Package 'NSTempRFA'

August 6, 2026

Title Adapts the Regional Frequency Analysis to Air Temperature

Version 0.2.0

Description Adapts the index-flood technique to extreme air temperature data. The package uses the additive approach proposed in Martins et al. (2022) <doi:10.1590/1678-4499.20220061> and adapt it to climate change conditions through the use of nonstationary parametric distributions.

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URL https://github.com/gabrielblain/NSTempRFA

BugReports https://github.com/gabrielblain/NSTempRFA/issues

Depends R (>= 3.5)

Imports extRemes, ismev, lmom, lmomRFA, MASS, Matrix, rrcov, spsUtil, stats, utils

Suggests knitr, rmarkdown, spelling, testthat (>= 3.0.0)

VignetteBuilder knitr

Config/roxygen2/version 8.0.0

Config/testthat/edition 3

Config/testthat/parallel true

Encoding UTF-8

Language en-US

LazyData true

RoxygenNote 7.3.3

NeedsCompilation no

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Repository CRAN

Date/Publication 2026-08-06 12:50:06 UTC

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`Add_Discord` *Discordance measures calculated from the additive approach*

Description

This function calculates the Hosking and Wallis' discordance measure (discord) and the robust discordance measure (Neykov et al. 2007) doi:10.1029/2006WR005322 using the additive approach proposed in Martins et al. (2022) doi:10.1590/1678-4499.20220061.

Usage

```
Add_Discord(dataset)
```

Arguments

`dataset`	A numeric matrix with extreme air temperature data from multiple sites. The first column must contain the years, and the remaining columns contain temperature data from each site.

Details

The discordance measures identify sites that are potentially discordant within a regional frequency analysis framework for extreme air temperature series.

Value

A `data.frame` with 8 columns:

Local Site identifier.

SampleSize Number of observations for each site.

l_1 First L-moment (mean).

l_2 Second L-moment (L-scale).

t_3 L-skewness ratio.

t_4 L-kurtosis ratio.

t_5 Fifth-order L-moment ratio.

discord Original discordance statistic indicating potential outlier status.

Examples

```
Add_Discord(TmaxCPC_SP)
```

`Add_Heterogeneity` *Add_Heterogeneity*

Description

Add_Heterogeneity

Usage

```
Add_Heterogeneity(dataset.add, rho, Ns)
```

Arguments

`dataset.add`	A numeric matrix of air temperature data as calculated by `Dataset_add()`.
`rho`	A single numeric value describing the average inter-site correlation. Must be strictly between -1 and 1.
`Ns`	Number of simulated groups of series. Default is 100; at least 500 is recommended.

Value

Hosking and Wallis' heterogeneity measure using an additive approach, as proposed in Martins et al. (2022) doi:10.1590/16784499.20220061. Returns `NA` if the regional distribution cannot be fitted or if simulated statistics have zero variance.

Examples

```
add.data <- Dataset_add(TmaxCPC_SP)
Add_Heterogeneity(dataset.add = add.data$add_data, rho = 0.51, Ns = 500)
```

Add_RegProb *Add_RegProb*

Description

Add_RegProb

Usage

```
Add_RegProb(quantiles, regional_pars, site_temp, n.year)
```

Arguments

quantiles	A numeric vector with no missing data containing extreme air temperatures.
regional_pars	A 5-column, 1-row data.frame or matrix as generated by Reg_par().
site_temp	A non-empty numeric vector or 1-column matrix of site air temperature data.
n.year	A single integer giving the year index for which parameters are calculated. Must be between 1 and length(site_temp).

Value

A numeric matrix of cumulative probabilities (clamped to [0.0001, 0.9999]) associated with the input quantiles from the regional GEV distribution.

Examples

```
quantiles <- c(37.8, 37.9, 38.0, 38.1, 38.2, 38.5, 39.0)
add.data <- Dataset_add(TmaxCPC_SP)
best.parms <- Best_model(add.data = add.data$add_data)
regional_pars <- Reg_par(best_model = best.parms$atsite.models)
Add_RegProb(
  quantiles     = quantiles,
  regional_pars = regional_pars,
  site_temp     = TmaxCPC_SP$Pixel_1,
  n.year        = 34
)
```

Add_RegQuant *Regional Quantile Estimation for a Site Using Time-Varying GEV Parameters*

Description

Computes quantiles for a given site based on regional GEV parameters and a time-varying location and scale model. Estimated quantiles are adjusted by the site's mean temperature.

Usage

```
Add_RegQuant(prob, regional_pars, site_temp, n.year)
```

Arguments

prob	A numeric vector of probabilities strictly between 0 and 1, with no missing values.
regional_pars	A 1-row, 5-column matrix or data.frame containing regional GEV parameters: location intercept, location slope, scale intercept, scale slope, and shape.
site_temp	A numeric vector or 1-column matrix of site air temperature data.
n.year	A single integer indicating the year index for which quantiles are calculated. Must be between 1 and length(site_temp).

Value

A named numeric vector of adjusted regional quantiles for the specified year. Names are of the form "Q90", '"Q95"', etc.

Examples

```
prob <- c(0.90, 0.92, 0.93, 0.94, 0.95, 0.97, 0.99)
add.data <- Dataset_add(TmaxCPC_SP)
best.parms <- Best_model(add.data = add.data$add_data)
regional_pars <- Reg_par(best_model = best.parms$atsite.models)
Add_RegQuant(
  prob          = prob,
  regional_pars = regional_pars,
  site_temp     = TmaxCPC_SP$Pixel_1,
  n.year        = 34
)
```

Best_model *Time-varying parameters of the best fitted GEV model*

Description

This function fits four time-varying GEV models (with different assumptions on non-stationarity in location and/or scale) to each temperature series, computes the AICc of each model, and selects the best one according to the lowest total AICc.

Usage

```
Best_model(add.data)
```

Arguments

add.data	A numeric matrix of air temperature data as calculated by Dataset_add().

Details

Model fitting is performed via `ismev::gev.fit()`. Four nested models are considered:

1. Stationary (constant location and scale).
2. Time-varying location only.
3. Time-varying scale only.
4. Time-varying location and scale.

For each site the function tries up to five optimisation methods (`Nelder-Mead`, `BFGS`, `CG`, `L-BFGS-B`, `SANN`) and uses the first that converges. Model selection is based on the sum of site-level AICc values.

Value

A list with:

best Index (1–4) of the model with the lowest total AICc across all sites.

atsite.models Data frame containing the estimated parameters (`mu0`, `mu1`, `sigma0`, `sigma1`, `shape`) and sample size for each site.

Examples

```
add.data <- Dataset_add(TmaxCPC_SP)
best.parms <- Best_model(add.data = add.data$add_data)
```

`Dataset_add` *dataset_add*

Description

dataset_add

Usage

```
Dataset_add(dataset)
```

Arguments

`dataset`	A numeric matrix with extreme air temperature data from multiple sites. The first column must contain the years, and the remaining columns contain temperature data from each site.

Value

A `list` object with the following elements:

add_data A matrix of centered temperature values for each site.

reg_mean Mean temperature values for each site.

Examples

```
Dataset_add(TmaxCPC_SP)
```

`Fit_model` *Time-varying parameters of a given GEV model*

Description

Time-varying parameters of a given GEV model

Usage

```
Fit_model(temperatures, model)
```

Arguments

`temperatures`	A vector or single-column matrix of air temperature data, either original or centered by subtracting the sample mean.
`model`	A single integer between 1 and 4 defining the GEV model. May be provided by `Best_model()`.

Details

The function attempts to fit the model using `ismev::gev.fit()` with the following optimisers in sequence: `Nelder-Mead`, `BFGS`, `CG`, `L-BFGS-B`, `SANN`. The first optimiser that converges is used; if all fail, `NA`s are returned for that site.

Value

A `data.frame` containing the estimated parameters (`mu0`, `mu1`, `sigma0`, `sigma1`, `shape`, `size`). If fitting fails for a site, `NA`s are returned for that site.

Examples

```
temperatures <- TmaxCPC_SP$Pixel_1
model <- 4
Fit_model(temperatures, model)
```

lonlat_Tmax *Geographical coordinates of the* TmaxCPC_SP *series*

Description

Geographical coordinates of the TmaxCPC_SP series

Usage

```
lonlat_Tmax
```

Format

lonlat_Tmax**:**
A data.frame with 2 columns and 10 rows.

lon Longitude in decinal degrees

lat Latitude in decinal degrees

Source

https://psl.noaa.gov/

Reg_par *Estimate the parameters of the regional distribution*

Description

Estimate the parameters of the regional distribution

Usage

```
Reg_par(best_model)
```

Arguments

best_model	A 6-column data.frame as generated by Best_model(). • Columns 1–5: mu0, mu1, sigma0, sigma1, shape. • Column 6: size (sample size per site, used as weight).

Value

A one-row data.frame with the size-weighted regional parameters of a time-varying generalized extreme value distribution.

Examples

```
add.data <- Dataset_add(TmaxCPC_SP)
best.parms <- Best_model(add.data = add.data$add_data)
Reg_par(best_model = best.parms$atsite.models)
```

`Reg_parCI` *Confidence intervals for regional GEV parameters*

Description

Confidence intervals for regional GEV parameters

Usage

```
Reg_parCI(add_data, model, reg_par, n.boots = 999, progress = NULL)
```

Arguments

`add_data`	A numeric matrix of air temperature data as calculated by `Dataset_add()`.
`model`	A single integer number from 1 to 4 defining the GEV model. May be provided by `Best_model()`.
`reg_par`	A 5-column and 1-row data.frame or matrix as generated by `Reg_par()`. • 1st column is the mu0 parameter, • 2nd is the mu1 parameter, • 3rd is the sigma0 parameter, • 4th is the sigma1 parameter, • 5th is the shape parameter.
`n.boots`	A single number describing the number of bootstrap replicates. Whenever possible, `n.boots` should be set to 999 (default), as suggested by Burn (2003) <10.1623/hysj.48.1.25.43485> and O'Brien and Burn (2014) <10.1016/j.jhydrol.2014.09.041>.
`progress`	Logical scalar controlling whether a progress bar is displayed. `TRUE` forces the bar on, `FALSE` forces it off, and `NULL` (default) defers to `getOption("NSTempRFA.progress")`, which itself falls back to `interactive()`. Set `options(NSTempRFA.progress = FALSE)` to suppress the bar globally.

Value

A matrix containing the 95% confidence intervals (lower and upper bounds) of the time-varying parameter estimates. The spatial dependence between sites is preserved.

Examples

```
add.data <- Dataset_add(TmaxCPC_SP)
best.parms <- Best_model(add.data = add.data$add_data)
regional.parms <- Reg_par(best_model = best.parms$atsite.models)

Reg_parCI(
  add_data  = add.data$add_data,
  model     = best.parms$best,
  reg_par   = regional.parms,
  n.boots   = 100
)
```

Site_parCI *Confidence intervals for site-specific GEV parameters*

Description

Confidence intervals for site-specific GEV parameters

Usage

```
Site_parCI(atsite_temp, model, site_par, n.boots = 999, progress = NULL)
```

Arguments

atsite_temp	A numeric vector or single-column matrix of air temperature data.
model	A single integer from 1 to 4 defining the GEV model.
site_par	A 1-row, 5-column data.frame or matrix generated by Fit_model().
n.boots	Number of bootstrap replicates. Values smaller than 100 are not allowed. Defaults to 999.
progress	Logical scalar controlling whether a progress bar is displayed. TRUE forces the bar on, FALSE forces it off, and NULL (default) defers to getOption("NSTempRFA.progress"), which itself falls back to interactive(). Set options(NSTempRFA.progress = FALSE) to suppress the bar globally.

Value

A matrix containing the lower and upper 95% confidence limits of the estimated parameters.

Examples

```
temperatures <- TmaxCPC_SP$Pixel_1
model <- 2
site_par <- Fit_model(temperatures, model)

Site_parCI(
```

```
  atsite_temp = temperatures,
  model       = model,
  site_par    = site_par[1, 1:5],
  n.boots     = 100
)
```

TmaxCPC_SP *Extreme air temperature data*

Description

Daily extremes for air temperature data sampled from the block maxima approach. A block corresponds to one year. The data belongs to The Climate Prediction Center - NOAA. location of Ribeirao Preto, State of Sao Paulo in Brazil.

Usage

```
TmaxCPC_SP
```

Format

TmaxCPC_SP**:**

A data.frame with 11 columns and 34 rows.

Year Year

Pixel_1 to Pixel_10 daily extremes for air temperature

Source

https://psl.noaa.gov/

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