Package: PowerSDI (via r-universe)

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Type Package

Title Calculate Standardised Drought Indices Using NASA POWER Data

Version 1.0.0.9000

Description A set of functions designed to calculate the standardised precipitation and standardised precipitation evapotranspiration indices using NASA POWER data as described in Blain et al. (2023) <doi:10.2139/ssrn.4442843>. These indices are calculated using a reference data source. The functions verify if the indices' estimates meet the assumption of normality and how well NASA POWER estimates represent real-world data. Indices are calculated in a routine mode. Potential evapotranspiration amounts and the difference between rainfall and potential evapotranspiration are also calculated. The functions adopt a basic time scale that splits each month into four periods. Days 1 to 7, days 8 to 14, days 15 to 21, and days 22 to 28, 29, 30, or 31, where 'TS=4' corresponds to a 1-month length moving window (calculated 4 times per month) and 'TS=48' corresponds to a 12-month length moving window (calculated 4 times per month).

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Encoding UTF-8

LazyData true

RoxygenNote 7.3.2

Depends R (>= 3.1.0)

Imports graphics, lmom, lubridate, nasapower, stats

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

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

Suggests knitr, rmarkdown, testthat (>= 3.0.0), vcr (>= 0.6.0), vdiffr (>= 1.0.0)

Config/testthat/edition 3

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VignetteBuilder knitr

Language en-GB

Repository https://gabrielblain.r-universe.dev

RemoteUrl https://github.com/gabrielblain/powersdi

RemoteRef HEAD

RemoteSha 10f64a351cb39f51b5f885b9f959a35a242c4586

Contents

`Accuracy` *Verify how well NASA-POWER Data Represent Observed Data*

Description

Calculates scalar measures of accuracy.

Usage

```
Accuracy(obs_est, conf.int = "Yes", sig.level = 0.95)
```

Arguments

`obs_est`	A 2-column matrix. The reference or observed and the estimated or predicted data. See `ObsEst` object as an example.
`conf.int`	A character variable (`Yes` or `No`) defining if the function must calculate confidence intervals. Default is "Yes".
`sig.level`	A numeric variable (between 0.90 and 0.95) defining the significance level for parameter the confidence intervals. Default is 0.95.

Value

An object of class `PowerSDI.Accuracy`, a `list`, which contains:

- Absolute mean error (AME),
- square root of the mean squared error (RMSE),
- Willmott's indices of agreement:
  - original (dorig),
  - modified (dmod) and
  - refined (dref)
- Pearson determination coefficient (R2), and
- if `conf.int = "Yes"`, confidence intervals.

Examples

```
a <- Accuracy(obs_est = ObsEst, conf.int = "No")
a

# A generic plotting method is also supplied
plot(a)
```

`DistPar` *Parameters for Calculating the SDIs Provided by the ScientSDI Function*

Description

Contains parameters of the gamma and GEV distributions and the `Pr(Rain = 0)`, "probzero.rain".

Usage

```
DistPar
```

Format

A `data.frame` with 13 variables and 48 rows.

lon longitude in decimal degrees

lat latitude in decimal degrees

quart.month The quartile of each month

alfa.rain Shape parameter of the gamma distribution

beta.rain Scale parameter of the gamma distribution

probzero.rain Probability of rain=0

loc.harg Location parameter of the GEV distribution, PE calculated by HS method

sc.harg Scale parameter of the GEV distribution, PE calculated by HS method

sh.harg Shape parameter of the GEV distribution, PE calculated by HS method

loc.pm Location parameter of the GEV distribution, PE calculated by PM method

sc.pm Scale parameter of the GEV distribution, PE calculated by PM method

sh.pm Shape parameter of the GEV distribution, PE calculated by PM method

TS Time scale at which the SDIs will be calculated

Source

Generated by the `ScientSDI()` function using NASA POWER data.

Examples

```
data(DistPar)
```

`ObsEst` *Example Data of the Input Required by the Accuracy Function*

Description

Contains pairs of reference and estimated data.

Usage

```
ObsEst
```

Format

A `data.frame` with 2 variables and 1434 rows.

PE_obs PE data from a reference weather station

PE_est PE data from the NASA POWER project

Source

Generated by the PowerSDI package using data from NASA POWER and Agronomic Institute.

Examples

```
data(ObsEst)
```

`OperatSDI` *Calculate Routine NASA-SPI and NASA-SPEI Estimates*

Description

Calculates the SPI (Standardized Precipitation Index) and SPEI (Standardized Precipitation-Evapotranspiration Index) using NASA POWER data.

Usage

```
OperatSDI(
  lon,
  lat,
  start.date,
  end.date,
  PEMethod = "HS",
  distr = "GEV",
  parms,
  TS = 4L
)
```

Arguments

`lon`	longitude in decimal degrees.
`lat`	latitude in decimal degrees.
`start.date`	Date at each time when the calculation must start ("YYYY-MM-DD").
`end.date`	Date at each time when the calculation must end ("YYYY-MM-DD").
`PEMethod`	A character variable ("HS" (Hargreaves & Samani) or "PM" (Penman-Monteith) defining the potential evapotranspiration method. Default is "HS".
`distr`	A character variable ("GEV" or "GLO") defining which distribution is used to calculate the SPEI. Default is "GEV" (generalized extreme value) with "GLO" (generalized logistic distributions) as an option.
`parms`	Parameters required for calculating the SPI and SPEI. It is provided by the `ScientSDI` function's `DistPar`.
`TS`	Time scale on the "quart.month" basis (integer values between 1 and 96).

Value

A data frame with six columns

- rainfall,
- potential evapotranspiration (PE),
- difference between rainfall and PE (in millimiters),
- the NASA-SPI,
- the NASA-SPEI and
- the SDI categories corresponding to each indices estimates.

Examples

```
# This example is not run as it requires data to be downloaded from an API,
#  which may fail.  It also uses data included in this package, "DistPar" for
#  `parms` here

OperatSDI(
  lon = -47.3,
  lat = -22.67,
  start.date = "2023-06-01",
  end.date = "2023-06-30",
  PEMethod = "HS",
  distr = "GEV",
  parms = DistPar,
  TS = 4)
```

`plot.PowerSDI.Accuracy` *Plots PowerSDI.Accuracy Objects*

Description

Custom `plot()` method for `PowerSDI.Accuracy` objects.

Usage

```
## S3 method for class 'PowerSDI.Accuracy'
plot(x, ...)
```

Arguments

`x`	a ‘PowerSDI.Accuracy‘ object
`...`	Other parameters as passed to `plot()`

Value

No return value, called for side effects. Using this will display a scatter plot of reference ETP data (x-axis) and estimated ETP (y-axis) in the active R session.

PlotData *Plot Rainfall and Potential Evapotranspiration Data*

Description

Plots rainfall and potential evapotranspiration, both Penman-Monteith and Hargreaves and Samani, amounts using NASA POWER data.

Usage

```
PlotData(lon, lat, start.date, end.date)
```

Arguments

lon	longitude in decimal degrees: (+) Eastern Hemisphere (-) Western Hemisphere.
lat	latitude in decimal degrees: (+) Northern Hemisphere (-) Southern Hemisphere.
start.date	date at which the indices estimates should start ("YYYY-MM-DD").
end.date	date at which the indices estimates should end ("YYYY-MM-DD").

Value

No return value, called for side effects. Using this will display scatter plots of rainfall and potential evapotranspiration accumulated at the 1-quart.month time scale in the active R session.

Examples

```
# This example requires an Internet connection to fetch data and so is only
# run in interactive sessions

PlotData(
  lon = -47.3,
  lat = -22.87,
  start.date = "2021-12-28",
  end.date = "2022-12-31"
)
```

print.PowerSDI.Accuracy *Prints PowerSDI.Accuracy Objects*

Description

Custom `print()` method for `PowerSDI.Accuracy` objects.

Usage

```
## S3 method for class 'PowerSDI.Accuracy'
print(x, digits = max(3L, getOption("digits") - 3L), ...)
```

Arguments

`x`	a `PowerSDI.Accuracy` object
`digits`	The number of digits to be used after the decimal when displaying accuracy values.
`...`	ignored

Value

Nothing. Side-effect: pretty prints a `PowerSDI.Accuracy` object in the R console.

Reference *Calculate the SPI and SPEI Using a Reference Data Source*

Description

Calculates the Standardised Precipitation Index (SPI) and Standardised Precipitation-Evapotranspiration Index (SPEI) using a reference data source.

Usage

```
Reference(ref, distr = "GEV", PEMethod = "HS", TS = 4L)
```

Arguments

`ref`	A data frame with the variables required for calculating the SDIs. See `refHS` or `refPM` as examples.
`distr`	A character variable ("GEV" or "GLO") defining which distribution is used to calculate the SPEI. Default is "GEV".
`PEMethod`	A character variable ("HS" or "PM") defining the potential evapotranspiration method. Default is "HS".
`TS`	Time scale on the "quart.month" basis (whole values between 1 and 96). Default is 4.

Value

A data frame with five columns

- rain,
- potential evapotranspiration,
- difference between rainfall and potential evapotranspiration,
- SPI calculated at the time scale selected by the user, and
- SPIE calculated at the time scale selected by the user

Examples

```
Reference(ref = refHS, distr = "GEV", PEMethod = "HS", TS = 4)
```

---

refHS *Example of the Input Required by the Reference Function*

Description

Contains data for calculating the SPI and SPEI.

Usage

```
refHS
```

Format

A `data.frame` with 10950 rows and 8 variables.

YEAR Year

MM Month

DD Day

tavg Daily average air temperature at 2 metres above the ground (degrees C)

tmax Daily maximum air temperature at 2 metres above the ground (degrees C)

tmin Daily minimum air temperature at 2 metres above the ground (degrees C)

Ra Daily top of the atmosphere radiation (MJ/m^2/day)

Rain Daily rainfall amounts (mm)

Source

Agronomic Institute and NASA POWER.

Examples

```
data(refHS)
```

refPM *Example of the Input Required by the Reference Function*

Description

Contains data for calculating the SPI and SPEI.

Usage

```
refPM
```

Format

A `data.frame` with 10958 rows and 11 variables.

YEAR Year

MM Month

DD Day

tavg Daily average air temperature at 2 metres above the ground (degrees C)

tmax Daily maximum air temperature at 2 metres above the ground (degrees C)

tmin Daily minimum air temperature at 2 metres above the ground (degrees C)

Ra Daily top of the atmosphere radiation (MJ/m^2/day)

Rs Daily global horizontal irradiance (MJ/m^2/day)

W Daily average wind speed at 2 metres above the ground (m/s)

RH Daily average relative humidity at 2 metres above the ground (in percentage)

Rain Daily rainfall amounts (mm)

Source

Agronomic Institute and NASA POWER.

Examples

```
data(refPM)
```

`ScientSDI` *Estimate parameters of Gamma, Generalized Extreme Value, or Generalized Logistic Distributions*

Description

Verifies concepts expected from SDI. The first step of the SPI and SPEI algorithms is to calculate the cumulative probabilities of their input variables (Guttman 1999). Function estimates the parameters of the gamma, generalized extreme value (GEV), or generalized logistic distributions (GLO) through the L-moments method are provided. This function also allows users to remove suspicious values from the data sample.

Usage

```
ScientSDI(
  lon,
  lat,
  start.date,
  end.date,
  distr = "GEV",
  TS = 4L,
  Good = "No",
  sig.level = 0.95,
  RainUplim = NULL,
  RainLowlim = NULL,
  PEUplim = NULL,
  PELowlim = NULL
)
```

Arguments

`lon`	longitude in decimal degrees: (+) Eastern Hemisphere, (-) Western Hemisphere.
`lat`	latitude in decimal degrees: (+) Northern hemisphere, (-) Southern Hemisphere.
`start.date`	date at which the indices estimates should start. Format: "YYYY-MM-DD".
`end.date`	date at which the indices estimates should end. Format: "YYYY-MM-DD".
`distr`	A character variable ("GEV" or "GLO") defining the distribution to calculate the SPEI. Default is `GEV`.
`TS`	Time scale on the quart.month basis (integer values between 1 and 96). Default is 4.
`Good`	A character variable ("Yes" or "No") to calculate or not the goodness-of-fit and normality tests. Default is "No".
`sig.level`	A numeric variable (between 0.90 and 0.95) defining the significance level for parameter Good. Default is "0.95".
`RainUplim`	Optional. Upper limit in millimetres from which rainfall values larger than it will be removed. Default is `NULL`.

`RainLowlim` Optional. Lower limit in millimetres from which rainfall values smaller than it will be removed. Default is `NULL`.

`PEUplim` Optional. Upper limit in millimetres from which evapotranspiration values larger than it will be removed. Valid for Hargreaves and Samani method Default is `NULL`.

`PELowlim` Optional. Lower limit in millimetres from which evapotranspiration values smaller than it will be removed. Valid for Hargreaves and Samani method Default is `NULL`.

Value

A `list` object with data calculated at the time scale selected by the user. If `Good = "Yes"`, this `list` object includes:

SDI The "NASA-SPI", "NASA-SPEI.HS" and "NASA-SPEI.PM."

DistPar The parameters of the distributions (gamma and GEV) used to calculate the indices.

GoodFit The Lilliefors and Anderson-Darling tests goodness-of-fit tests.

Normality The outcomes of the two normality checking procedures (Wu *et al*., 2006 and Stagge *et al*., 2015).

If `Good = "No"`, this `list` object includes SDI and DistPar.

This function also presents other data (in millimiters) calculated from the NASA POWER project:

- Rainfall amounts (Rain),
- potential evapotranspiration values estimated through the Hargreaves and Samani method (PEHS),
- potential evapotranspiration values estimated through the FAO-56 Penman-Monteith method (PEPM), and
- the difference between rainfall and potential evapotranspiration (PPEHS and PPEPM).

References

Guttman, N.B., 1999. Accepting the standardized precipitation index: a calculation algorithm 1. JAWRA Journal of the American Water Resources Association, 35(2), pp.311-322.

Stagge, J.H., Tallaksen, L.M., Gudmundsson, L., Van Loon, A.F. and Stahl, K., 2015. Candidate distributions for climatological drought indices (SPI and SPEI). International Journal of Climatology, 35(13), pp.4027-4040.

Wu, H., Svoboda, M.D., Hayes, M.J., Wilhite, D.A. and Wen, F., 2006. Appropriate application of the standardized precipitation index in arid locations and dry seasons. International Journal of Climatology: A Journal of the Royal Meteorological Society, 27(1), pp.65-79.

Examples

```
# This example requires an Internet connection to fetch data and takes >5s
#  to run, and so is only run in interactive sessions
```

```
ScientSDI(
  lon = -47.3,
  lat = -22.87,
  start.date = "1993-01-01",
  end.date = "2022-12-31",
  TS = 1,
  Good = "no"
)
```

Index