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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.

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`MetFns-package` *Analysis of Visual Meteor Data*

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
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Author(s)

Kristina Veljkovic

Maintainer: Kristina Veljkovic <mackikac@gmail.com>

date_sol.table *Calculation of table of solar longitudes*

Description

Calculates table of solar longitudes for given dates and step.

Usage

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

Arguments

`date.beg`	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 *Calculation of solar longitude*

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

Hour, seconds and minutes does not have to be provided in function call.

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` *Computation of Heliocentric Spherical Longitude and Latitude for the Earth*

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

`filter` *Global filter*

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

`data`	data frame consisting of visual meteor data (rate or 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.
`lat.low`	numeric vector taking a value between -90 (default) and 90, specifying lower boundary of latitude in degrees.
`lat.up`	numeric vector taking a value between -90 and 90 (default), specifying upper boundary of latitude in degrees.
`long.low`	numeric vector taking a value between -180(default) and 180, specifying lower boundary of longitude in degrees.
`long.up`	numeric vector taking a value between -180 and 180(default), specifying upper boundary of longitude in degrees.
`fname`	character string specifying observer's first name.
`lname`	character string specifying observer's last name.
`site`	character string specifying name of the observing site.
`country`	character string specifying name of the observing country.
`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.
`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.
`sol.low`	numeric vector with value between 0 and 360, specifying lower boundary of solar longitude in degrees.
`sol.up`	numeric vector with value between 0 and 360, specifying upper boundary of solar longitude in degrees.
`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.
`r`	numeric vector specifying population index of a meteor shower.
`C`	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

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

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

Hour, seconds and minutes do not have to be provided in function call.

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

data	data frame consisting of visual meteor data (rate or magnitude data).
lat.low	numeric vector taking a value between -90 (default) and 90, specifying lower boundary of latitude in degrees.
lat.up	numeric vector taking a value between -90 and 90 (default), specifying upper boundary of latitude in degrees.
long.low	numeric vector taking a value between -180 (default) and 180, specifying lower boundary of longitude in degrees.
long.up	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` *Selection of visual meteor data by observer's first and last name*

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 *Selection of visual meteor data by percentage of field-of-view obstruction*

Description

Selects data for a given visual meteor rate 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 rate 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 *Selection of visual meteor data by observing site*

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 — *Selection of visual meteor data by solar longitude*

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` *Selection of visual meteor data by total correction factor*

Description

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

Usage

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

Arguments

`data`	data frame consisting of visual meteor rate 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.

If right ascension and declination of shower radiant are not specified, the values from the data frame `radiant` are used.

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 dataset for the year 2015.

Usage

```
magn2015
```

Format

A data frame with 9336 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

Visual Meteor Database, http://www.imo.net/observations/methods/visual-observation/

`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)
```

---

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)
```

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.
mag.range	numeric vector specifying range of magnitudes. It should consist of at least 5 magnitude classes.
k	numeric vector specifying bin size in degrees of solar longitude. Minimum accepted value is 0.001 and maximum accepted value is 5.

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 substitutiong $0, 1, ...m$ magnitudes, equation $\Phi(m) = \Phi(0)r^m$ (or $ln(\Phi(m)) = ln(\Phi(0)) + rln(m)$ 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, $j = 1, 2, ...n$.

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<=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 and 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)
```

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.

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 0.1 degree, max bin size 1 degrees,
## 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=0.1,kmax=1,num=100)
pop.index.plot(oripop,xlim1=207,xlim2=211,xinc=1,ylim1=1.5,ylim2=2.5,yinc=0.2)
```

---

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)
```

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.

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 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 0.1 degree, max bin size 1 degrees,
## 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=0.1,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` *Coordinates of radiants of meteor showers*

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 Puppid-Velids radiant

`PUP.Delta` numeric Declination of Puppid-Velids radiant

`MON.Alpha` numeric Right ascension of Monocerotids radiant

`MON.Delta` numeric Declination of Monocerotids radiant

`HYD.Alpha` numeric Right ascension of Sigma-Hydrids radiant

`HYD.Delta` numeric Declination of Sigma-Hydrids 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 27568 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

Visual Meteor Database, http://www.imo.net/observations/methods/visual-observation/

shw_list *List of meteor showers*

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

date	character vector or factor specifying dates, 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

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 — *Calculation of date corresponding to given value of solar longitude*

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 od 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 — *Vectorized calculation of date corresponding to given value of solar longitude*

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 corresonding 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)
```

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 between 0 and 1.
`rdata`	data frame consisting of population index values calculated on corresponding visual meteor magnitude data.

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

$$ZHR = \frac{c + \sum_i N_i}{\left(\sum_i \frac{T_{eff,i}}{C_i}\right)}, i = 1, 2, ..., k$$

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

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

,

where r is population index, lmg_i limiting magnitude, F_i correction factor for field-of-view obstruction, h_i radiant elevation for each observer in observing period i.

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

$$st.error = \frac{\sqrt{c + \sum_i N_i}}{\sum_i \frac{T_{eff,i}}{C_i}}, i = 1, 2, ..., k$$

.

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

$$\rho = \frac{(10.65r - 12.15)ZHR}{3600178700r^(-1.82)V}$$

,

where V is stream's geocentric velocity.

Standard error of spatial number density is approximated with

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

.

If right ascension and declination of shower radiant are not specified, the values from the data frame `radiant` are used. 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 dataframe `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 `sollong`

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,
## 2th to 25th October, min bin size 0.1 degree, 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=0.1,kmax=1,num=100)
zhr(ori2015,date.start="2015-10-21",date.end="2015-10-25",shw="ORI",
kmin=0.1,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)
```

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	numeric vector specifying increment between labels on y-axis.

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 0.1 degree, 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=0.1,kmax=1,num=100)

## make graphic of ZHR
## x-axis limits: min(sollong)=207.115, max(sollong)=210.276
```

```
## y-axis limits: min(ZHR-st.err)=14.2,max(ZHR+st.err)=22.6
zhr.plot(orizhr,xlim1=207,xlim2=211,xinc=1,ylim1=14,ylim2=23,yinc=1)
```

Index