corresponding to sites with latitude 60N and above
filter.gc(rate2015,lat.low=60)
filter.gc(magn2015,lat.low=60)
```

---

filter.h

*Selection of visual meteor data by radiant elevation*

---

**Description**

Selects data for a given visual meteor dataset, specified shower and its radiant elevation or interval of radiant elevations.

**Usage**

```
filter.h(data,shw,h.low = 0,h.up = 90)
```

**Arguments**

data	data frame consisting of visual meteor rate data.
shw	character string consisting of three capital letters which represent meteor shower code.
h.low	numeric vector with value between 0 (default) and 90, specifying lower boundary of radiant elevation in degrees.
h.up	numeric vector with value between 0 and 90 (default), specifying upper boundary of radiant elevation in degrees.

**Details**

Radiant elevation  $h$  is measured from the observer's horizon towards zenith.

Values from the data frame [radiant](#) are used for right ascension and declination of shower radiant.

**Value**

filter.h returns data frame containing observations corresponding to the radiant elevation between h.low and h.up.

**Note**

Argument data has to consist of the columns named "Shower", "Start.Date", "End.Date", "Longitude" and "Latitude".

**Author(s)**

Kristina Veljkovic

**References**

Rendtel J. and Arlt R., editors (2014). *Handbook For Meteor Observers*. IMO, Potsdam.

**See Also**

[filter](#), [filter.totcor](#)

**Examples**

```
## select visual meteor rate data for the elevation of Orionids radiant between 20 and 90 degrees,
## period between 10-25th October 2015
rateOri<-filter.date(rate2015,"2015-10-10","2015-10-25")
filter.h(rateOri,shw="ORI", h.low=20)
```

---

filter.mag

*Selection of visual meteor data by limiting magnitude*

---

**Description**

Selects data for a given visual meteor dataset and specified limiting magnitude or interval of magnitudes.

**Usage**

```
filter.mag(data,mag.low=1,mag.up = 8)
```

**Arguments**

data	data frame consisting of visual meteor rate data.
mag.low	numeric vector with value between 1 (default) and 8, specifying lower boundary of limiting magnitude.
mag.up	numeric vector with value between 1 and 8 (default), specifying upper boundary of limiting magnitude.

**Value**

filter.mag returns data frame with the same number of columns as the argument data, containing observations with the limiting magnitudes between mag.low and mag.up.

**Note**

Argument data has to consist of the column named "Lmg".

**Author(s)**

Kristina Veljkovic

**See Also**

[filter](#), [filter.totcor](#)

**Examples**

```
## select visual meteor rate data for 13th August 2015, limiting magnitude between 5.5 and 6.5
rate_13.08<-filter.date(rate2015,date.start="2015-08-13",date.end="2015-08-13")
filter.mag(rate_13.08,mag.low=5.5,mag.up=6.5)

## select visual meteor rate data for the 13th August 2015 and limiting magnitude above 6
filter.mag(rate_13.08,mag.low=6)
```

---

filter.obsname	<i>Selection of visual meteor data by observer's first and last name</i>
----------------	--

---

**Description**

Selects data for a given visual meteor dataset and specified observer's first and last name.

**Usage**

```
filter.obsname(data, fname, lname)
```

**Arguments**

data	data frame consisting of visual meteor data (rate or magnitude data).
fname	character string specifying observer's first name.
lname	character string specifying observer's last name.

**Value**

filter.obsname returns data frame with the same number of columns as the argument data, containing values which correspond to the observer with specified first and last name.

**Note**

Argument data has to consist of the columns named "First.Name" and "Last.Name".

**Author(s)**

Kristina Veljkovic

**See Also**

[filter](#)

**Examples**

```
## select 2015 rate and magnitude data of observer Javor Kac
filter.obsname(rate2015, fname="Javor", lname="Kac")
filter.obsname(magn2015, fname="Javor", lname="Kac")
```

---

filter.P	<i>Selection of visual meteor data by percentage of field-of-view obstruction</i>
----------	---

---

**Description**

Selects data for a given visual meteor dataset and specified percentage or interval of percentages of field-of-view obstruction.

**Usage**

```
filter.P(data, P.low = 0, P.up = 90)
```

**Arguments**

data	data frame consisting of visual meteor data (rate or magnitude data).
P.low	numeric vector with value between 0 (default) and 90, specifying lower boundary of percentage of field-of-view obstruction.
P.up	numeric vector with value between 0 and 90 (default), specifying upper boundary of percentage of field-of-view obstruction.

**Value**

filter.P returns data frame with the same number of columns as the argument data, containing observations with the percentage of field-of-view obstruction between P.low and P.up.

**Note**

Argument data has to consist of the column named "P".

**Author(s)**

Kristina Veljkovic

**References**

Rendtel J. and Arlt R., editors (2014). *Handbook For Meteor Observers*. IMO, Potsdam.

**See Also**

[filter](#), [filter.totcor](#)

**Examples**

```
## select visual meteor rate data for the period between 10-25th October 2015 and
## percentage of field-of-view obstruction below 20%
rateOct<-filter.date(rate2015,date.start="2015-10-10",date.end="2015-10-25")
filter.P(rateOct,P.up=20)
```

---

filter.shw

*Selection of visual meteor data by shower code*

---

**Description**

Selects data for a given visual meteor dataset and specified shower code.

**Usage**

```
filter.shw(data, shw)
```

**Arguments**

data	data frame consisting of visual meteor data (rate or magnitude data).
shw	character string consisting of three capital letters which represent meteor shower code.

**Details**

List of meteor shower codes can be found in the dataframe [shw\\_list](#). Code "SPO" represents sporadic showers.

**Value**

filter.shw returns data frame containing observations which correspond to specified meteor shower.

**Note**

Argument data has to consist of the column named "Shower".

**Author(s)**

Kristina Veljkovic

**See Also**

[filter](#)

**Examples**

```
## select rate and magnitude data for 2015 Geminids
filter.shw(rate2015,shw="GEM")
filter.shw(magn2015,shw="GEM")
```

---

filter.site	<i>Selection of visual meteor data by observing site</i>
-------------	--

---

**Description**

Selects data for a given visual meteor dataset and specified observing site.

**Usage**

```
filter.site(data,site)
```

**Arguments**

data	data frame consisting of visual meteor data (rate or magnitude data).
site	character string specifying name of the observing site.

**Value**

filter.site returns data frame with the same number of columns as the argument data, containing observations which correspond to specified observing site.

**Note**

Argument data has to consist of the column named "City".

**Author(s)**

Kristina Veljkovic

**See Also**

[filter](#),[filter.country](#)

## Examples

```
## select 2015 rate and magnitude data from Debelo Brdo site
filter.site(rate2015,site="Debelo Brdo")
filter.site(magn2015,site="Debelo Brdo")
```

---

filter.sol	<i>Selection of visual meteor data by solar longitude</i>
------------	---

---

## Description

Selects data for a given visual meteor dataset and specified interval of solar longitudes.

## Usage

```
filter.sol(data, sol.low, sol.up)
```

## Arguments

data	data frame consisting of visual meteor data (rate or magnitude data).
sol.low	numeric vector specifying lower boundary of solar longitude in degrees.
sol.up	numeric vector specifying upper boundary of solar longitude in degrees.

## Details

The function `filter.sol` selects data with solar longitudes bounded by `sol.low` and `sol.up`. In selection of the data, solar longitude corresponding to the middle of the observing time period is used.

## Value

`filter.sol` returns data frame with the same number of columns as the argument `data`, containing observations with solar longitudes between `sol.low` and `sol.up`.

## Note

Argument `data` has to consist of the column named "Sollong".

## Author(s)

Kristina Veljkovic

## See Also

[filter,solar.long](#)



**Examples**

```
## select 2015 rate and magnitude data with solar longitudes between 191 and 222 degrees
filter.sol(rate2015,sol.low=191,sol.up=222)
filter.sol(magn2015,sol.low=191,sol.up=222)
```

---

filter.totcor	<i>Selection of visual meteor data by total correction factor</i>
---------------	---

---

**Description**

Selects data for a given visual meteor dataset, specified shower, population index and total correction factor.

**Usage**

```
filter.totcor(data,shw,r,C)
```

**Arguments**

data	data frame consisting of visual meteor data (rate or magnitude data).
shw	character string consisting of three capital letters which represent meteor shower code.
r	numeric vector specifying population index of a meteor shower.
C	numeric vector specifying upper boundary of total correction factor.

**Details**

Total correction factor accounts for all non-ideal observing conditions such as clouds, low radiant, low limiting magnitude.

Total correction factor is equal to  $C = \frac{Fr^{(6.5-lmg)}}{\sin h}$ , where  $r$  is population index,  $lmg$  limiting magnitude,  $F$  correction factor for field-of-view obstruction,  $h$  radiant elevation.

**Value**

filter.totcor returns data frame containing observations with total correction factors upper bounded (smaller or equal) by argument C

**Note**

Argument data has to consist of the columns named "Latitude", "Longitude", "F","Lmg" and "Shower".

**Author(s)**

Kristina Veljkovic

**References**

Rendtel J. and Arlt R., editors (2014). *Handbook For Meteor Observers*. IMO, Potsdam.

**See Also**

[filter](#), [filter.h](#), [filter.mag](#), [filter.P](#), [zhr](#)

**Examples**

```
## select 2015 visual meteor rate data during the period between 10-25 October and then
## select observations of Orionids with total correction factor smaller or equal to 5
rateOct<-filter.date(rate2015,date.start="2015-10-10",date.end="2015-10-25")
filter.totcor(rateOct,shw="ORI",r=2.5,C=5)
```

---

mag.distr

*Summarized magnitude distribution*

---

**Description**

Table and graphical representation of summarized magnitude distribution for a given magnitude dataset, specified meteor shower and time period.

**Usage**

```
mag.distr(data,date.start,date.end,shw)
```

**Arguments**

data	data frame consisting of visual meteor magnitude data.
date.start	character vector or factor specifying start date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
date.end	character vector or factor specifying end date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
shw	character string consisting of three capital letters which represent meteor shower code.

**Details**

Summarized magnitude distribution is formed by summing magnitude frequencies of all observing time intervals.

**Value**

Table and plot of summarized magnitude distribution consisting of histogram and boxplot.

The histogram cells are intervals of length 1, with midpoints at magnitudes -6 to +7.

**Author(s)**

Kristina Veljkovic

**See Also**

[pop.index](#)

**Examples**

```
## select 2015 magnitude data for observations of Orionids during the period 10-25th October
## and make graphics of magnitude distribution
mag.distr(magn2015,date.start="2015-10-10",date.end="2015-10-25", shw="ORI")
```

---

magn2015

*Magnitude data for the year 2015*

---

**Description**

Visual meteor magnitude data for the year 2015.

**Usage**

magn2015

**Format**

A data frame with 9264 observations on the following 32 variables.

Magnitude.ID numeric Magnitude ID number

Obs.Session.ID numeric Observing session ID number

User.ID numeric User ID number

First.Name character Observer's first name

Last.Name character Observer's last name

City character Observing site

Country character Observing country

Latitude numeric Latitude of the observing site, from -90 to 90 degrees

Longitude numeric Longitude of the observing site, from -180 to 180 degrees

Elevation numeric Elevation above sea level of observing site, in metres

Start.Date POSIXct Beginning of the observing time interval, UTC timezone

End.Date POSIXct End of the observing time interval, UTC timezone

Sollong numeric Solar longitude of the middle of observing time period

P numeric Percentage of field-of-view obstruction

F numeric Correction factor for field-of-view obstruction

Lmg numeric Limiting magnitude  
 Shower character Meteor shower three-letter code  
 Mag.N6 numeric Number of observed meteors of -6 magnitude  
 Mag.N5 numeric Number of observed meteors of -5 magnitude  
 Mag.N4 numeric Number of observed meteors of -4 magnitude  
 Mag.N3 numeric Number of observed meteors of -3 magnitude  
 Mag.N2 numeric Number of observed meteors of -2 magnitude  
 Mag.N1 numeric Number of observed meteors of -1 magnitude  
 Mag.0 numeric Number of observed meteors of 0 magnitude  
 Mag.1 numeric Number of observed meteors of +1 magnitude  
 Mag.2 numeric Number of observed meteors of +2 magnitude  
 Mag.3 numeric Number of observed meteors of +3 magnitude  
 Mag.4 numeric Number of observed meteors of +4 magnitude  
 Mag.5 numeric Number of observed meteors of +5 magnitude  
 Mag.6 numeric Number of observed meteors of +6 magnitude  
 Mag.7 numeric Number of observed meteors of +7 magnitude  
 Number numeric Total number of observed meteors

### Source

IMO Visual Meteor Database, [https://www.imo.net/members/imo\\_vmdb](https://www.imo.net/members/imo_vmdb)

---

midint

*Calculation of the middle of time interval*

---

### Description

Calculates the middle of observing time interval for a given visual meteor dataset.

### Usage

midint(data)

### Arguments

data data frame consisting of visual meteor data (rate or magnitude data).

### Value

midint returns the middle of observing time interval, in "%Y-%m-%d %H:%M:%S" format, UTC timezone (object of POSIXct class).

**Note**

Argument data has to consist of the columns named "Start.Date" and "End.Date". These dates should be given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).

**Author(s)**

Kristina Veljkovic

**See Also**

[solar.long](#)

**Examples**

```
## calculate middle of time interval for rate and magnitude data, year 2015
midint(rate2015)

midint(magn2015)
```

---

opt.bin

*Divides data in blocks of optimal bin sizes*

---

**Description**

Divides given rate or magnitude data into blocks of optimal bin sizes, for specified shower, period of days, minimum and maximum bin sizes, number of meteors.

**Usage**

```
opt.bin(data,date.start,date.end,shw,kmin=0.01,kmax=1,num)
```

**Arguments**

data	data frame consisting of visual meteor rate data.
date.start	character vector or factor specifying start date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
date.end	character vector or factor specifying end date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
shw	character string consisting of three capital letters which represent meteor shower code.
kmin	numeric vector specifying minimum bin size, in degrees of solar longitude. By default, it is equal to 0.01. Minimum accepted value is 0.001.
kmax	numeric vector specifying maximum bin size, in degrees of solar longitude. By default, it is equal to 1. Maximum accepted values is 5.
num	numeric vector specifying total number of meteors per interval. Minimum accepted value is 1.

**Details**

Data is divided into blocks using optimal bin size algorithm. For each block of data, it searches for an optimal bin size between minimum bin size *kmin* and maximum bin size *kmax* with total number of meteors per bin *num*. If there are not enough meteors, a maximum bin size is used. For further calculations, only observing intervals with lengths smaller or equal to optimal bin are used.

**Value**

List containing blocks of rate or magnitude data of optimal bin sizes.

**Author(s)**

Kristina Veljkovic

**See Also**

[zhr](#), [pop.index2](#)

**Examples**

```
## Divide 2015 Orionids rate data into blocks of optimal sizes.
## Consider time period around the maximum, 21th to 25th October,
## min bin size 0.16 degrees (4 hours), max bin size 1 degree,
## number of meteors equals 100

## First select rate data for Orionids activity from 21th to 25th October,
## limiting magnitudes above 5, radiant elevation above 20 degrees,
## percentage of clouds below 20
ori2015<-filter(rate2015,date.start="2015-10-21",date.end="2015-10-25",shw="ORI",
P.up=20,mag.low=5,mag.up=8,h.low=20)
opt.bin(ori2015,date.start="2015-10-21",date.end="2015-10-25",shw="ORI",
kmin=0.16,kmax=1,num=100)
```

---

pop.index

*Calculation of population index*

---

**Description**

Calculates population index of a meteor shower for a given magnitude data, specified time period, magnitude values and bin size.

**Usage**

```
pop.index(data,date.start,date.end,shw,mag.range=-6:7,k,gamma=1)
```

**Arguments**

<code>data</code>	data frame consisting of visual meteor magnitude data.
<code>date.start</code>	character vector or factor specifying start date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
<code>date.end</code>	character vector or factor specifying end date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
<code>shw</code>	character string consisting of three capital letters which represent meteor shower code.
<code>mag.range</code>	numeric vector specifying range of magnitudes. It should consist of at least 5 magnitude classes.
<code>k</code>	numeric vector specifying bin size in degrees of solar longitude. Minimum accepted value is 0.001 and maximum accepted value is 5.
<code>gamma</code>	numeric vector specifying zenith exponent. It takes value between 1 (default) and 2.

**Details**

Probabilities of perception are incorporated in magnitude distributions for each observing interval. Cummulative summarized magnitude distribution  $\Phi(m)$  is formed by summing cummulative frequencies of all observers for each magnitude class  $m$ .

Using the relationship for population index  $r = \frac{\Phi(m+1)}{\Phi(m)}$  and substitiung  $0, 1, \dots, m$  magnitudes, equation  $\Phi(m) = \Phi(0)r^m$  (or  $\ln(\Phi(m)) = \ln(\Phi(0)) + r\ln(m)$  in logarithmic form) can be written. Then, population index  $r$  is calculated by the method of least squares, for chosen range of magnitude values.

Standard error of population index is approximated with

$$\sigma_r = r \sqrt{\exp\left(\frac{\sum_j e_j^2}{(n-2)\sum_j m_j^2}\right) \left(\exp\left(\frac{\sum_j e_j^2}{(n-2)\sum_j m_j^2}\right) - 1\right)}$$

where  $n$  is number of magnitude values,  $m_j$  magnitude values,  $e_j$  regression residuals,  $j = 1, 2, \dots, n$ .

**Value**

Data frame containing following vectors

**sollong** numeric Mean of observers' solar longitudes weighted by  $\frac{N_{obs}}{C_{obs}}$ , observers' numbers of meteors divided by total correction factor

**date** POSIXct Calendar date and time in UTC corresponding to sollong

**mag** factor Range of magnitude values

**nINT** numeric Number of observing time intervals

**nSHW** numeric Number of observed meteors belonging to the shower

**pop.index** numeric Population index

**r.error** numeric Standard error of population index

**Note**

The interval for regression is chosen such that: there is at least 3 meteors per magnitude class, the magnitude classes  $m \leq 5$  are included and there are at least 5 magnitude classes available. All these conditions are fulfilled for the range of magnitude values printed in results.

For calculation of population index, only observing intervals with lengths smaller or equal to bin size  $k$  are used.

**Author(s)**

Kristina Veljkovic

**References**

Koschack R. and Rendtel J. (1990). Determination of spatial number density and mass index from visual meteor observations (1). *WGN, Journal of the IMO*, 18(2), 44 - 58.

Koschack R. and Rendtel J. (1990). Determination of spatial number density and mass index from visual meteor observations (2). *WGN, Journal of the IMO*, 18(4), 119 - 140.

Rendtel J. and Arlt R., editors (2008). *IMO Handbook For Meteor Observers*. IMO, Potsdam.

**See Also**

[mag.distr](#), [pop.index2,zhr](#)

**Examples**

```
##calculate population index for observations of 2015 Orionids,
## time period 21th to 25th October, bin size 1 degree

## First select magnitude data for Orionids activity from 21th to 25th October,
## limiting magnitudes above 5, radiant elevation above 20 degrees,
## percentage of clouds below 20
magnOri<-filter(magn2015,date.start="2015-10-21",date.end="2015-10-25",
shw="ORI",P.up=20,mag.low=5,h.low=20)
pop.index(magnOri,date.start="2015-10-21",date.end="2015-10-25",shw="ORI",k=1)
```

---

pop.index.plot

*Plot of population index*

---

**Description**

Plots population index of a meteor shower for data containing population index values and given limits on x and y axes.

**Usage**

```
pop.index.plot(rdata,xlim1,xlim2,xinc,ylim1,ylim2,yinc,dlim1=NULL,dlim2=NULL,
dinc=NULL,dunit=NULL)
```



**Arguments**

rdata	data frame consisting of population index values.
xlim1	numeric vector specifying minimum value on x-axis.
xlim2	numeric vector specifying maximum value on x-axis.
xinc	numeric vector specifying increment between labels on x-axis.
ylim1	numeric vector specifying minimum value on y-axis.
ylim2	numeric vector specifying maximum value on y-axis.
yinc	numeric vector specifying increment between labels on y-axis.
dlim1	character vector specifying start date on secondary x-axis, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
dlim2	character vector specifying end date on secondary x-axis, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
dinc	numeric vector specifying increment between labels on secondary x-axis.
dunit	character vector specifying unit of increment dinc. Accepted values are "min" for minute, "h" for hour and "day" for day.

**Details**

rdata represents table of population index values calculated using functions pop.index or pop.index2.

**Value**

xy plot of population index is made. Solar longitude is on x-axis and population index on y-axis. Population index is represented with black filled circles and 68% confidence intervals. Values of limits (minimum and maximum values) on x and y axis (xlim1,xlim2,ylim1,ylim2), as well as increments between the axis labels (xinc,yinc) should be provided to function call.

**Author(s)**

Kristina Veljkovic

**References**

Arlt, R. (2003). Bulletin 19 of the International Leonid Watch: Population index study of the 2002 Leonid meteors. *WGN, Journal of the IMO*,31:3, 77-87.

**See Also**

[pop.index](#),[pop.index2](#)

**Examples**

```
## calculate and make plot of population index for observations of 2015 Orionids,
## time period around maximum, 21th to 25th October,
## min bin size 0.16 degrees (4 hours), max bin size 1 degree,
## number of meteors equals 100
## First select magnitude data for Orionids activity from 21th to 25th October,
## limiting magnitudes above 5, radiant elevation above 20 degrees,
## percentage of clouds below 20
ori2015mag<-filter(magn2015,date.start="2015-10-21",date.end="2015-10-25",
shw="ORI",P.up=20,mag.low=5,h.low=20)
oripop<-pop.index2(ori2015mag,date.start="2015-10-21",date.end="2015-10-25",
shw="ORI",kmin=0.16,kmax=1,num=100)
pop.index.plot(oripop,xlim1=207,xlim2=211,xinc=1,ylim1=1.6,ylim2=2.4,yinc=0.2)

## change date tick marks on secondary x-axis, to show date at midnight
pop.index.plot(oripop,xlim1=207,xlim2=211,xinc=1,ylim1=1.5,ylim2=2.5,
yinc=0.2,dlim1="2015-10-21",dlim2="2015-10-25",dinc=1,dunit="day")
```

---

pop.index2

*Calculation of population index based on average distance from the limiting magnitude*

---

**Description**

Calculates population index of a meteor shower for a given magnitude data, specified time period, minimum and maximum bin size, and number of meteors.

**Usage**

```
pop.index2(data,date.start,date.end,shw,kmin=0.01,kmax=1,num,gamma=1)
```

**Arguments**

data	data frame consisting of visual meteor magnitude data.
date.start	character vector or factor specifying start date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
date.end	character vector or factor specifying end date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
shw	character string consisting of three capital letters which represent meteor shower code.
kmin	numeric vector specifying minimum bin size, in degrees of solar longitude. By default, it is equal to 0.01. Minimum accepted value is 0.001.
kmax	numeric vector specifying maximum bin size, in degrees of solar longitude. By default, it is equal to 1. Maximum accepted values is 5.
num	numeric vector specifying total number of meteors per interval.
gamma	numeric vector specifying zenith exponent. It takes value between 1 (default) and 2.

## Details

Optimal bin size algorithm is used. It searches for an optimal bin size between minimum bin size  $k_{min}$  and maximum bin size  $k_{max}$  with total number of meteors per bin  $num$ . If there are not enough meteors, a maximum bin size is used. For further calculations, only observing intervals with lengths smaller or equal to optimal bin are used.

Average distance from the limiting magnitude, as difference between the limiting magnitude and average meteor magnitude, is calculated for each observing time interval. Final average distance from the limiting magnitude is calculated as a weighted average of all individual average distances, where numbers of meteors in each observing interval represent weights. Conversion of average distance from limiting magnitude to population index is done using natural spline interpolation spline of table values `popind`. Error margins of population index are calculated using bilinear interpolation `interp2` of table values `popind.err`.

If total number of meteors per bin is smaller than 10, NA values are returned for population index and its standard error. For the case when total number of meteors is greater than 9369, polynomial regression of second degree is used in calculation of standard error of population index.

## Value

Data frame containing following vectors

**sollong** numeric Mean of observers' solar longitudes weighted by  $\frac{N_{obs}}{C_{obs}}$ , observers' numbers of meteors divided by total correction factor

**date** POSIXct Calendar date and time in UTC corresponding to `sollong`

**nINT** numeric Number of observing time intervals

**nSHW** numeric Number of observed meteors belonging to the shower

**pop.index** numeric Population index

**r.error** numeric Error margins of population index

## Author(s)

Kristina Veljkovic

## References

Arlt, R. (2003). Bulletin 19 of the International Leonid Watch: Population index study of the 2002 Leonid meteors. *WGN, Journal of the IMO*,31:3, 77-87.

## See Also

[pop.index](#),[pop.index.plot](#)

## Examples

```
## calculate population index for observations of 2015 Orionids,
## time period around maximum, 21th to 25th October,
## min bin size 0.16 degrees (4 hours), max bin size 1 degree,
## number of meteors equals 100
## First select magnitude data for Orionids activity from 21th to 25th October,
```

```
## limiting magnitudes above 5, radiant elevation above 20 degrees,
## percentage of clouds below 20
ori2015mag<-filter(magn2015,date.start="2015-10-21",date.end="2015-10-25",
shw="ORI",P.up=20,mag.low=5,h.low=20)
pop.index2(ori2015mag,date.start="2015-10-21",date.end="2015-10-25",shw="ORI",
kmin=0.16,kmax=1,num=100)
```

---

popind

*Conversion for the population index*

---

### Description

The data represents conversion from the average distance from the limiting magnitude to the population index.

### Usage

popind

### Format

A data frame with the following two numeric variables.

r Population index

avdeltam Average distance from the limiting magnitude

### Source

Arlt, R. (2003). Bulletin 19 of the International Leonid Watch: Population index study of the 2002 Leonid meteors. *WGN, Journal of the IMO*,31:3, 77-87.

---

popind.err

*Error margins for population index*

---

### Description

The data represents error margins for the population index with a given number of meteors and value of the population index.

### Usage

popind.err

**Format**

A data frame with the following three numeric variables.

r Population index

n Number of meteors

r.err Error margins for the population index

**Source**

Arlt, R. (2003). Bulletin 19 of the International Leonid Watch: Population index study of the 2002 Leonid meteors. *WGN, Journal of the IMO*,31:3, 77-87.

---

radiant	<i>Coordinates of radiants of meteor showers</i>
---------	--

---

**Description**

Coordinates of radiants of meteor showers during the year.

**Usage**

radiant

**Format**

A data frame with 365 observations on the following 80 variables.

Day numeric Day of the month

Month numeric Month of the year

ANT.Alpha numeric Right ascension of Antihelion Source radiant

ANT.Delta numeric Declination of Antihelion Source radiant

QUA.Alpha numeric Right ascension of Quadrantids radiant

QUA.Delta numeric Declination of Quadrantids radiant

GUM.Alpha numeric Right ascension of Gamma-Ursae Minorids radiant

GUM.Delta numeric Declination of Gamma-Ursae Minorids radiant

ACE.Alpha numeric Right ascension of Alpha-Centaurids radiant

ACE.Delta numeric Declination of Alpha-Centaurids radiant

GNO.Alpha numeric Right ascension of Gamma-Normids radiant

GNO.Delta numeric Declination of Gamma-Normids radiant

LYR.Alpha numeric Right ascension of Lyrids radiant

LYR.Delta numeric Declination of Lyrids radiant

PPU.Alpha numeric Right ascension of Pi-Puppids radiant

PPU.Delta numeric Declination of Pi-Puppids radiant  
ETA.Alpha numeric Right ascension of Eta-Aquarids radiant  
ETA.Delta numeric Declination of Eta-Aquarids radiant  
ELY.Alpha numeric Right ascension of Eta-Lyrids radiant  
ELY.Delta numeric Declination of Eta-Lyrids radiant  
ARI.Alpha numeric Right ascension of Daytime Arietids radiant  
ARI.Delta numeric Declination of Daytime Arietids radiant  
JBO.Alpha numeric Right ascension of June Bootids radiant  
JBO.Delta numeric Declination of June Bootids radiant  
PAU.Alpha numeric Right ascension of Piscis Austrinids radiant  
PAU.Delta numeric Declination of Piscis Austrinids radiant  
SDA.Alpha numeric Right ascension of Southern Delta-Aquarids radiant  
SDA.Delta numeric Declination of Southern Delta-Aquarids radiant  
CAP.Alpha numeric Right ascension of Alpha-Capricornids radiant  
CAP.Delta numeric Declination of Alpha-Capricornids radiant  
PER.Alpha numeric Right ascension of Perseids radiant  
PER.Delta numeric Declination of Perseids radiant  
KCG.Alpha numeric Right ascension of Kappa-Cygnids radiant  
KCG.Delta numeric Declination of Kappa-Cygnids radiant  
AUR.Alpha numeric Right ascension of Aurigids radiant  
AUR.Delta numeric Declination of Aurigids radiant  
SPE.Alpha numeric Right ascension of September Epsilon-Perseids radiant  
SPE.Delta numeric Declination of September Epsilon-Perseids radiant  
CCY.Alpha numeric Right ascension of Chi-Cygnids radiant  
CCY.Delta numeric Declination of Chi-Cygnids radiant  
DSX.Alpha numeric Right ascension of Daytime Sextantids radiant  
DSX.Delta numeric Declination of Daytime Sextantids radiant  
OCT.Alpha numeric Right ascension of October Camelopardalids radiant  
OCT.Delta numeric Declination of October Camelopardalids radiant  
DRA.Alpha numeric Right ascension of Draconids radiant  
DRA.Delta numeric Declination of Draconids radiant  
STA.Alpha numeric Right ascension of Southern Taurids radiant  
STA.Delta numeric Declination of Southern Taurids radiant  
DAU.Alpha numeric Right ascension of Delta-Aurigids radiant  
DAU.Delta numeric Declination of Delta-Aurigids radiant  
EGE.Alpha numeric Right ascension of Epsilon-Geminids radiant  
EGE.Delta numeric Declination of Epsilon-Geminids radiant

ORI.Alpha numeric Right ascension of Orionids radiant  
ORI.Delta numeric Declination of Orionids radiant  
LMI.Alpha numeric Right ascension of Leo Minorids radiant  
LMI.Delta numeric Right ascension of Leo Minorids radiant  
NTA.Alpha numeric Right ascension of Northern Taurids radiant  
NTA.Delta numeric Declination of Northern Taurids radiant  
LEO.Alpha numeric Right ascension of Leonids radiant  
LEO.Delta numeric Declination of Leonids radiant  
AMO.Alpha numeric Right ascension of Alpha-Monocerotids radiant  
AMO.Delta numeric Declination of Alpha-Monocerotids radiant  
NOO.Alpha numeric Right ascension of November Orionids radiant  
NOO.Delta numeric Declination of November Orionids radiant  
PHO.Alpha numeric Right ascension of Phoenicids radiant  
PHO.Delta numeric Declination of Phoenicids radiant  
PUP.Alpha numeric Right ascension of Puppis-Velids radiant  
PUP.Delta numeric Declination of Puppis-Velids radiant  
MON.Alpha numeric Right ascension of Monocerotids radiant  
MON.Delta numeric Declination of Monocerotids radiant  
HYD.Alpha numeric Right ascension of Sigma-Hydris radiant  
HYD.Delta numeric Declination of Sigma-Hydris radiant  
GEM.Alpha numeric Right ascension of Geminids radiant  
GEM.Delta numeric Declination of Geminids radiant  
COM.Alpha numeric Right ascension of Comae Berenicids radiant  
COM.Delta numeric Declination of Comae Berenicids radiant  
DLM.Alpha numeric Right ascension of December Leonis Minorids radiant  
DLM.Delta numeric Declination of December Leonis Minorids radiant  
URS.Alpha numeric Right ascension of Ursids radiant  
URS.Delta numeric Declination of Ursids radiant

### Details

Coordinates of radiants of meteor showers are given on 5-days intervals on IMO site. Natural spline interpolation and extrapolation were used to calculate radiant coordinates for in-between days and outside the given period.

### Source

Meteor Shower Calendar, <http://www.imo.net/files/meteor-shower/cal2018.pdf>

List of Meteor Showers for MetRec V5.3, <http://www.metrec.org/download/metrec53win7/metrec.shw>

rate2015

*Rate data for the year 2015***Description**

Visual meteor rate data for the year 2015.

**Usage**

rate2015

**Format**

A data frame with 27408 observations on the following 21 variables.

Rate.ID numeric Rate ID number

Obs.Session.ID numeric Observing session ID number

User.ID numeric User ID number

First.Name character Observer's first name

Last.Name character Observer's last name

City character Observing site

Country character Observing country

Latitude numeric Latitude of the observing site, from -90 to 90 degrees

Longitude numeric Longitude of the observing site, from -180 to 180 degrees

Elevation numeric Elevation above sea level of observing site, in metres

Start.Date POSIXct Beginning of the observing time interval, UTC timezone

End.Date POSIXct End of the observing time interval, UTC timezone

Sollong numeric Solar longitude of the middle of observing time period

Ra numeric Right ascension of the center of the field of view, from 0 to 360 degrees

Decl numeric Declination of the center of the field of view, from -90 to 90 degrees

Teff numeric Effective observing time

P numeric Percentage of field-of-view obstruction

F numeric Correction factor for field-of-view obstruction

Lmg numeric Limiting magnitude

Shower character Meteor shower three-letter code

Number numeric Number of meteors belonging to the observed shower

**Source**

IMO Visual Meteor Database, [https://www.imo.net/members/imo\\_vmdb](https://www.imo.net/members/imo_vmdb)



---

shw_list	<i>List of meteor showers</i>
----------	-------------------------------

---

### Description

The data consists of a list of visual meteor showers.

### Usage

```
shw_list
```

### Format

A data frame with 38 observations on the following 11 variables.

Shw factor Three-letter shower code

Name factor Shower name

Activity.beg factor The beginning of the activity period

Activity.end factor The end of the activity period

Max factor The date of maximum activity

Sollong numeric Solar longitude of the date of maximum

Alpha numeric Right ascension of radiant at date of maximum

Delta numeric Declination of radiant at date of maximum

V numeric Geocentric velocity of the stream

r numeric Population index of a meteor shower

ZHR numeric Zenithal Hourly Rate of meteor shower during maximum activity

### Note

Data is taken from Table 5. Working List of Visual Meteor Showers. *Details in this Table were correct according to the best information available in June 2017, with maximum dates accurate only for 2018.*

### Source

2018 Meteor Shower Calendar, <http://www.imo.net/files/meteor-shower/cal2018.pdf>

---

`solar.long`*Vectorized calculation of solar longitude*

---

**Description**

Calculates solar longitudes with respect to the equinox of 2000.0 for given dates.

**Usage**

```
solar.long(date, prec=4)
```

**Arguments**

<code>date</code>	character vector or factor specifying dates, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
<code>prec</code>	numeric vector specifying number of decimals of calculated solar longitude (between 2 and 5 decimals). By default it is equal to 4.

**Details**

The function `solar.long` represents vectorized version of function `sollong`. It calculates solar longitudes corresponding to multiple dates.

**Value**

`solar.long` returns solar longitude(s), numeric vector with specified number of decimal places.

**Author(s)**

Kristina Veljkovic

**See Also**

[date\\_sollong](#), [filter.sol](#)

**Examples**

```
## calculate solar longitudes corresponding to the middle of time intervals
## of 2015 Orionids rate data
## first select Orionids from 2015 rate data
rateOri<-filter.shw(rate2015,shw="ORI")

## calculate middle of observing time intervals of 2015 Orionids rate data
midintOri<-midint(rateOri)

## calculate solar longitudes corresponding to the middle of time intervals
solar.long(midintOri)
```

---

sollong_date	<i>Calculation of date corresponding to given value of solar longitude</i>
--------------	--

---

**Description**

Calculates calendar date and time corresponding to specified value of solar longitude (J2000.0) and specified year.

**Usage**

```
sollong_date(solval, year, date1=NULL, date2=NULL)
```

**Arguments**

solval	numeric vector of length one specifying solar longitude.
year	numeric vector of length one specifying year.
date1	character vector of length one specifying start date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
date2	character vector of length one specifying end date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).

**Details**

The function `sollong_date` calculates date corresponding to the given value of solar longitude, for specified year between 1984 and 2030. It searches for a solution in a interval bounded by `date1` and `date2`. If user does not specify `date1` and `date2`, they are, by default, equal to the 1st of January and the 31st of December, respectively.

**Value**

`sollong_date` returns object of POSIXct class, calendar date in "%Y-%m-%d %H:%M:%S" format (UTC timezone).

**Note**

Arguments `date1` and `date2` should belong to the same year.

**Author(s)**

Kristina Veljkovic

**See Also**

[date\\_sollong](#)

**Examples**

```
## calculate date corresponding to 1 degree of solar longitude
## search between dates 1 and 31 March 2017
sollong_date(1,year=2017,"2017-03-01","2017-03-31")
```

---

sol_date.table	<i>Vectorized calculation of date corresponding to given value of solar longitude</i>
----------------	---

---

**Description**

Calculates table of dates corresponding to the given values of solar longitude and year.

**Usage**

```
sol_date.table(solval,year)
```

**Arguments**

solval	numeric vector specifying solar longitude(s).
year	numeric vector specifying year(s).

**Details**

The function `sol_date.table` represents vectorized version of function `sollong_date`. It calculates table of dates corresponding to multiple values of either solar longitude or year.

**Value**

`sol_date.table` returns dataframe. Each column is object of POSIXct class, calendar dates in "%Y-%m-%d %H:%M:%S" format (UTC timezone). Column names are solar longitudes and row names are years.

**Author(s)**

Kristina Veljkovic

**See Also**

[sollong\\_date](#)

**Examples**

```
## calculate dates corresponding to the solar longitudes 347-350, year 2016
sol_date.table(347:350,year=2016)

## calculate dates corresponding to the solar longitude 347, years 2015-2017
sol_date.table(347,year=2015:2017)
```

---

zhr *Calculates zenithal hourly rate (ZHR)*

---

### Description

Calculates average zenithal hourly rate of a meteor shower for a given rate data, specified shower, period of days, population index, minimum and maximum bin sizes, number of meteors and ZHR correction.

### Usage

```
zhr(data, date.start, date.end, shw, r=NULL, kmin=0.01, kmax=1, num, c.zhr=0.5,
     rdata=NULL, gamma=1)
```

### Arguments

data	data frame consisting of visual meteor rate data.
date.start	character vector or factor specifying start date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
date.end	character vector or factor specifying end date, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
shw	character string consisting of three capital letters which represent meteor shower code.
r	numeric vector specifying population index of a meteor shower.
kmin	numeric vector specifying minimum bin size, in degrees of solar longitude. By default, it is equal to 0.01. Minimum accepted value is 0.001.
kmax	numeric vector specifying maximum bin size, in degrees of solar longitude. By default, it is equal to 1. Maximum accepted values is 5.
num	numeric vector specifying total number of meteors per interval. Minimum accepted value is 1.
c.zhr	numeric vector specifying value of ZHR correction. By default, it is equal to 0.5. Accepted values are 0.5 and 1.
rdata	data frame consisting of population index values calculated on corresponding visual meteor magnitude data.
gamma	numeric vector specifying zenith exponent. It takes value between 1 (default) and 2.

### Details

Optimal bin size algorithm is used. It searches for an optimal bin size between minimum bin size `kmin` and maximum bin size `kmax` with total number of meteors per bin `num`. If there are not enough meteors, a maximum bin size is used. For further calculations, only observing intervals with lengths smaller or equal to optimal bin are used.

Average zenithal hourly rate is calculated by the formula

$$ZHR = \frac{c + \sum_i N_i}{\sum_i \frac{T_{eff,i}}{C_i}}, i = 1, 2, \dots, k$$

where  $k$  is the number of observing periods,  $N_i$  - the raw number of meteors seen by each observer in observing period  $i$ ,  $T_{eff,i}$  - the effective time or amount of time an observer actually scans the sky for meteors during observing period  $i$ , and  $C_i$  - total correction factor that accounts for all the imperfections in the observing period  $i$  such as clouds, low radiant, low limiting magnitude.

Total correction factor is equal to

$$C_i = \frac{r^{(6.5-lm_i)} F_i}{\sin^\gamma(h_i)}$$

where  $r$  is population index,  $lm_i$  limiting magnitude,  $F_i$  correction factor for field-of-view obstruction,  $h_i$  radiant elevation for each observer in observing period  $i$  and  $\gamma$  zenith exponent gamma. In the numerator,  $c$  is included to correct for the asymmetric high and low end possibilities in a Poisson distribution (distribution of the number of observed meteors).

Standard error of the average zenithal rate is calculated by the formula

$$\sigma = \frac{\sqrt{c + \sum_i N_i}}{\sum_i \frac{T_{eff,i}}{C_i}}, i = 1, 2, \dots, k$$

The spatial number density of meteoroids producing meteors of magnitude at least 6.5 is (per  $10^9 km^3$ )

$$\rho = \frac{(10.65r - 12.15)ZHR}{3600 \times 178700r^{(-1.82)}V}$$

where  $V$  is stream's geocentric velocity.

Standard error of spatial number density is approximated with

$$\sigma_\rho = \frac{\sigma \rho}{ZHR}$$

Values from the data frame `radiant` are used for right ascension and declination of shower radiant. If population index is not specified, it should be calculated using functions `pop.index` or `pop.index2` and then incorporated in the calculation of ZHR (through data frame `rdata`).

## Value

Data frame containing following vectors

**sollong** numeric Mean of observers' solar longitudes weighted by  $\frac{T_{eff,obs}}{C_{obs}}$ , observers effective time divided by total correction factor

**date** POSIXct Calendar date and time in UTC corresponding to so1long  
**nINT** numeric Number of observing time intervals  
**nSHW** numeric Number of observed meteors. String SHW is replaced with the code of meteor shower.  
**ZHR** numeric Zenithal Hourly Rate  
**st.error** numeric Standard error of ZHR  
**density** numeric Spatial number density  
**dens.error** numeric Standard error of spatial number density

### Author(s)

Kristina Veljkovic

### References

Rendtel J. and Arlt R., editors (2014). *Handbook For Meteor Observers*. IMO, Potsdam.  
 Bias, P.V. (2011). A Note on Poisson inference and extrapolations under low raw data and short interval observation conditions. *WGN, Journal of the IMO*,39:1, 14-19.

### See Also

[zhr.plot,pop.index2](#)

### Examples

```
## calculate ZHR for observations of 2015 Orionids,
## time period around maximum 21th to 25th October,
## min bin size 0.16 degrees (4 hours), max bin size 1 degree,
## number of meteors equals 100, population index calculated from magnitude data

## First select rate data for Orionids activity from 21th to 25th October,
## limiting magnitudes above 5, radiant elevation above 20 degrees,
## percentage of clouds below 20
ori2015<-filter(rate2015,date.start="2015-10-21",date.end="2015-10-25",
shw="ORI",P.up=20,mag.low=5,mag.up=8,h.low=20)
ori2015mag<-filter(magn2015,date.start="2015-10-21",date.end="2015-10-25",
shw="ORI",P.up=20,mag.low=5,h.low=20)

oripop<-pop.index2(ori2015mag,date.start="2015-10-21",date.end="2015-10-25",
shw="ORI",kmin=0.16,kmax=1,num=100)
zhr(ori2015,date.start="2015-10-21",date.end="2015-10-25",shw="ORI",
kmin=0.16,kmax=1,num=100,rdata=oripop)
```

zhr.plot

*Plot of zenithal hourly rate (ZHR)***Description**

Plots average zenithal hourly rate of a meteor shower for data containing ZHR values and given limits on x and y axes.

**Usage**

```
zhr.plot(zhrdata,xlim1,xlim2,xinc,ylim1,ylim2,yinc,
         dlim1=NULL,dlim2=NULL,dinc=NULL,dunit=NULL)
```

**Arguments**

zhrdata	data frame consisting of ZHR values.
xlim1	numeric vector specifying minimum value on x-axis.
xlim2	numeric vector specifying maximum value on x-axis.
xinc	numeric vector specifying increment between labels on x-axis.
ylim1	numeric vector specifying minimum value on y-axis.
ylim2	numeric vector specifying maximum value on y-axis.
yinc	c vector specifying increment between labels on y-axis.
dlim1	character vector specifying start date on secondary x-axis, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
dlim2	character vector specifying end date on secondary x-axis, given in "%Y-%m-%d %H:%M:%S" format (UTC timezone).
dinc	numeric vector specifying increment between labels on secondary x-axis.
dunit	character vector specifying unit of increment dinc. Accepted values are "min" for minute, "h" for hour and "day" for day.

**Details**

zhrdata represents table of ZHR values calculated using zhr function.

**Value**

xy plot of Zenithal Hourly Rate is made. Solar longitude is on x-axis and ZHR on y-axis. ZHR is represented with black filled circles and 68% confidence intervals. Values of limits (minimum and maximum values) on x and y axis (xlim1,xlim2,ylim1,ylim2), as well as increments between the axis labels (xinc,yinc) should be provided to function call.

**Author(s)**

Kristina Veljkovic



## References

- Rendtel J. and Arlt R., editors (2014). *Handbook For Meteor Observers*. IMO, Potsdam.
- Bias, P.V. (2011). A Note on Poisson inference and extrapolations under low raw data and short interval observation conditions. *WGN, Journal of the IMO*,39:1, 14-19.

## See Also

[zhr,pop.index2](#)

## Examples

```
## calculate and make plot of ZHR for observations of 2015 Perseids, time period
## around maximum, 21th to 25th October, min bin size 0.16 degrees (4 hours),
## max bin size 1 degree, number of meteors equals 100
## First select rate data for Orionids activity from 21th to 25th October,
## limiting magnitudes above 5, radiant elevation above 20 degrees,
## percentage of clouds below 20
ori2015<-filter(rate2015,date.start="2015-10-21",date.end="2015-10-25",shw="ORI",
P.up=20,mag.low=5,h.low=20)
orizhr<-zhr(ori2015,date.start="2015-10-21",date.end="2015-10-25",shw="ORI",
r=2.5,kmin=0.16,kmax=1,num=100)

## make graphic of ZHR
## x-axis limits: min(sollong)=207.137, max(sollong)=210.276
## y-axis limits: min(ZHR-st.err)=14.2,max(ZHR+st.err)=21.9
zhr.plot(orizhr,xlim1=207,xlim2=211,xinc=1,ylim1=14,ylim2=22,yinc=1)

## change date tick marks on secondary x-axis, to show date at midnight
zhr.plot(orizhr,xlim1=207,xlim2=211,xinc=1,ylim1=14,ylim2=22,yinc=1,
dlim1="2015-10-21",dlim2="2015-10-25",dinc=1,dunit="day")
```

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