

# Package: meteoland (via r-universe)

October 18, 2024

**Type** Package

**Title** Landscape Meteorology Tools

**Version** 2.2.2

**Date** 2024-10-17

**Description** Functions to estimate weather variables at any position of a landscape [De Cáceres et al. (2018) <[doi:10.1016/j.envsoft.2018.08.003](https://doi.org/10.1016/j.envsoft.2018.08.003)>].

**License** GPL (>= 2)

**URL** <https://emf-creaf.github.io/meteoland/>,  
<https://github.com/emf-creaf/meteoland>

**BugReports** <https://github.com/emf-creaf/meteoland/issues>

**LazyData** TRUE

**Depends** R (>= 3.5.0)

**Imports** methods, sf, stars, stats, Rcpp, units, lifecycle, cli, dplyr, tidy, rlang, assertthat, purrr, ncdgeom, nmeta, lubridate, cubelyr

**Suggests** knitr, rmarkdown, testthat (>= 3.0.0), meteospain, worldmet, tibble

**LinkingTo** Rcpp

**Encoding** UTF-8

**NeedsCompilation** yes

**VignetteBuilder** knitr

**RoxygenNote** 7.3.2

**Config/testthat/edition** 3

**Config/testthat/parallel** true

**Author** Miquel De Cáceres [aut, cre]

(<<https://orcid.org/0000-0001-7132-2080>>), Víctor Granda [aut]

(<<https://orcid.org/0000-0002-0469-1991>>), Nicolas Martin [aut]

(<<https://orcid.org/0000-0001-7574-0108>>), Antoine Cabon [aut]

(<<https://orcid.org/0000-0001-6426-1726>>)

**Maintainer** Miquel De Cáceres <miquelcaceres@gmail.com>

**Repository** CRAN

**Date/Publication** 2024-10-17 17:30:02 UTC

## Contents

add_topo . . . . .	2
complete_meteo . . . . .	3
create_meteo_interpolator . . . . .	5
defaultInterpolationParams . . . . .	6
get_interpolation_params . . . . .	7
humidity_relative2dewtemperature . . . . .	8
interpolate_data . . . . .	9
interpolation_cross_validation . . . . .	11
interpolation_precipitation . . . . .	14
meteoland_interpolator_example . . . . .	18
meteoland_meteo_example . . . . .	19
meteoland_meteo_no_topo_example . . . . .	19
meteoland_topo_example . . . . .	20
meteospain2meteoland . . . . .	20
penman . . . . .	21
points_to_interpolate_example . . . . .	23
precipitation_concentration . . . . .	23
precipitation_rainfall_erosivity . . . . .	24
radiation_julianDay . . . . .	25
raster_to_interpolate_example . . . . .	29
read_interpolator . . . . .	30
set_interpolation_params . . . . .	31
summarise_interpolated_data . . . . .	32
summarise_interpolator . . . . .	34
utils_saturationVP . . . . .	36
with_meteo . . . . .	37
worldmet2meteoland . . . . .	38
write_interpolator . . . . .	39

<b>Index</b>	<b>41</b>
--------------	-----------

---

add_topo	<i>Add topography data to meteo object</i>
----------	--

---

### Description

Add topography data to meteo object

### Usage

```
add_topo(meteo, topo, verbose = getOption("meteoland_verbosity", TRUE))
```

**Arguments**

meteo	meteo object
topo	topo object
verbose	Logical indicating if the function must show messages and info. Default value checks "meteoland_verbosity" option and if not set, defaults to TRUE. It can be turned off for the function with FALSE, or session wide with options(meteoland_verbosity = FALSE)

**Details**

When using meteo data without topography info to create an interpolator, topography must be added

**Value**

meteo with the topography info added

**See Also**

Other interpolator functions: [create\\_meteo\\_interpolator\(\)](#), [get\\_interpolation\\_params\(\)](#), [read\\_interpolator\(\)](#), [set\\_interpolation\\_params\(\)](#), [with\\_meteo\(\)](#), [write\\_interpolator\(\)](#)

**Examples**

```
# example meteo
data(meteoland_meteo_no_topo_example)
# example topo
data(meteoland_topo_example)
# add topo
with_meteo(meteoland_meteo_no_topo_example) |>
  add_topo(meteoland_topo_example)
```

---

complete\_meteo

*Complete missing meteo variables*

---

**Description**

Calculates missing values of relative humidity, radiation and potential evapotranspiration from a data frame with daily values of minimum/maximum/mean temperature and precipitation. The function takes a meteo object (with meteoland names) and complete any missing variable if it is possible

**Usage**

```
complete_meteo(meteo, verbose = getOption("meteoland_verbosity", TRUE))
```

**Arguments**

meteo	meteoland weather data
verbose	Logical indicating if the function must show messages and info. Default value checks "meteoland_verbosity" option and if not set, defaults to TRUE. It can be turned off for the function with FALSE, or session wide with options(meteoland_verbosity = FALSE)

**Details**

#' The function fills values for humidity, radiation and PET only if they are missing in the input data frame. If a column 'SpecificHumidity' is present in the input data, relative humidity is calculated from it. Otherwise, relative humidity is calculated assuming that dew point temperature equals the minimum temperature. Potential solar radiation is calculated from latitude, slope and aspect. Incoming solar radiation is then corrected following Thornton & Running (1999) and potential evapotranspiration following Penman (1948).

**Value**

the same meteo data provided with the the variables completed

**Author(s)**

Miquel De Cáceres Ainsa, EMF-CREAF

Victor Granda García, EMF-CREAF

**References**

Thornton, P.E., Running, S.W., 1999. An improved algorithm for estimating incident daily solar radiation from measurements of temperature, humidity, and precipitation. *Agric. For. Meteorol.* 93, 211-228.

Penman, H. L. 1948. Natural evaporation from open water, bare soil and grass. *Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences*, 193, 120-145.

**Examples**

```
# example data
data("meteoland_meteo_example")

# remove MinRelativeHumidity
meteoland_meteo_example$MinRelativeHumidity <- NULL
# complete vars
completed_meteo <- complete_meteo(meteoland_meteo_example)
# check MinRelativeHumidity
completed_meteo$MinRelativeHumidity
```

---

`create_meteo_interpolator`*Meteoland interpolator creation*

---

## Description

Function to create the meteoland interpolator

## Usage

```
create_meteo_interpolator(  
  meteo_with_topo,  
  params = NULL,  
  verbose = getOption("meteoland_verbosity", TRUE)  
)
```

## Arguments

<code>meteo_with_topo</code>	Meteo object, as returned by <a href="#">with_meteo</a>
<code>params</code>	Interpolation parameters as a list. Typically the result of <a href="#">defaultInterpolationParams</a> .
<code>verbose</code>	Logical indicating if the function must show messages and info. Default value checks "meteoland_verbosity" option and if not set, defaults to TRUE. It can be turned off for the function with FALSE, or session wide with <code>options(meteoland_verbosity = FALSE)</code>

## Details

This function takes meteorology information and a list of interpolation parameters and creates the interpolator object to be ready to use.

## Value

an interpolator object (stars)

## Author(s)

Victor Granda García, EMF-CREAF

Miquel De Cáceres Ainsa, EMF-CREAF

## See Also

Other interpolator functions: [add\\_topo\(\)](#), [get\\_interpolation\\_params\(\)](#), [read\\_interpolator\(\)](#), [set\\_interpolation\\_params\(\)](#), [with\\_meteo\(\)](#), [write\\_interpolator\(\)](#)

**Examples**

```
# example meteo data
data(meteoland_meteo_example)

# create the interpolator with default params
with_meteo(meteoland_meteo_example) |>
  create_meteo_interpolator()

# create the interpolator with some params changed
with_meteo(meteoland_meteo_example) |>
  create_meteo_interpolator(params = list(debug = TRUE))
```

---

defaultInterpolationParams

*Default interpolation parameters*

---

**Description**

Returns a list with the default parameterization for interpolation. Most parameter values are set according to Thornton et al. (1997).

**Usage**

```
defaultInterpolationParams()
```

**Value**

A list with the following items (default values in brackets):

- `initial_Rp [= 140000]`: Initial truncation radius.
- `iterations [= 3]`: Number of station density iterations.
- `alpha_MinTemperature [= 3.0]`: Gaussian shape parameter for minimum temperature.
- `alpha_MaxTemperature [= 3.0]`: Gaussian shape parameter for maximum temperature.
- `alpha_DewTemperature [= 3.0]`: Gaussian shape parameter for dew-point temperature.
- `alpha_PrecipitationEvent [= 5.0]`: Gaussian shape parameter for precipitation events.
- `alpha_PrecipitationAmount [= 5.0]`: Gaussian shape parameter for the regression of precipitation amounts.
- `alpha_Wind [= 3.0]`: Gaussian shape parameter for wind.
- `N_MinTemperature [= 30]`: Average number of stations with non-zero weights for minimum temperature.
- `N_MaxTemperature [= 30]`: Average number of stations with non-zero weights for maximum temperature.
- `N_DewTemperature [= 30]`: Average number of stations with non-zero weights for dew-point temperature.

- N\_PrecipitationEvent [= 5]: Average number of stations with non-zero weights for precipitation events.
- N\_PrecipitationAmount [= 20]: Average number of stations with non-zero weights for the regression of precipitation amounts.
- N\_Wind [= 2]: Average number of stations with non-zero weights for wind.
- St\_Precipitation [= 5]: Number of days for the temporal smoothing of precipitation.
- St\_TemperatureRange [= 15]: Number of days for the temporal smoothing of temperature range.
- pop\_crit [= 0.50]: Critical precipitation occurrence parameter.
- f\_max [= 0.6]: Maximum value for precipitation regression extrapolations (0.6 equals to a maximum of 4 times extrapolation).
- wind\_height [= 10]: Wind measurement height (in m).
- wind\_roughness\_height [= 0.001]: Wind roughness height (in m), for PET calculations.
- penman\_albedo [= 0.25]: Albedo for PET calculations.
- penman\_windfun [= "1956"]: Wind speed function version, either "1948" or "1956", for PET calculation.
- debug [= FALSE]: Boolean flag to show extra console output.

**Author(s)**

Miquel De Cáceres Ainsa, CREAM

**References**

Thornton, P.E., Running, S.W., White, M. A., 1997. Generating surfaces of daily meteorological variables over large regions of complex terrain. *J. Hydrol.* 190, 214–251. doi:10.1016/S0022-1694(96)03128-9.

De Cáceres M, Martin-StPaul N, Turco M, Cabon A, Granda V (2018) Estimating daily meteorological data and downscaling climate models over landscapes. *Environmental Modelling and Software* 108: 186-196.

**See Also**

[interpolate\\_data](#)

---

get\_interpolation\_params

*Retrieving interpolation parameters from interpolator object*

---

**Description**

Retrieve the parameter list from and interpolator object

**Usage**

```
get_interpolation_params(interpolator)
```

**Arguments**

interpolator    interpolator object as returned by [create\\_meteo\\_interpolator](#)

**Value**

The complete parameter list from the interpolator object

**Author(s)**

Victor Granda García, EMF-CREAF

**See Also**

Other interpolator functions: [add\\_topo\(\)](#), [create\\_meteo\\_interpolator\(\)](#), [read\\_interpolator\(\)](#), [set\\_interpolation\\_params\(\)](#), [with\\_meteo\(\)](#), [write\\_interpolator\(\)](#)

**Examples**

```
# example interpolator
data(meteoland_interpolator_example)
# get the params from the interpolator
get_interpolation_params(meteoland_interpolator_example)
```

---

humidity\_relative2dewtemperature

*Humidity conversion tools*

---

**Description**

Functions to transform relative humidity to specific humidity or dew point temperature and viceversa.

**Usage**

```
humidity_relative2dewtemperature(Tc, HR)
```

```
humidity_dewtemperature2relative(Tc, Td, allowSaturated = FALSE)
```

```
humidity_specific2relative(Tc, HS, allowSaturated = FALSE)
```

```
humidity_relative2specific(Tc, HR)
```

**Arguments**

Tc	A numeric vector of temperature in degrees Celsius.
HR	A numeric vector of relative humidity (in %).
Td	A numeric vector of dew temperature in degrees Celsius.
allowSaturated	Logical flag to allow values over 100%
HS	A numeric vector of specific humidity (unitless).

**Value**

A numeric vector with specific or relative humidity.

**Author(s)**

Nicholas Martin-StPaul, INRA  
Miquel De Cáceres Ainsa, CREAM

**See Also**

[complete\\_meteo](#)

---

interpolate\_data      *Interpolation process for spatial data*

---

**Description**

Interpolate spatial data to obtain downscaled meteorologic variables

**Usage**

```
interpolate_data(
  spatial_data,
  interpolator,
  dates = NULL,
  variables = NULL,
  ignore_convex_hull_check = FALSE,
  verbose = getOption("meteoland_verbosity", TRUE)
)
```

**Arguments**

spatial_data	An sf or stars raster object to interpolate
interpolator	A meteoland interpolator object, as created by <a href="#">create_meteo_interpolator</a>
dates	vector with dates to interpolate (must be within the interpolator date range). Default to NULL (all dates present in the interpolator object)

variables	vector with variable names to be interpolated. NULL (default), will interpolate all variables. Accepted names are "Temperature", "Precipitation", "RelativeHumidity", "Radiation" and "Wind"
ignore_convex_hull_check	Logical indicating whether errors in convex hull checks should be ignored. Checking for points to be inside the convex hull will normally raise an error if >10% of points are outside. Setting ignore_convex_hull_check = TRUE means that a warning is raised but interpolation is performed, which can be useful to users interpolating on a few points close but outside of the convex hull.
verbose	Logical indicating if the function must show messages and info. Default value checks "meteoland_verbosity" option and if not set, defaults to TRUE. It can be turned off for the function with FALSE, or session wide with options(meteoland_verbosity = FALSE)

### Details

This function takes a spatial data object (sf or stars raster), an interpolator object ([create\\_meteo\\_interpolator](#)) and a vector of dates to perform the interpolation of the meteorologic variables for the spatial locations present in the spatial\_data object.

### Value

an object with the same class and structure as the provided spatial data with the results of the interpolation joined. In the case of spatial data being an sf, the results are added as a list-type column that can be unnested with [unnest](#). In the case of a stars raster object, interpolation results are added as attributes (variables)

### Spatial data

The spatial data provided must be of two types. (I) A sf object containing POINT for each location to interpolate or (II) a stars raster object for which the interpolation should be done. Independently of the class of spatial\_data it has to have some mandatory variables, namely elevation. It should also contain aspect and slope for a better interpolation process, though this two variables are not mandatory.

### Author(s)

Victor Granda García, EMF-CREAF  
Miquel De Cáceres Ainsa, EMF-CREAF

### Examples

```
# example of data to interpolate and example interpolator
data("points_to_interpolate_example")
data("meteoland_interpolator_example")

# interpolate data
res <- interpolate_data(points_to_interpolate_example, meteoland_interpolator_example)
```

```

# check result
# same class as input data
class(res)
# data
res
# results for the first location
res[["interpolated_data"]][1]
# unnest results
tidyr::unnest(res, cols = "interpolated_data")

```

---

interpolation\_cross\_validation

*Calibration and validation of interpolation procedures*

---

### Description

Calibration and validation of interpolation procedures

### Usage

```

interpolation_cross_validation(
  interpolator,
  stations = NULL,
  verbose = getOption("meteoland_verbosity", TRUE)
)

```

```

interpolator_calibration(
  interpolator,
  stations = NULL,
  update_interpolation_params = FALSE,
  variable = "MinTemperature",
  N_seq = seq(5, 30, by = 5),
  alpha_seq = seq(0.25, 10, by = 0.25),
  verbose = getOption("meteoland_verbosity", TRUE)
)

```

### Arguments

interpolator	A meteoland interpolator object, as created by <a href="#">create_meteo_interpolator</a>
stations	A vector with the stations (numeric for station indexes or character for stations id) to be used to calculate "MAE". All stations with data are included in the training set but predictive "MAE" are calculated for the stations subset indicated in stations param only. If NULL all stations are used in the predictive "MAE" calculation.

verbose	Logical indicating if the function must show messages and info. Default value checks "meteoland_verbosity" option and if not set, defaults to TRUE. It can be turned off for the function with FALSE, or session wide with options(meteoland_verbosity = FALSE)
update_interpolation_params	Logical indicating if the interpolator object must be updated with the calculated parameters. Default to FALSE
variable	A string indicating the meteorological variable for which interpolation parameters "N" and "alpha" will be calibrated. Accepted values are: <ul style="list-style-type: none"> <li>• MinTemperature (kernel for minimum temperature)</li> <li>• MaxTemperature (kernel for maximum temperature)</li> <li>• DewTemperature (kernel for dew-temperature (i.e. relative humidity))</li> <li>• Precipitation (to calibrate the same kernel for both precipitation events and regression of precipitation amounts; not recommended)</li> <li>• PrecipitationAmount (kernel for regression of precipitation amounts)</li> <li>• PrecipitationEvent (kernel for precipitation events)</li> </ul>
N_seq	Numeric vector with "N" values to be tested
alpha_seq	Numeric vector with "alpha"

### Details

Function `interpolator_calibration` determines optimal interpolation parameters "N" and "alpha" for a given meteorological variable. Optimization is done by minimizing mean absolute error ("MAE") (Thornton *et al.* 1997). Function `interpolation_cross_validation` calculates average mean absolute errors ("MAE") for the prediction period of the interpolator object. In both calibration and cross validation procedures, predictions for each meteorological station are made using a *leave-one-out* procedure (i.e. after excluding the station from the predictive set).

### Value

`interpolation_cross_validation` returns a list with the following items

- `errors`: Data frame with each combination of station and date with observed variables, predicted variables and the total error (predicted - observed) calculated for each variable
- `station_stats`: Data frame with error and bias statistics aggregated by station
- `dates_stats`: Data frame with error and bias statistics aggregated by date
- `r2`: correlation indexes between observed and predicted values for each meteorological variable

If `update_interpolation_params` is FALSE (default), `interpolator_calibration` returns a list with the following items

- `MAE`: A numeric matrix with the mean absolute error values, averaged across stations, for each combination of parameters "N" and "alpha"
- `minMAE`: Minimum MAE value
- `N`: Value of parameter "N" corresponding to the minimum MAE

- alpha: Value of parameter "alpha" corresponding the the minimum MAE
- observed: matrix with observed values (meteorological measured values)
- predicted: matrix with interpolated values for the optimum parameter combination

If `update_interpolation_params` is `FALSE`, `interpolator_calibration` returns the interpolator provided with the parameters updated

## Functions

- `interpolation_cross_validation()`:

## Author(s)

Miquel De Cáceres Ainsa, EMF-CREAF

Victor Granda García, EMF-CREAF

## References

Thornton, P.E., Running, S.W., 1999. An improved algorithm for estimating incident daily solar radiation from measurements of temperature, humidity, and precipitation. *Agric. For. Meteorol.* 93, 211–228. doi:10.1016/S0168-1923(98)00126-9.

De Cáceres M, Martin-StPaul N, Turco M, Cabon A, Granda V (2018) Estimating daily meteorological data and downscaling climate models over landscapes. *Environmental Modelling and Software* 108: 186-196.

## Examples

```
# example interpolator
data("meteoland_interpolator_example")

# As the cross validation for all stations can be time consuming, we are
# gonna use only for the first 5 stations of the 198
cv <- interpolation_cross_validation(meteoland_interpolator_example, stations = 1:5)

# Inspect the results
cv$errors
cv$station_stats
cv$dates_stats
cv$r2

# example interpolator
data("meteoland_interpolator_example")

# As the calibration for all stations can be time consuming, we are gonna
# interpolate only for the first 5 stations of the 198 and only a handful
# of parameter combinations
```

```
calibration <- interpolator_calibration(  
  meteoland_interpolator_example,  
  stations = 1:5,  
  variable = "MaxTemperature",  
  N_seq = seq(10, 20, by = 5),  
  alpha_seq = seq(8, 9, by = 0.25)  
)  
  
# we can update the interpolator params directly:  
updated_interpolator <- interpolator_calibration(  
  meteoland_interpolator_example,  
  stations = 1:5,  
  update_interpolation_params = TRUE,  
  variable = "MaxTemperature",  
  N_seq = seq(10, 20, by = 5),  
  alpha_seq = seq(8, 9, by = 0.25)  
)  
  
# check the new interpolator have the parameters updated  
get_interpolation_params(updated_interpolator)$N_MaxTemperature  
get_interpolation_params(updated_interpolator)$alpha_MaxTemperature
```

---

interpolation\_precipitation

*Low-level interpolation functions*

---

## Description

Low-level functions to interpolate meteorology (one day) on a set of points.

## Usage

```
interpolation_precipitation(  
  Xp,  
  Yp,  
  Zp,  
  X,  
  Y,  
  Z,  
  P,  
  Psmooth,  
  iniRp = 140000,  
  alpha_event = 6.25,  
  alpha_amount = 6.25,  
  N_event = 20L,  
  N_amount = 20L,
```

```
    iterations = 3L,  
    popcrit = 0.5,  
    fmax = 0.95,  
    debug = FALSE  
)  
  
interpolation_dewtemperature(  
  Xp,  
  Yp,  
  Zp,  
  X,  
  Y,  
  Z,  
  T,  
  iniRp = 140000,  
  alpha = 3,  
  N = 30L,  
  iterations = 3L,  
  debug = FALSE  
)  
  
interpolation_temperature(  
  Xp,  
  Yp,  
  Zp,  
  X,  
  Y,  
  Z,  
  T,  
  iniRp = 140000,  
  alpha = 3,  
  N = 30L,  
  iterations = 3L,  
  debug = FALSE  
)  
  
interpolation_wind(  
  Xp,  
  Yp,  
  WS,  
  WD,  
  X,  
  Y,  
  iniRp = 140000,  
  alpha = 2,  
  N = 1L,  
  iterations = 3L,  
  directionsAvailable = TRUE
```

)

**Arguments**

Xp, Yp, Zp	Spatial coordinates and elevation (Zp; in m.a.s.l) of target points.
X, Y, Z	Spatial coordinates and elevation (Zp; in m.a.s.l) of reference locations (e.g. meteorological stations).
P	Precipitation at the reference locations (in mm).
Psmooth	Temporally-smoothed precipitation at the reference locations (in mm).
iniRp	Initial truncation radius.
iterations	Number of station density iterations.
popcrit	Critical precipitation occurrence parameter.
fmax	Maximum value for precipitation regression extrapolations (0.6 equals to a maximum of 4 times extrapolation).
debug	Boolean flag to show extra console output.
T	Temperature (e.g., minimum, maximum or dew temperature) at the reference locations (in degrees).
alpha, alpha_amount, alpha_event	Gaussian shape parameter.
N, N_event, N_amount	Average number of stations with non-zero weights.
WS, WD	Wind speed (in m/s) and wind direction (in degrees from north clock-wise) at the reference locations.
directionsAvailable	A flag to indicate that wind directions are available (i.e. non-missing) at the reference locations.

**Details**

This functions exposes internal low-level interpolation functions written in C++ not intended to be used directly in any script or function. The are maintained for compatibility with older versions of the package and future versions of meteoland will remove this functions (they will be still accessible through the triple colon notation (: : :), but their use is not recommended)

**Value**

All functions return a vector with interpolated values for the target points.

**Functions**

- interpolation\_precipitation(): Precipitation
- interpolation\_dewtemperature(): Dew temperature
- interpolation\_wind(): Wind

**Author(s)**

Miquel De Cáceres Ainsa, CREAM

**References**

Thornton, P.E., Running, S.W., White, M. A., 1997. Generating surfaces of daily meteorological variables over large regions of complex terrain. *J. Hydrol.* 190, 214–251. doi:10.1016/S0022-1694(96)03128-9.

De Cáceres M, Martin-StPaul N, Turco M, Cabon A, Granda V (2018) Estimating daily meteorological data and downscaling climate models over landscapes. *Environmental Modelling and Software* 108: 186-196.

**See Also**

[defaultInterpolationParams](#)

**Examples**

```
Xp <- as.numeric(sf::st_coordinates(points_to_interpolate_example)[,1])
Yp <- as.numeric(sf::st_coordinates(points_to_interpolate_example)[,2])
Zp <- points_to_interpolate_example$elevation
X <- as.numeric(
  sf::st_coordinates(stars::st_get_dimension_values(meteoland_interpolator_example, "station"))[,1]
)
Y <- as.numeric(
  sf::st_coordinates(stars::st_get_dimension_values(meteoland_interpolator_example, "station"))[,2]
)
Z <- as.numeric(meteoland_interpolator_example[["elevation"]][1,])
Temp <- as.numeric(meteoland_interpolator_example[["MinTemperature"]][1,])
P <- as.numeric(meteoland_interpolator_example[["Precipitation"]][1,])
Psmooth <- as.numeric(meteoland_interpolator_example[["SmoothedPrecipitation"]][1,])
WS <- as.numeric(meteoland_interpolator_example[["WindSpeed"]][1,])
WD <- as.numeric(meteoland_interpolator_example[["WindDirection"]][1,])
iniRp <- get_interpolation_params(meteoland_interpolator_example)$initial_Rp
alpha <- get_interpolation_params(meteoland_interpolator_example)$alpha_MinTemperature
N <- get_interpolation_params(meteoland_interpolator_example)$N_MinTemperature
alpha_event <- get_interpolation_params(meteoland_interpolator_example)$alpha_PrecipitationEvent
N_event <- get_interpolation_params(meteoland_interpolator_example)$N_PrecipitationEvent
alpha_amount <- get_interpolation_params(meteoland_interpolator_example)$alpha_PrecipitationAmount
N_amount <- get_interpolation_params(meteoland_interpolator_example)$N_PrecipitationAmount
alpha_wind <- get_interpolation_params(meteoland_interpolator_example)$alpha_Wind
N_wind <- get_interpolation_params(meteoland_interpolator_example)$N_Wind
iterations <- get_interpolation_params(meteoland_interpolator_example)$iterations
popcrit <- get_interpolation_params(meteoland_interpolator_example)$pop_crit
fmax <- get_interpolation_params(meteoland_interpolator_example)$f_max
debug <- get_interpolation_params(meteoland_interpolator_example)$debug

interpolation_temperature(
  Xp, Yp, Zp,
  X[!is.na(Temp)], Y[!is.na(Temp)], Z[!is.na(Temp)],
  Temp[!is.na(Temp)],
```

```
    iniRp, alpha, N, iterations, debug
  )

  interpolation_wind(
    Xp, Yp,
    WS[!is.na(WD)], WD[!is.na(WD)],
    X[!is.na(WD)], Y[!is.na(WD)],
    iniRp, alpha_wind, N_wind, iterations, directionsAvailable = FALSE
  )

  interpolation_precipitation(
    Xp, Yp, Zp,
    X[!is.na(P)], Y[!is.na(P)], Z[!is.na(P)],
    P[!is.na(P)], Psmooth[!is.na(P)],
    iniRp, alpha_event, alpha_amount, N_event, N_amount,
    iterations, popcrit, fmax, debug
  )
```

---

meteoland\_interpolator\_example

*Example interpolator object*

---

## Description

### [Experimental]

Example interpolator with daily meteorological records from 189 weather stations in Catalonia (NE Spain) corresponding to April 2022.

## Format

stars data cube object

## Source

Spanish National Forest Inventory

## Examples

```
data(meteoland_interpolator_example)
```

---

meteoland\_meteo\_example

*Example data set for meteo data from weather stations*

---

### Description

#### [Experimental]

Example data set of spatial location, topography and daily meteorological records from 189 weather stations in Catalonia (NE Spain) corresponding to April 2022.

### Format

sf object

### Source

'Servei Meteorològic de Catalunya' (SMC)

### Examples

```
data(meteoland_meteo_example)
```

---

meteoland\_meteo\_no\_topo\_example

*Example data set for meteo data from weather stations, without topography*

---

### Description

#### [Experimental]

Example data set of spatial location and daily meteorological records from 189 weather stations in Catalonia (NE Spain) corresponding to April 2022.

### Format

sf object

### Source

'Servei Meteorològic de Catalunya' (SMC)

### Examples

```
data(meteoland_meteo_no_topo_example)
```

---

meteoland\_topo\_example

*Example data set for topography data from weather stations, without meteo*

---

### Description

#### [Experimental]

Example data set of spatial location and topography records from 189 weather stations in Catalonia (NE Spain).

### Format

sf object

### Source

'Servei Meteorològic de Catalunya' (SMC)

### Examples

```
data(meteoland_topo_example)
```

---

meteospain2meteoland *From meteospain to meteoland meteo objects*

---

### Description

Adapting meteospain meteo objects to meteoland meteo objects

### Usage

```
meteospain2meteoland(meteo, complete = FALSE)
```

### Arguments

meteo	meteospain meteo object.
complete	logical indicating if the meteo data missing variables should be calculated (if possible). Default to FALSE.

### Details

This function converts meteospain R package meteo objects to compatible meteoland meteo objects by selecting the needed variables and adapting the names to comply with meteoland requirements.

**Value**

a compatible meteo object to use with meteoland.

**Examples**

```
if (interactive()) {
  # meteospain data
  library(meteospain)
  mg_april_2022_data <- get_meteo_from(
    "meteogalicia",
    meteogalicia_options("daily", as.Date("2022-04-01"), as.Date("2022-04-30"))
  )

  # just convert
  meteospain2meteoland(mg_april_2022_data)
  # convert and complete
  meteospain2meteoland(mg_april_2022_data, complete = TRUE)
}
```

---

penman

*Potential evapotranspiration*

---

**Description**

Functions to calculate potential evapotranspiration using Penman or Penman-Monteith.

**Usage**

```
penman(
  latrad,
  elevation,
  slorad,
  asprad,
  J,
  Tmin,
  Tmax,
  RHmin,
  RHmax,
  R_s,
  u,
  z = 10,
  z0 = 0.001,
  alpha = 0.25,
  windfun = "1956"
)
```

```
penmanmonteith(rc, elevation, Tmin, Tmax, RHmin, RHmax, Rn, u = NA_real_)
```

**Arguments**

latrad	Latitude in radians.
elevation	Elevation (in m).
slorad	Slope (in radians).
asprad	Aspect (in radians from North).
J	Julian day, number of days since January 1, 4713 BCE at noon UTC.
Tmin	Minimum temperature (degrees Celsius).
Tmax	Maximum temperature (degrees Celsius).
RHmin	Minimum relative humidity (percent).
RHmax	Maximum relative humidity (percent).
R_s	Solar radiation (MJ/m <sup>2</sup> ).
u	With wind speed (m/s).
z	Wind measuring height (m).
z0	Roughness height (m).
alpha	Albedo.
windfun	Wind speed function version, either "1948" or "1956".
rc	Canopy vapour flux (stomatal) resistance (s·m <sup>-1</sup> ).
Rn	Daily net radiation (MJ·m <sup>-2</sup> ·day <sup>-1</sup> ).

**Details**

The code was adapted from package ‘Evapotranspiration’, which follows McMahon et al. (2013). If wind speed is not available, an alternative formulation for potential evapotranspiration is used as an approximation (Valiantzas 2006)

**Value**

Potential evapotranspiration (in mm of water).

**Functions**

- `penmanmonteith()`: Penman Monteith method

**Author(s)**

Miquel De Cáceres Ainsa, CREAM

**References**

- Penman, H. L. 1948. Natural evaporation from open water, bare soil and grass. Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences, 193, 120-145.
- Penman, H. L. 1956. Evaporation: An introductory survey. Netherlands Journal of Agricultural Science, 4, 9-29.
- McMahon, T.A., Peel, M.C., Lowe, L., Srikanthan, R., McVicar, T.R. 2013. Estimating actual, potential, reference crop and pan evaporation using standard meteorological data: a pragmatic synthesis. Hydrology & Earth System Sciences 17, 1331–1363. doi:10.5194/hess-17-1331-2013.

**See Also**

[interpolate\\_data](#)

---

points\_to\_interpolate\_example

*Example data set of points for interpolation of weather variables*

---

**Description**

**[Experimental]**

Example data set of spatial location and topography records from 15 experimental plots in Catalonia (NE Spain).

**Format**

sf object

**Source**

Spanish National Forest Inventory

**Examples**

```
data(points_to_interpolate_example)
```

---

precipitation\_concentration

*Precipitation daily concentration*

---

**Description**

Function `precipitation_concentration()` calculates daily precipitation concentration (Martin-Vide et al. 2004).

**Usage**

```
precipitation_concentration(p)
```

**Arguments**

`p` A numeric vector with daily precipitation values.

**Value**

Function `precipitation_concentration()` returns a value between 0 (equal distribution of rainfall) and 1 (one day concentrates all rainfall).

**Author(s)**

Miquel De Cáceres Ainsa, CREAM.

**References**

Martin-Vide J (2004) Spatial distribution of a daily precipitation concentration index in peninsular Spain. *International Journal of Climatology* 24, 959–971. doi:10.1002/joc.1030.

---

```
precipitation_rainfall_erosivity
      Precipitation rainfall erosivity
```

---

**Description****[Experimental]**

Function `precipitation_rainfall_erosivity()` calculates a multi-year average of monthly rainfall erosivity using the MedREM model proposed by Diodato and Bellochi (2010) for the Mediterranean area (see also Guerra et al. 2016).

**Usage**

```
precipitation_rainfall_erosivity(
  meteo_data,
  longitude,
  scale = c("month", "year"),
  average = TRUE
)
```

**Arguments**

<code>meteo_data</code>	A meteo tibble as with the dates and meteorological variables as returned by <a href="#">interpolate_data</a> in the "interpolated_data" column.
<code>longitude</code>	Longitude in degrees.
<code>scale</code>	Character, either 'month' or 'year'. Default to 'month'
<code>average</code>	Boolean flag to calculate multi-year averages before applying MedREM's formula.

**Details**

MedREM model is:  $R_m = b_0 \cdot P \cdot \sqrt{d} \cdot (\alpha + b_1 \cdot \text{longitude})$ , where  $P$  is accumulated precipitation and  $d$  is maximum daily precipitation. Parameters used for the MedREM model are  $b_0 = 0.117$ ,  $b_1 = -0.015$ ,  $\alpha = 2$ . Note that there is a mistake in Guerra et al. (2016) regarding parameters  $b_1$  and  $\alpha$ .

**Value**

A vector of values for each month (in MJ·mm·ha<sup>-1</sup>·h<sup>-1</sup>·month<sup>-1</sup>) or each year (in MJ·mm·ha<sup>-1</sup>·h<sup>-1</sup>·yr<sup>-1</sup>), depending on the scale

**Author(s)**

Miquel De Cáceres Ainsa, CREAM.

Víctor Granda García, CREAM.

**References**

Diodato, N., Bellocchi, G., 2010. MedREM, a rainfall erosivity model for the Mediterranean region. *J. Hydrol.* 387, 119–127, doi:10.1016/j.jhydrol.2010.04.003.

Guerra CA, Maes J, Geijzendorffer I, Metzger MJ (2016) An assessment of soil erosion prevention by vegetation in Mediterranean Europe: Current trends of ecosystem service provision. *Ecol Indic* 60:213–222. doi: 10.1016/j.ecolind.2015.06.043.

**Examples**

```
interpolated_example <-  
  interpolate_data(points_to_interpolate_example, meteoland_interpolator_example)  
  
precipitation_rainfall_erosivity(  
  meteo_data = interpolated_example$interpolated_data[[1]],  
  longitude = 2.32,  
  scale = "month",  
  average = TRUE  
)
```

---

radiation\_julianDay     *Solar radiation utility functions*

---

**Description**

Set of functions used in the calculation of incoming solar radiation and net radiation.

**Usage**

```
radiation_julianDay(year, month, day)  
  
radiation_dateStringToJulianDays(dateStrings)  
  
radiation_solarDeclination(J)  
  
radiation_solarConstant(J)
```

```
radiation_sunRiseSet(latrad, slorad, asprad, delta)

radiation_solarElevation(latrad, delta, hrad)

radiation_daylength(latrad, slorad, asprad, delta)

radiation_daylengthseconds(latrad, slorad, asprad, delta)

radiation_potentialRadiation(solarConstant, latrad, slorad, asprad, delta)

radiation_solarRadiation(
    solarConstant,
    latrad,
    elevation,
    slorad,
    asprad,
    delta,
    diffTemp,
    diffTempMonth,
    vpa,
    precipitation
)

radiation_directDiffuseInstant(
    solarConstant,
    latrad,
    slorad,
    asprad,
    delta,
    hrad,
    R_s,
    clearday
)

radiation_directDiffuseDay(
    solarConstant,
    latrad,
    slorad,
    asprad,
    delta,
    R_s,
    clearday,
    nsteps = 24L
)

radiation_skyLongwaveRadiation(Tair, vpa, c = 0)
```

```

radiation_outgoingLongwaveRadiation(
    solarConstant,
    latrad,
    elevation,
    slorad,
    asprad,
    delta,
    vpa,
    tmin,
    tmax,
    R_s
)

```

```

radiation_netRadiation(
    solarConstant,
    latrad,
    elevation,
    slorad,
    asprad,
    delta,
    vpa,
    tmin,
    tmax,
    R_s,
    alpha = 0.08
)

```

### Arguments

year, month, day	Year, month and day as integers.
dateStrings	A character vector with dates in format "YYYY-MM-DD".
J	Julian day (integer), number of days since January 1, 4713 BCE at noon UTC.
latrad	Latitude (in radians North).
slorad	Slope (in radians).
asprad	Aspect (in radians from North).
delta	Solar declination (in radians).
hrad	Solar hour (in radians).
solarConstant	Solar constant (in kW·m <sup>-2</sup> ).
elevation	Elevation above sea level (in m).
diffTemp	Difference between maximum and minimum temperature (°C).
diffTempMonth	Difference between maximum and minimum temperature, averaged over 30 days (°C).
vpa	Average daily vapor pressure (kPa).
precipitation	Precipitation (in mm).
R_s	Daily incident solar radiation (MJ·m <sup>-2</sup> ).

clearday	Boolean flag to indicate a clearsky day (vs. overcast).
nsteps	Number of daily substeps.
Tair	Air temperature (in degrees Celsius).
c	Proportion of sky covered by clouds (0-1).
tmin, tmax	Minimum and maximum daily temperature (°C).
alpha	Surface albedo (from 0 to 1).

### Value

Values returned for each function are:

- radiation\_dateStringToJulianDays: A vector of Julian days (i.e. number of days since January 1, 4713 BCE at noon UTC).
- radiation\_daylength: Day length (in hours).
- radiation\_daylengthseconds: Day length (in seconds).
- radiation\_directDiffuseInstant: A vector with instantaneous direct and diffusive radiation rates (for both SWR and PAR).
- radiation\_directDiffuseDay: A data frame with instantaneous direct and diffusive radiation rates (for both SWR and PAR) for each subdaily time step.
- radiation\_potentialRadiation: Daily (potential) solar radiation (in MJ·m<sup>-2</sup>).
- radiation\_julianDay: Number of days since January 1, 4713 BCE at noon UTC.
- radiation\_skyLongwaveRadiation: Instantaneous incoming (sky) longwave radiation (W·m<sup>-2</sup>).
- radiation\_outgoingLongwaveRadiation: Daily outgoing longwave radiation (MJ·m<sup>-2</sup>·day<sup>-1</sup>).
- radiation\_netRadiation: Daily net solar radiation (MJ·m<sup>-2</sup>·day<sup>-1</sup>).
- radiation\_solarConstant: Solar constant (in kW·m<sup>-2</sup>).
- radiation\_solarDeclination: Solar declination (in radians).
- radiation\_solarElevation: Angle of elevation of the sun with respect to the horizon (in radians).
- radiation\_solarRadiation: Daily incident solar radiation (MJ·m<sup>-2</sup>·day<sup>-1</sup>).
- radiation\_sunRiseSet: Sunrise and sunset hours in hour angle (radians).

### Functions

- radiation\_dateStringToJulianDays(): Date string to julian days
- radiation\_solarDeclination(): solar declination
- radiation\_solarConstant(): solar constant
- radiation\_sunRiseSet(): sun rise and set
- radiation\_solarElevation(): solar elevation
- radiation\_daylength(): Day length
- radiation\_daylengthseconds(): Day length seconds

- radiation\_potentialRadiation(): Potential radiation
- radiation\_solarRadiation(): solar Radiation
- radiation\_directDiffuseInstant(): Direct diffuse instant
- radiation\_directDiffuseDay(): Direct diffuse day
- radiation\_skyLongwaveRadiation(): Sky longwave radiation
- radiation\_outgoingLongwaveRadiation(): Outgoing longwave radiation
- radiation\_netRadiation(): Net radiation

**Note**

Code for radiation\_julianDay(), radiation\_solarConstant() and radiation\_solarDeclination() was translated to C++ from R code in package 'insol' (by J. G. Corripio).

**Author(s)**

Miquel De Cáceres Ainsa, CREAM

**References**

Danby, J. M. Eqn. 6.16.4 in Fundamentals of Celestial Mechanics, 2nd ed. Richmond, VA: Willmann-Bell, p. 207, 1988.

Garnier, B.J., Ohmura, A., 1968. A method of calculating the direct shortwave radiation income of slopes. J. Appl. Meteorol. 7: 796-800

McMahon, T. A., M. C. Peel, L. Lowe, R. Srikanthan, and T. R. McVicar. 2013. Estimating actual, potential, reference crop and pan evaporation using standard meteorological data: a pragmatic synthesis. Hydrology & Earth System Sciences 17:1331–1363. See also: <http://www.fao.org/docrep/x0490e/x0490e06.htm>.

Reda, I. and Andreas, A. 2003. Solar Position Algorithm for Solar Radiation Applications. 55 pp.; NREL Report No. TP-560-34302, Revised January 2008. <http://www.nrel.gov/docs/fy08osti/34302.pdf>

Spitters, C.J.T., Toussaint, H.A.J.M. and Goudriaan, J. (1986). Separating the diffuse and direct components of global radiation and its implications for modeling canopy photosynthesis. I. Components of incoming radiation. Agricultural and Forest Meteorology, 38, 231–242.

**See Also**

[interpolate\\_data](#)

---

raster\_to\_interpolate\_example

*Example raster data set for interpolation of weather variables*

---

**Description****[Experimental]**

Example raster data set of spatial location and topography records from Catalonia (NE Spain). Cell size is 1km x 1km and raster size is 10x10 cells.

**Format**

stars object

**Source**

ICGC

**Examples**

```
data(raster_to_interpolate_example)
```

---

read\_interpolator      *Read interpolator files*

---

**Description**

Read interpolator files created with [write\\_interpolator](#)

**Usage**

```
read_interpolator(filename)
```

**Arguments**

filename      interpolator file name

**Details**

This function takes the file name of the nc file storing an interpolator object and load it into the work environment

**Value**

an interpolator (stars) object

**Author(s)**

Victor Granda García, EMF-CREAF

**See Also**

Other interpolator functions: [add\\_topo\(\)](#), [create\\_meteo\\_interpolator\(\)](#), [get\\_interpolation\\_params\(\)](#), [set\\_interpolation\\_params\(\)](#), [with\\_meteo\(\)](#), [write\\_interpolator\(\)](#)

## Examples

```
# example interpolator
data(meteoland_interpolator_example)

# temporal folder
tmp_dir <- tempdir()

# write interpolator
write_interpolator(
  meteoland_interpolator_example,
  file.path(tmp_dir, "meteoland_interpolator_example.nc")
)

# check file exists
file.exists(file.path(tmp_dir, "meteoland_interpolator_example.nc"))

# read it again
read_interpolator(file.path(tmp_dir, "meteoland_interpolator_example.nc"))
```

---

set\_interpolation\_params

*Setting interpolation parameters in an interpolator object*

---

## Description

Changing or updating interpolation parameters in an interpolator object

## Usage

```
set_interpolation_params(
  interpolator,
  params = NULL,
  verbose = getOption("meteoland_verbosity", TRUE)
)
```

## Arguments

interpolator	interpolator object to update
params	list with the parameters provided by the user
verbose	Logical indicating if the function must show messages and info. Default value checks "meteoland_verbosity" option and if not set, defaults to TRUE. It can be turned off for the function with FALSE, or session wide with options(meteoland_verbosity = FALSE)

## Details

This function ensures that if no parameters are provided, the default ones are used (see [defaultInterpolationParams](#)). Also, if params are partially provided, this function ensures that the rest of the parameters are not changed.

## Value

The same interpolator object provided, with the updated interpolation parameters

## Author(s)

Victor Granda García, EMF-CREAF

## See Also

Other interpolator functions: [add\\_topo\(\)](#), [create\\_meteo\\_interpolator\(\)](#), [get\\_interpolation\\_params\(\)](#), [read\\_interpolator\(\)](#), [with\\_meteo\(\)](#), [write\\_interpolator\(\)](#)

## Examples

```
# example interpolator
data(meteoland_interpolator_example)
# store the actual parameters
old_parameters <- get_interpolation_params(meteoland_interpolator_example)
# we can provide only the parameter we want to change
meteoland_interpolator_example <- set_interpolation_params(
  meteoland_interpolator_example,
  list(debug = TRUE)
)
# check
get_interpolation_params(meteoland_interpolator_example)$debug
# compare with old
old_parameters$debug
# the rest should be the same
setdiff(old_parameters, get_interpolation_params(meteoland_interpolator_example))
```

---

summarise\_interpolated\_data

*Summarise interpolated data by temporal dimension*

---

## Description

### [Experimental]

Summarises the interpolated meteorology in one or more locations by the desired temporal scale

**Usage**

```

summarise_interpolated_data(
  interpolated_data,
  fun = "mean",
  frequency = NULL,
  vars_to_summary = c("MeanTemperature", "MinTemperature", "MaxTemperature",
    "Precipitation", "MeanRelativeHumidity", "MinRelativeHumidity",
    "MaxRelativeHumidity", "Radiation", "WindSpeed", "WindDirection", "PET"),
  dates_to_summary = NULL,
  months_to_summary = 1:12,
  verbose = getOption("meteoland_verbosity", TRUE),
  ...
)

```

**Arguments**

<code>interpolated_data</code>	An interpolated data object as returned by <a href="#">interpolate_data</a> .
<code>fun</code>	The function to use for summarising the data.
<code>frequency</code>	A string indicating the interval specification (allowed ones are "week", "month", "quarter" and "year"). If NULL (default), aggregation is done in one interval for all the dates present.
<code>vars_to_summary</code>	A character vector with one or more variable names to summarise. By default, all interpolated variables are summarised.
<code>dates_to_summary</code>	A Date object to define the dates to be summarised. If NULL (default), all dates in the interpolated data are processed.
<code>months_to_summary</code>	A numeric vector with the month numbers to subset the data before summarising. (e.g. <code>c(7,8)</code> for July and August). This parameter allows studying particular seasons, when combined with <code>frequency</code> . For example <code>frequency = "years"</code> and <code>months = 6:8</code> leads to summarizing summer months of each year.
<code>verbose</code>	Logical indicating if the function must show messages and info. Default value checks "meteoland_verbosity" option and if not set, defaults to TRUE. It can be turned off for the function with FALSE, or session wide with <code>options(meteoland_verbosity = FALSE)</code>
<code>...</code>	Arguments needed for fun

**Details**

If `interpolated_data` is a nested interpolated data sf object, as returned by [interpolate\\_data](#), temporal summary is done for each location present in the interpolated data. If `interpolated_data` is an unnested interpolated data sf object, temporal summary is done for all locations together. If `interpolated_data` is a single location data.frame containing the dates and the interpolated variables, temporal summary is done for that location. If `interpolated_data` is a stars object as returned by [interpolate\\_data](#), temporal summary is done for all the raster.

**Value**

For a nested interpolated data, the same sf object with a new column with the temporal summaries. For an unnested interpolated data, a data.frame with the summarised meteo variables. For an interpolated raster (stars object), the same raster with the temporal dimension aggregated as desired.

**Author(s)**

Víctor Granda García, CREAMF

**Examples**

```
# points interpolation aggregation
points_to_interpolate_example |>
  interpolate_data(meteoland_interpolator_example, verbose = FALSE) |>
  summarise_interpolated_data()

# raster interpolation aggregation
raster_to_interpolate_example |>
  interpolate_data(meteoland_interpolator_example, verbose = FALSE) |>
  summarise_interpolated_data()
```

---

summarise\_interpolator

*Summarise interpolator objects by temporal dimension*

---

**Description****[Experimental]**

Summarises an interpolator object by the desired temporal scale.

**Usage**

```
summarise_interpolator(
  interpolator,
  fun = "mean",
  frequency = NULL,
  vars_to_summary = c("Temperature", "MinTemperature", "MaxTemperature", "Precipitation",
    "RelativeHumidity", "MinRelativeHumidity", "MaxRelativeHumidity", "Radiation",
    "WindSpeed", "WindDirection", "PET", "SmoothedPrecipitation",
    "SmoothedTemperatureRange", "elevation", "slope", "aspect"),
  dates_to_summary = NULL,
  months_to_summary = 1:12,
  verbose = getOption("meteoland_verbosity", TRUE),
  ...
)
```

**Arguments**

interpolator	An interpolator object as created by <code>create_meteo_interpolator</code> .
fun	The function to use for summarising the data.
frequency	A string indicating the interval specification (allowed ones are "week", "month", "quarter" and "year"). If NULL (default), aggregation is done in one interval for all the dates present.
vars_to_summary	A character vector with one or more variable names to summarise. By default, all interpolated variables are summarised.
dates_to_summary	A Date object to define the dates to be summarised. If NULL (default), all dates in the interpolated data are processed.
months_to_summary	A numeric vector with the month numbers to subset the data before summarising. (e.g. <code>c(7,8)</code> for July and August). This parameter allows studying particular seasons, when combined with frequency. For example frequency = "years" and months = 6:8 leads to summarizing summer months of each year.
verbose	Logical indicating if the function must show messages and info. Default value checks "meteoland_verbosity" option and if not set, defaults to TRUE. It can be turned off for the function with FALSE, or session wide with <code>options(meteoland_verbosity = FALSE)</code>
...	Arguments needed for fun

**Value**

`summarise_interpolator` function returns the same interpolator object provided with the temporal dimension aggregated to desired frequency.

**Author(s)**

Víctor Granda García, CREAM

**Examples**

```
# example interpolator
meteoland_interpolator_example

# aggregate all dates in the interpolator, calculating the maximum values
summarise_interpolator(meteoland_interpolator_example, fun = "max")

# aggregate weekly, calculating mean values
summarise_interpolator(meteoland_interpolator_example, frequency = "week")
```

---

utils\_saturationVP      *Physical utility functions*

---

### Description

Set of functions used in the calculation of physical variables.

### Usage

```
utils_saturationVP(temperature)
utils_averageDailyVP(Tmin, Tmax, RHmin, RHmax)
utils_atmosphericPressure(elevation)
utils_airDensity(temperature, Patm)
utils_averageDaylightTemperature(Tmin, Tmax)
utils_latentHeatVaporisation(temperature)
utils_latentHeatVaporisationMol(temperature)
utils_psychrometricConstant(temperature, Patm)
utils_saturationVaporPressureCurveSlope(temperature)
```

### Arguments

temperature	Air temperature (°C).
Tmin, Tmax	Minimum and maximum daily temperature (°C).
RHmin, RHmax	Minimum and maximum relative humidity (%).
elevation	Elevation above sea level (in m).
Patm	Atmospheric air pressure (in kPa).

### Value

Values returned for each function are:

- `utils_airDensity`: air density (in kg·m<sup>-3</sup>).
- `utils_atmosphericPressure`: Air atmospheric pressure (in kPa).
- `utils_averageDailyVP`: average (actual) vapour pressure (in kPa).
- `utils_averageDaylightTemperature`: average daylight air temperature (in °C). `utils_latentHeatVaporisation`: Latent heat of vaporisation (MJ·kg<sup>-1</sup>). `utils_latentHeatVaporisationMol`: Latent heat of vaporisation (J·mol<sup>-1</sup>).

- `utils_psychrometricConstant`: Psychrometric constant (kPa·°C-1).
- `utils_saturationVP`: saturation vapour pressure (in kPa).
- `utils_saturationVaporPressureCurveSlope`: Slope of the saturation vapor pressure curve (kPa·°C-1).

### Functions

- `utils_averageDailyVP()`: Average daily VP
- `utils_atmosphericPressure()`: Atmospheric pressure
- `utils_airDensity()`: Air density
- `utils_averageDaylightTemperature()`: Daylight temperature
- `utils_latentHeatVaporisation()`: latent heat vaporisation
- `utils_latentHeatVaporisationMol()`: Heat vaporisation mol
- `utils_psychrometricConstant()`: psychrometric constant
- `utils_saturationVaporPressureCurveSlope()`: Saturation VP curve slope

### Author(s)

Miquel De Cáceres Ainsa, CREAM

### References

McMurtrie, R. E., D. A. Rook, and F. M. Kelliher. 1990. Modelling the yield of *Pinus radiata* on a site limited by water and nitrogen. *Forest Ecology and Management* 30:381–413.

McMahon, T. A., M. C. Peel, L. Lowe, R. Srikanthan, and T. R. McVicar. 2013. Estimating actual, potential, reference crop and pan evaporation using standard meteorological data: a pragmatic synthesis. *Hydrology & Earth System Sciences* 17:1331–1363. See also: <http://www.fao.org/docrep/x0490e/x0490e06.htm>

---

with\_meteo

*Ensure meteo object is ready to create an interpolator object*

---

### Description

Check integrity of meteo objects

### Usage

```
with_meteo(meteo, verbose = getOption("meteoland_verbosity", TRUE))
```

### Arguments

<code>meteo</code>	meteo object
<code>verbose</code>	Logical indicating if the function must show messages and info. Default value checks "meteoland_verbosity" option and if not set, defaults to TRUE. It can be turned off for the function with FALSE, or session wide with <code>options(meteoland_verbosity = FALSE)</code>

**Details**

This function is the first step in the creation of a meteoland interpolator, ensuring the meteo provided contains all the required elements

**Value**

invisible meteo object ready to pipe in the interpolator creation

**See Also**

Other interpolator functions: [add\\_topo\(\)](#), [create\\_meteo\\_interpolator\(\)](#), [get\\_interpolation\\_params\(\)](#), [read\\_interpolator\(\)](#), [set\\_interpolation\\_params\(\)](#), [write\\_interpolator\(\)](#)

**Examples**

```
# example meteo
data(meteoland_meteo_example)
with_meteo(meteoland_meteo_example)
```

---

worldmet2meteoland      *From worldmet to meteoland meteo objects*

---

**Description**

Adapting [importNOAA](#) meteo objects to meteoland meteo objects

**Usage**

```
worldmet2meteoland(meteo, complete = FALSE)
```

**Arguments**

meteo	worldmet meteo object.
complete	logical indicating if the meteo data missing variables should be calculated (if possible). Default to FALSE.

**Details**

This function converts [importNOAA](#) meteo objects to compatible meteoland meteo objects by selecting the needed variables and adapting the names to comply with meteoland requirements. Also it aggregates subdaily data as well as complete missing variables if possible (setting complete = TRUE)

**Value**

a compatible meteo object to use with meteoland.

## Examples

```
if (interactive()) {
  # worldmet data
  library(worldmet)
  worldmet_stations <- worldmet::getMeta(lat = 42, lon = 0, n = 2, plot = FALSE)
  worldmet_subdaily_2022 <-
    worldmet::importNOAA(worldmet_stations$code, year = 2022, hourly = TRUE)

  # just convert
  worldmet2meteoland(worldmet_subdaily_2022)
  # convert and complete
  worldmet2meteoland(worldmet_subdaily_2022, complete = TRUE)
}
```

---

write\_interpolator      *Write the interpolator object*

---

## Description

Write the interpolator object to a file

## Usage

```
write_interpolator(interpolator, filename, .overwrite = FALSE)
```

## Arguments

interpolator	meteoland interpolator object, as created by <a href="#">create_meteo_interpolator</a>
filename	file name for the interpolator nc file
.overwrite	logical indicating if the file should be overwritten if it already exists

## Details

This function writes the interpolator object created with [create\\_meteo\\_interpolator](#) in a NetCDF-CF standard compliant format, as specified in <https://cfconventions.org/cf-conventions/cf-conventions.html>

## Value

invisible interpolator object, to allow using this function as a step in a pipe

## Author(s)

Victor Granda García, EMF-CREAF

**See Also**

Other interpolator functions: [add\\_topo\(\)](#), [create\\_meteo\\_interpolator\(\)](#), [get\\_interpolation\\_params\(\)](#), [read\\_interpolator\(\)](#), [set\\_interpolation\\_params\(\)](#), [with\\_meteo\(\)](#)

**Examples**

```
# example interpolator
data(meteoland_interpolator_example)

# temporal folder
tmp_dir <- tempdir()

# write interpolator
write_interpolator(
  meteoland_interpolator_example,
  file.path(tmp_dir, "meteoland_interpolator_example.nc"),
  .overwrite = TRUE
)

# check file exists
file.exists(file.path(tmp_dir, "meteoland_interpolator_example.nc"))

# read it again
read_interpolator(file.path(tmp_dir, "meteoland_interpolator_example.nc"))
```

# Index

- \* **datasets**
  - meteoland\_interpolator\_example, 18
  - meteoland\_meteo\_example, 19
  - meteoland\_meteo\_no\_topo\_example, 19
  - meteoland\_topo\_example, 20
  - points\_to\_interpolate\_example, 23
  - raster\_to\_interpolate\_example, 29
- add\_topo, 2, 5, 8, 30, 32, 38, 40
- complete\_meteo, 3, 9
- create\_meteo\_interpolator, 3, 5, 8–11, 30, 32, 35, 38–40
- defaultInterpolationParams, 5, 6, 17, 32
- get\_interpolation\_params, 3, 5, 7, 30, 32, 38, 40
- humidity\_dewtemperature2relative (humidity\_relative2dewtemperature), 8
- humidity\_relative2dewtemperature, 8
- humidity\_relative2specific (humidity\_relative2dewtemperature), 8
- humidity\_specific2relative (humidity\_relative2dewtemperature), 8
- importNOAA, 38
- interpolate\_data, 7, 9, 23, 24, 29, 33
- interpolation\_cross\_validation, 11
- interpolation\_dewtemperature (interpolation\_precipitation), 14
- interpolation\_precipitation, 14
- interpolation\_temperature (interpolation\_precipitation), 14
- interpolation\_wind (interpolation\_precipitation), 14
- interpolator\_calibration (interpolation\_cross\_validation), 11
- meteoland\_interpolator\_example, 18
- meteoland\_meteo\_example, 19
- meteoland\_meteo\_no\_topo\_example, 19
- meteoland\_topo\_example, 20
- meteospain2meteoland, 20
- penman, 21
- penmanmonteith (penman), 21
- points\_to\_interpolate\_example, 23
- precipitation\_concentration, 23
- precipitation\_rainfall\_erosivity, 24
- radiation\_dateStringToJulianDays (radiation\_julianDay), 25
- radiation\_daylength (radiation\_julianDay), 25
- radiation\_daylengthseconds (radiation\_julianDay), 25
- radiation\_directDiffuseDay (radiation\_julianDay), 25
- radiation\_directDiffuseInstant (radiation\_julianDay), 25
- radiation\_julianDay, 25
- radiation\_netRadiation (radiation\_julianDay), 25
- radiation\_outgoingLongwaveRadiation (radiation\_julianDay), 25
- radiation\_potentialRadiation (radiation\_julianDay), 25
- radiation\_skyLongwaveRadiation (radiation\_julianDay), 25
- radiation\_solarConstant (radiation\_julianDay), 25

radiation\_solarDeclination  
    (radiation\_julianDay), 25

radiation\_solarElevation  
    (radiation\_julianDay), 25

radiation\_solarRadiation  
    (radiation\_julianDay), 25

radiation\_sunRiseSet  
    (radiation\_julianDay), 25

raster\_to\_interpolate\_example, 29

read\_interpolator, 3, 5, 8, 30, 32, 38, 40

set\_interpolation\_params, 3, 5, 8, 30, 31,  
    38, 40

summarise\_interpolated\_data, 32

summarise\_interpolator, 34

unnest, 10

utils\_airDensity (utils\_saturationVP),  
    36

utils\_atmosphericPressure  
    (utils\_saturationVP), 36

utils\_averageDailyVP  
    (utils\_saturationVP), 36

utils\_averageDaylightTemperature  
    (utils\_saturationVP), 36

utils\_latentHeatVaporisation  
    (utils\_saturationVP), 36

utils\_latentHeatVaporisationMol  
    (utils\_saturationVP), 36

utils\_psychrometricConstant  
    (utils\_saturationVP), 36

utils\_saturationVaporPressureCurveSlope  
    (utils\_saturationVP), 36

utils\_saturationVP, 36

with\_meteo, 3, 5, 8, 30, 32, 37, 40

worldmet2meteoland, 38

write\_interpolator, 3, 5, 8, 30, 32, 38, 39