Package ‘resourcecode’

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Title Access to the 'RESOURCECODE' Hindcast Database

Version 0.5.2

Description Utility functions to download data from the 'RESOURCECODE' hindcast database of sea-states, time series of sea-state parameters and time series of 1D and 2D wave spectra. See <https://resourcecode.ifremer.fr> for more details about the available data. Also provides facilities to plot and analyse downloaded data, such as computing the sea-state parameters from both the 1D and 2D surface elevation variance spectral density.

License GPL (>= 3)

URL https://github.com/Resourcecode-project/r-resourcecode, https://resourcecode-project.github.io/r-resourcecode/, https://resourcecode-project.r-universe.dev/resourcecode

BugReports https://github.com/Resourcecode-project/r-resourcecode/issues

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Author Nicolas Raillard [aut, cre] (ORCID: <https://orcid.org/0000-0003-3385-5104>)

Maintainer Nicolas Raillard <nicolas.raillard@ifremer.fr>

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`closest_point_field` *Find the closest point of the FIELD grid to the specified position*

Description

Find the closest point of the FIELD grid to the specified position

Usage

```
closest_point_field(x, lat = NULL, closest = 1L, ...)
```

Arguments

x	vector of coordinates in the form longitude/latitude data frame
lat	alternatively, x and lat can be vector of the same length
closest	an integer to specify the number of point to output.
...	currently unused

Value

a list with two components: the closest point(s) of the grid and the distance (s).

Examples

```
semrev_west <- closest_point_field(c(-2.786, 47.239))
semrev_west
```

---

closest_point_spec *Find the closest point of the SPEC grid to the specified position*

Description

Find the closest point of the SPEC grid to the specified position

Usage

```
closest_point_spec(x, lat = NULL, closest = 1L, ...)
```

Arguments

x	vector of coordinates in the form longitude/latitude data frame
lat	alternatively, x and lat can be vector of the same length
closest	an integer to specify the number of point to output.
...	currently unused

Value

a list with two components: the closest point(s) of the grid and the distance (s).

Examples

```
semrev_west <- closest_point_spec(c(-2.786, 47.239))
semrev_west
```

compute_orbital_speeds *Compute the orbital speed at a given depth from the wave elevation 1D spectra*

Description

Compute the orbital speed at a given depth from the wave elevation 1D spectra

Usage

```
compute_orbital_speeds(spec, freq, z = 0, depth = Inf, output_speeds = FALSE)
```

Arguments

spec	1D spectral data: TxM matrix
freq	the M frequencies
z	distance above the floor at which we want the orbital speed (single numeric)
depth	depth time series (vector length T. Recycled if a single value is given)
output_speeds	TRUE if the spectral speed are needed. Otherwise, returns the RMS (default)

Value

depending on spec, a list with the spectral velocities for each component (if output_speeds==FALSE) or a data.frame with a time series of horizontal and vertical components of (spectral) orbital speed.

Examples

```
# Compute orbital speed for varying Hs
S <- t(sapply(1:10, function(h) {
  jonswap(h)$spec
}))
orb_speeds <- compute_orbital_speeds(S, rscd_freq, depth = 100, z = 10)
plot(1:10, orb_speeds[, 1],
  type = "l",
  ylim = range(orb_speeds),
  xlab = "Hs (m)",
  ylab = "Orbital speed RMS (m/s)"
)
lines(1:10, orb_speeds[, 2], type = "l", col = "red")
```

`compute_sea_state_1d_spectrum`
Compute sea_state parameter from wave spectrum

Description

Compute sea_state parameter from wave spectrum

Usage

```
compute_sea_state_1d_spectrum(spec, ...)
```

Arguments

`spec`	1D spectrum data, e.g. from `get_1Dspectrum`
`...`	currently unused

Value

a tibble with the sea-state parameters computed from the time series of 2D spectrum

Examples

```
rscd_params <- get_parameters(
  node = "134865",
  start = "1994-01-01",
  end = "1994-01-31 23:00:00",
  parameters = c("hs", "tp")
)
spec <- resourcecodedata::rscd_1d_spectra
param_calc <- compute_sea_state_1d_spectrum(spec)
oldpar <- par(mfcol = c(2, 1))
plot(param_calc$time, param_calc$hs, type = "l", xlab = "Time", ylab = "Hs (m)")
lines(rscd_params$time, rscd_params$hs, col = "red")
plot(param_calc$time, param_calc$tp, type = "l", xlab = "Time", ylab = "Tp (s)")
lines(rscd_params$time, rscd_params$tp, col = "red")
par(oldpar)
```

`compute_sea_state_2d_spectrum`
Compute sea_state parameter from wave directional spectrum

Description

Compute sea_state parameter from wave directional spectrum

Usage

```
compute_sea_state_2d_spectrum(spec, ...)
```

Arguments

spec	2D spectrum data, e.g. from get_2Dspectrum
...	currently unused

Value

a tibble with the sea-state parameters computed from the time series of 2D spectrum

Examples

```
rscd_params <- get_parameters(
  node = "134865",
  start = "1994-01-01",
  end = "1994-01-31 23:00:00",
  parameters = c("hs", "tp")
)
spec <- resourcecodedata::rscd_2d_spectra
param_calc <- compute_sea_state_2d_spectrum(spec)
oldpar <- par(mfcol = c(2, 1))
plot(param_calc$time, param_calc$hs, type = "l", xlab = "Time", ylab = "Hs (m)")
lines(rscd_params$time, rscd_params$hs, col = "red")
plot(param_calc$time, param_calc$tp, type = "l", xlab = "Time", ylab = "Tp (s)")
lines(rscd_params$time, rscd_params$tp, col = "red")
par(oldpar)
```

---

convert_spectrum_2d1d *Converts a 2D spectrum time series to a 1D spectrum*

Description

Converts a 2D spectrum time series to a 1D spectrum

Usage

```
convert_spectrum_2d1d(spec, ...)
```

Arguments

spec	a structure with the needed fields, as an output from 'get_2Dspectrum' for example
...	unused yet

Value

a structure comparable to 'get_1Dspectrum'.

Examples

```
spec <- resourcecodedata::rscd_2d_spectra
spec1D_RSCD <- resourcecodedata::rscd_1d_spectra
spec1D <- convert_spectrum_2d1d(spec)
# Check the differences, should be low
max(abs(spec1D_RSCD$ef - spec1D$ef))

# Plot the different spectrum
plot(spec1D$freq, spec1D$ef[, 1], type = "l", log = "xy")
lines(spec1D_RSCD$freq, spec1D_RSCD$ef[, 1], col = "red")

# Images
lims <- c(0, 360)
r <- as.POSIXct(round(range(spec1D$forcings$time), "hours"))
oldpar <- par(mfcol = c(2, 1))
image(spec1D$forcings$time, spec1D$freq, t(spec1D$th1m),
  zlim = lims,
  xlab = "Time",
  ylab = "Freq (Hz)",
  xaxt = "n",
  main = "Directionnal spreading"
)
axis.POSIXct(1, spec1D$forcings$time,
  at = seq(r[1], r[2], by = "week"),
  format = "%Y-%m-%d",
  las = 2
)
image(spec1D_RSCD$forcings$time, spec1D_RSCD$freq, t(spec1D_RSCD$th1m),
  zlim = lims,
  xlab = "Time",
  ylab = "Freq (Hz)",
  xaxt = "n"
)
axis.POSIXct(1, spec1D$forcings$time,
  at = seq(r[1], r[2], by = "week"),
  format = "%Y-%m-%d",
  las = 2
)
par(oldpar)
```

---

cut_directions *Directional binning*

Description

Cuts direction vector into directional bins

Usage

```
cut_directions(directions, n_bins = 8, labels = NULL)
```

Arguments

`directions`	vector of directions to be binned, in degree, 0° being the North.
`n_bins`	number of bins, default: 8 sectors.
`labels`	optional character vector giving the sectors names.

Value

a factor vector the same size as `directions` with the values binned into sectors.

Examples

```
# Example usage and demonstration
set.seed(123)
directions <- runif(20, 0, 360)

# Test with different numbers of bins
cat("Original directions:\n")
print(round(directions, 1))

cat("\n8 bins (default):\n")
bins_8 <- cut_directions(directions, n_bins = 8)
print(bins_8)

cat("\n4 bins:\n")
bins_4 <- cut_directions(directions, n_bins = 4)
print(bins_4)
```

---

cut_seasons *Get season from date time object*

Description

Get season from date time object

Usage

```
cut_seasons(
  datetime,
  definition = "meteorological",
  hemisphere = "northern",
  labels = NULL
)
```

Arguments

`datetime`	a POSIXct vector from with the season is constructed
`definition`	the definition used to compute the season. See details section.
`hemisphere`	in the Southern hemisphere, seasons are reversed compared to the Northern one.
`labels`	optional, a character vector of length fours with the seasons' names.

Details

Available Definitions:

- meteorological: Standard seasons (Dec-Feb = Winter, etc.)
- astronomical: Based on equinoxes/solstices
- djf: Dec-Jan-Feb, Mar-Apr-May, Jun-Jul-Aug, Sep-Oct-Nov
- jfm: Jan-Feb-Mar, Apr-May-Jun, Jul-Aug-Sep, Oct-Nov-Dec
- fma: Feb-Mar-Apr, May-Jun-Jul, Aug-Sep-Oct, Nov-Dec-Jan
- amj, jas, ond: Alternative starting points for quarterly seasons

Value

a Factor vector with 4 levels depending on the definitions (and labels if provided)

Examples

```
dates <- seq(
  from = as.POSIXct("2023-01-15"),
  to = as.POSIXct("2023-12-15"),
  by = "month"
)
cut_seasons(dates)
```

`dispersion` *Compute the dispersion relation of waves Find* k *s.t. (2.pi.f)^2 = g.k.tanh(k.d)*

Description

Compute the dispersion relation of waves Find *k* s.t. (2.pi.f)^2 = g.k.tanh(k.d)

Usage

```
dispersion(frequencies, depth, iter_max = 200, tol = 1e-06)
```

Arguments

frequencies	frequency vector
depth	depth (m)
iter_max	maximum number of iterations in the solver
tol	tolerance for termination.

Value

the wave numbers (same size as frequencies)

Examples

```
freq <- seq(from = 0, to = 1, length.out = 100)
k1 <- dispersion(freq, depth = 1)
k10 <- dispersion(freq, depth = 10)
kInf <- dispersion(freq, depth = Inf)
plot(freq, k1, type = "l")
lines(freq, k10, col = "red")
lines(freq, kInf, col = "green")
```

---

fastTrapz *Fast implementation of pracma::trapz from the Armadillo C++ library*

Description

Compute the area of a multivariate function with (matrix) values Y at the points x.

Usage

```
fastTrapz(x, Y, dim = 1L)
```

Arguments

x	x-coordinates of points on the x-axis (vector)
Y	y-coordinates of function values (matrix)
dim	an integer giving the subscripts which the function will be applied over. 1 indicates rows, 2 indicates columns

Value

a vector with one dimension less than Y

Examples

```
x = 1:10
Y = sin(pi/10*matrix(1:10,ncol=10,nrow=10))
fastTrapz(x*pi/10,Y,2)
```

fractional_day_of_year — *Compute Fractional Day of Year from POSIXct*

Description

Calculates the fractional day of year from a POSIXct datetime object. The fractional day is zero-indexed, starting at 0 for January 1st at midnight and ending at approximately 365.958 for December 31st at 23:00 in a non-leap year (or 366.958 in a leap year).

Usage

```
fractional_day_of_year(datetime)
```

Arguments

`datetime`	A POSIXct object or vector of POSIXct objects representing date-time values. Must have a timezone attribute.

Details

The function computes the time difference in hours between the input datetime and midnight on January 1st of the same year, then divides by 24 to obtain fractional days. The calculation accounts for leap years automatically.

Value

A numeric vector of the same length as `datetime`, containing fractional day of year values. January 1st at midnight corresponds to 0, and each hour adds approximately 0.04167 (1/24) to the value.

Examples

```
dates <- seq(
  from = as.POSIXct("2024-01-01 00:00:00", tz = "UTC"),
  to = as.POSIXct("2024-01-02 00:00:00", tz = "UTC"),
  by = "6 hours"
)
fractional_day_of_year(dates) # Returns 0.00, 0.25, 0.50, 0.75, 1.00

# End of year
dt_end <- as.POSIXct("2024-12-31 23:00:00", tz = "UTC")
fractional_day_of_year(dt_end) # Returns ~365.958
```

get_1d_spectrum *Download the 1D spectrum data from IFREMER ftp*

Description

Download the 1D spectrum data from IFREMER ftp

Usage

```
get_1d_spectrum(point, start = "1994-01-01", end = "1994-02-28")
```

Arguments

point	the location name (string) requested. Alternatively, the node number. The consistency is checked internally.
start	the starting date (as a string). The consistency is checked internally.
end	the ending date as a string

Value

A list with 12 elements:

longitude Longitude

latitude Latitude

frequency1 Lower frequency

frequency2 Upper frequency

ef Surface elevation variance spectral density

th1m Mean direction from first spectral moment

th2m Mean direction from second spectral moment

sth1m Mean directional spreading from first spectral moment

sth2m Mean directional spreading from second spectral moment

freq Central frequency

forcings A data.frame with 14 variables:

- **time** Time
- **dpt** Depth, positive downward
- **wnd** Wind intensity, at 10m above sea level
- **wnddir** Wind direction, comes from
- **cur** Current intensity, at the surface
- **curdir** Current direction, going to
- **hs** Significant wave height
- **fp** Peak wave frequency
- **f02** Mean wave frequency

f0m1 Mean wave frequency at spectral moment minus one
th1p Mean wave direction at spectral peak
sth1p Directional spreading at spectral peak
dir Mean wave direction
spr Mean directional spreading

station Station name

Examples

```
spec1D <- get_1d_spectrum("SEMREVO", start = "1994-01-01", end = "1994-02-28")
r <- as.POSIXct(round(range(spec1D$forcings$time), "month"))
image(spec1D$forcings$time, spec1D$freq, t(spec1D$ef),
  xaxt = "n", xlab = "Time",
  ylab = "Frequency (Hz)"
)
axis.POSIXct(1, spec1D$forcings$time,
  at = seq(r[1], r[2], by = "week"),
  format = "%Y-%m-%d", las = 2
)
```

---

get_2d_spectrum *Download the 2D spectrum data from IFREMER ftp*

Description

Download the 2D spectrum data from IFREMER ftp

Usage

```
get_2d_spectrum(point, start = "1994-01-01", end = "1994-02-28")
```

Arguments

point	the location name (string) requested. Alternatively, the node number. The consistency is checked internally.
start	the starting date (as a string). The consistency is checked internally.
end	the ending date as a string

Value

A list with 9 elements:

longitude Longitude

latitude Latitude

frequency1 Lower frequency

frequency2 Upper frequency

ef Surface elevation variance spectral density

th1m Mean direction from first spectral moment

th2m Mean direction from second spectral moment

sth1m Mean directional spreading from first spectral moment

sth2m Mean directional spreading from second spectral moment

freq Central frequency

dir Directionnal bins

forcings A data.frame with 6 variables:

- **time** Time
- **dpt** Depth, positive downward
- **wnd** Wind intensity, at 10m above sea level
- **wnddir** Wind direction, comes from
- **cur** Current intensity, at the surface
- **curdir** Current direction, going to

station Station name

Examples

```
spec2D <- get_2d_spectrum("SEMREVO", start = "1994-01-01", end = "1994-02-28")
image(spec2D$dir, spec2D$freq, spec2D$efth[, , 1],
  xlab = "Direction (°)",
  ylab = "Frequency (Hz"
)
```

`get_parameters` *Download time series of sea-state parameters from RESOURCE-CODE database*

Description

If the remote resource is unavailable or returns an error, the function returns NULL and emits an informative message.

Usage

```
get_parameters(
  parameters = "hs",
  node = 42,
  start = as.POSIXct("1994-01-01 00:00:00", tz = "UTC"),
  end = as.POSIXct("1994-12-31 23:00:00", tz = "UTC")
)
```

Arguments

`parameters`	character vector of sea-state parameters
`node`	single integer with the node to get
`start`	starting date (as integer, character or posixct)
`end`	ending date (as integer, character or posixct)

Value

a tibble with N-rows and `length(parameters)` columns.

Examples

```
ts <- get_parameters(parameters = c("hs", "tp"), node = 42)
plot(ts$time, ts$hs, type = "l")
```

`jonswap` *JONWSAP spectrum*

Description

Creates a JONWSAP density spectrum (one-sided), defined by its integral parameters.

Usage

```
jonswap(hs = 5, tp = 15, fmax = rscd_freq, df = NULL, gam = 3.3)
```

Arguments

`hs`	Hs (default: 5m)
`tp`	Period (default: 10s)
`fmax`	higher frequency of the spectrum or vector of frequencies (default to resource-code frequency vector)
`df`	frequency step (unused if fmax=vector of frequencies)
`gam`	peak enhancement factor (default: 3.3)

Details

Reference :

- O.G.Houmb and T.Overvik, "Parametrization of Wave Spectra and Long Term Joint Distribution of Wave Height and Period," in Proceedings, First International Conference on Behaviour of Offshore Structures (BOSS), Trondheim 1976. 23rd International Towing Tank Conference, vol. II, pp. 544-551
- ITTC Committee, 2002, "The Specialist Committee on Waves - Final Report and Recommendations to the 23rd ITTC", Proc. ITTC, vol. II, pp. 505-736.

Value

Density spectrum with corresponding parameters

Examples

```
S1 <- jonswap(tp = 15)
S2 <- jonswap(tp = 15, fmax = 0.95, df = 0.003)
plot(S1, type = "l", ylim = c(0, 72))
lines(S2, col = "red")
abline(v = 1 / 15)
```

---

mean_direction *Mean Direction*

Description

Function for computing the (weighted) arithmetic mean of directional data in **meteorological convention**.

Usage

```
mean_direction(directions, weights = NULL)
```

Arguments

directions	numeric vector of directions, in degree, 0° being the North
weights	numeric vector, usually wind speed of wave height.

Value

The (weighted) mean of the values in `directions` is computed.

Examples

```
# Test with some wind directions (unweighted)
wind_directions <- c(10, 20, 350, 5, 15) # Directions mostly around North
mean_dir <- mean_direction(wind_directions)
cat("Mean wind direction (unweighted):", round(mean_dir, 1), "degrees\n")
wind_directions <- c(350, 10, 20, 340, 30) # Directions around North
wind_speeds <- c(15, 5, 2, 12, 3) # Higher speeds for directions closer to North
mean_dir_weighted <- mean_direction(wind_directions, wind_speeds)
cat("Mean wind direction (weighted):", round(mean_dir_weighted, 1), "degrees\n")

# Compare weighted vs unweighted for the same data
mean_dir_unweighted <- mean_direction(wind_directions)
cat("Same data unweighted:", round(mean_dir_unweighted, 1), "degrees\n")
```

metconv2zmcomp	*Convert meteorological wind speed and direction to u/v components*

Description

Converts wind speed (magnitude) and direction (in degrees, meteorological convention: direction from which the wind blows, measured clockwise from north) into zonal (u) and meridional (v) components.

Usage

```
metconv2zmcomp(speed, direction, names = c("uwnd", "vwnd"))
```

Arguments

`speed`	Numeric vector of wind speeds.
`direction`	Numeric vector of wind directions in degrees (0° = from north, 90° = from east, 180° = from south, 270° = from west).
`names`	(optional) ames to construct the resulting data.frame.

Value

A data.frame with two columns:

- **u** Zonal wind component (m/s), positive eastward.
- **v** Meridional wind component (m/s), positive northward.

Examples

```
# Example 1: North wind of 10 m/s (blowing southward)
metconv2zmcomp(10, 0)

# Example 2: East wind of 5 m/s (blowing westward)
metconv2zmcomp(5, 90)

# Example 3: South wind of 8 m/s (blowing northward)
metconv2zmcomp(8, 180)
```

plot_1d_specta *Plot a wave density 1D spectrum at a given time*

Description

Plot a wave density 1D spectrum at a given time

Usage

```
plot_1d_specta(spec, time = 1L, print_sea_state = TRUE, ...)
```

Arguments

`spec`	the spectral data, as an output from `get_2Dspectrum`
`time`	the time to plot. Either an integer or the date.
`print_sea_state`	should the sea_states parameters being plot ? Default to TRUE.
`...`	currently unused

Value

a ggplot object

Examples

```
plot_1d_specta(resourcecodedata::rscd_1d_spectra, 1)
```

plot_2d_specta *Plot a wave density 2D spectrum*

Description

Plot a wave density 2D spectrum

Usage

```
plot_2d_specta(
  spec,
  time = 1L,
  normalize = TRUE,
  trim = 0.01,
  cut_off = 0.4,
  ...
)
```

Arguments

spec	the spectral data, as an output from get_2Dspectrum
time	the time to plot. Either an integer or the date.
normalize	Should the spectrum be normalized to have maximum 1 before plotting
trim	removes the values of the spectral density lower than this value
cut_off	cut-off frequency above which the spectrum is not plotted
...	currently unused

Value

a ggplot object

Examples

```
plot_2d_specta(resourcecodedata::rscd_2d_spectra, 1)
```

---

rscd_data_example *Resourcecode data extract*

Description

An extract of the Resourcecode Hindcast database, at node 123456, spanning from 1994-01-01 00:00:00 to 1999-12-31 23:00:00.

Usage

```
rscd_data_example
```

Format

A data frame with 87,648 rows and 7 variables::

time POSIXct. Timestamp in UTC (hourly resolution).

hs numeric. Significant wave height (m).

tp numeric. Peak wave period (s).

dp numeric. Mean wave direction (degrees, coming from true North, clockwise).

uwnd numeric. Zonal (east–west) component of the 10-m wind (m/s). Positive eastward.

vwnd numeric. Meridional (north–south) component of the 10-m wind (m/s). Positive northward.

dpt numeric.Depth (m).

Source

User Manual of the RESOURCECODE database https://archimer.ifremer.fr/doc/00751/86306/

---

rscd_dir *Resourcecode directional bins*

Description

(equivalent to a directional resolution of 10°;

Usage

```
rscd_dir
```

Format

`rscd_dir`: An array of length 36 with the directionnal bins

Source

User Manual of the RESOURCECODE database https://archimer.ifremer.fr/doc/00751/86306/

---

rscd_freq *Resourcecode frequency vector of 1D and 2D spectra*

Description

The wave spectrum discretization considers 36 frequencies, starting from 0.0339 Hz up to 0.9526 Hz with a frequency increment factor of 1.1

Usage

```
rscd_freq
```

Format

`rscd_freq`: An array 36 elements with the frequencies values

Source

User Manual of the RESOURCECODE database https://archimer.ifremer.fr/doc/00751/86306/

rscd_mapplot *Create a map of the provided variable on the RESOURCECODE field grid*

Description

Create a map of the provided variable on the RESOURCECODE field grid

Usage

```
rscd_mapplot(
  z,
  name = "Depth (m)",
  zlim = NULL,
  palette = "YlOrRd",
  direction = 1,
  transform = "identity"
)
```

Arguments

z	the data ro plot: a vector of the same size as the grid (328,030 rows).
name	name of the variable plored, to be included in the legend.
zlim	limits of the scale. See continuous_scale for details.
palette	If a string, will use that named palette. See scale_colour_brewer for other options.
direction	Sets the order of colours in the scale. See scale_colour_brewer for details.
transform	Transformation to apply to the color scale. See continuous_scale for details.

Value

a ggplot2 object

Examples

```
rscd_mapplot(resourcecodedata::rscd_field$depth)
```

weather_windows — *Compute Weather Windows*

Description

Computes and returns start date of each weather window, implemented in C++ for speed.

Usage

```
weather_windows(
  valid_periods,
  window_length,
  allow_overlap = TRUE,
  time_step = 3600
)
```

Arguments

valid_periods	A data frame with a 'time' column (POSIXct).
window_length	Minimum window duration (hours).
allow_overlap	Logical; If TRUE, the algorithm searches for window, if a window is found, search of next window will start from the end of the previous window. If FALSE, it uses continuous window search: The algorithm searches for window starting from every time step that meets the criteria.
time_step	Expected time step between consecutive timestamps (seconds).

Value

POSIXct vector of detected window start times.

zmcomp2metconv — *Convert u/v to meteorological wind speed and direction*

Description

Converts wind or current zonal and meridional velocity components to magnitude and direction according to meteorological convention.

Usage

```
zmcomp2metconv(u, v = NULL, names = c("wspd", "wdir"))
```

Arguments

`u`	zonal velocity (1D vector) or matrix with zonal and meridional velocity (Nx2 matrix)
`v`	meridional velocity (1D vector)
`names`	names to construct the resulting data.frame

Value

a Nx2 data.frame with the norm and direction (meteorological convention)

Examples

```
u <- matrix(rnorm(200), nrow = 100, ncol = 2)
vdir <- zmcomp2metconv(u)
```

`%nin%` *Value Matching*

Description

Value Matching

Usage

```
x %nin% table
```

Arguments

`x`	value to search
`table`	table of values

Value

the opposite of x %in% table

Examples

```
1:10 %in% c(1, 3, 5, 9)
1:10 %nin% c(1, 3, 5, 9)
```

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