Package: ClimateAnomaly (via r-universe)

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Type Package

Title Rainfall and Temperature Anomaly Indices for Climate Analysis

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Maintainer Ranjit Kumar Paul <ranjitstat@gmail.com>

Description Computes rainfall anomaly indices and a standardised temperature anomaly from monthly or annual precipitation and temperature data supplied by the user. The rainfall indices are the Rainfall Anomaly Index (RAI; Van Rooy, 1965), the Modified Rainfall Anomaly Index (MRAI) and the Standardized Rainfall Anomaly Index (SRAI) of Ekpetere (2025) <doi:10.1016/j.jenvman.2025.124160>, the Simplified Standardized Precipitation Index (SSPI) of Raziei (2021) <doi:10.1016/j.jhydrol.2021.126761>, and the Standardized Precipitation Index (SPI; McKee et al., 1993). The temperature anomaly is a z-score computed within each calendar month. All indices are computed group-wise, so the user can stratify by any combination of spatial units (state, district, grid cell) and calendar month, and each value can be classified into a descriptive severity class.

License GPL-3

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Author Md Yeasin [aut], Ranjit Kumar Paul [aut, cre], Pushkar Bora [aut]

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`ClimateAnomaly-package`

ClimateAnomaly: Rainfall and Temperature Anomaly Indices for Climate Analysis

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Description

ClimateAnomaly provides a unified interface for computing six widely-used rainfall anomaly indices and a standardised temperature anomaly from any user-supplied monthly or annual climate data frame.

Details

Indices available:

Function	Index	Reference
`calc_rai`	Rainfall Anomaly Index (RAI)	Van Rooy (1965)
`calc_mrai`	Modified RAI (MRAI)	Ekpetere (2025)
`calc_srai`	Standardized RAI (SRAI)	Ekpetere (2025)
`calc_sspi`	Simplified SPI (SSPI)	Raziei (2021)
`calc_spi`	Standardized Precipitation Index (SPI)	McKee et al. (1993)
`calc_temp_anomaly`	Temperature anomaly z-score	(none)

The convenience wrapper `calc_all_indices` computes all of the above in a single call on a user-supplied data frame, grouped by any combination of spatial and temporal identifiers.

Typical workflow:

```
library(ClimateAnomaly)

# Load your own data (must have at least a precipitation column
# plus grouping columns such as state/district/grid and month)
my_data <- read.csv("my_climate_data.csv")

result <- calc_all_indices(
  data       = my_data,
  group_cols = c("state", "month_num"),   # or c("district", "month_num")
  rain_col   = "rainfall_mm",
  tmax_col   = "tmax_c",                  # NULL to skip temperature
  tmin_col   = "tmin_c"
)
```

Data format requirements: The input data frame must contain:

- One or more **grouping columns** (e.g. `state`, `month_num`).
- A **precipitation column** (numeric, mm).
- Optionally, **tmax** and **tmin** columns (numeric, degrees Celsius).

No fixed column names are required; you pass the actual names as arguments.

Author(s)

Maintainer: Ranjit Kumar Paul <ranjitstat@gmail.com>

Authors:

- Ranjit Kumar Paul <ranjitstat@gmail.com>
- Md Yeasin
- Pushkar Bora

References

Van Rooy, M.P. (1965). A rainfall anomaly index independent of time and space. *Notos*, 14, 97–104.

Ekpetere, K.O. (2025). Development and evaluation of the modified and standardized rainfall anomaly indices for extreme variability analysis. *Journal of Environmental Management*, 375, 124160. doi:10.1016/j.jenvman.2025.124160

Raziei, T. (2021). Revisiting the Rainfall Anomaly Index to serve as a Simplified Standardized Precipitation Index. *Journal of Hydrology*, 602, 126761. doi:10.1016/j.jhydrol.2021.126761

Raziei, T. (2022). Improving the normalization procedure of the simplified standardized precipitation index (SSPI) using Box-Cox transformation. *Stochastic Environmental Research and Risk Assessment*, 37, 925–951. doi:10.1007/s00477022023179

McKee, T.B., Doesken, N.J., & Kleist, J. (1993). The relationship of drought frequency and duration to time scales. *Proc. 8th Conf. Applied Climatology*, AMS, 179–184.

calc_all_indices *Compute all rainfall and temperature anomaly indices*

Description

This is the main user-facing function. It accepts a data frame (or `data.table` / `tibble`) with monthly (or annual) climate records and computes all six anomaly indices in one call, stratified by any combination of grouping columns the user specifies.

Usage

```
calc_all_indices(
  data,
  group_cols = c("state", "month_num"),
  rain_col = "rainfall_mm",
  tmax_col = "tmax_mean_c",
  tmin_col = "tmin_mean_c",
  indices = c("RAI", "MRAI", "SRAI", "SSPI", "SPI", "TEMP"),
  n_extreme = 10L,
  classify = TRUE
)
```

Arguments

`data`	A `data.frame` (or compatible) containing at minimum a precipitation column and the grouping columns.
`group_cols`	Character vector of column names that define the groups over which indices are computed. Typical: `c("state", "month_num")`. For annual data use `c("state")` (or `c("station")`).
`rain_col`	Name of the precipitation column. Default `"rainfall_mm"`.
`tmax_col`	Name of the maximum temperature column (optional). Default `"tmax_mean_c"`. Set to `NULL` to skip.
`tmin_col`	Name of the minimum temperature column (optional). Default `"tmin_mean_c"`. Set to `NULL` to skip.
`indices`	Character vector specifying which indices to compute. Any subset of `c("RAI","MRAI","SRAI","SSPI",` Default: all six.
`n_extreme`	Integer. Passed to `calc_rai` for the number of extreme values used as reference thresholds. Default `10`.
`classify`	Logical. If `TRUE` (default), classification label columns are added alongside every numeric index column.

Details

The function applies each index to every *group* defined by `group_cols`. In the typical use case, `group_cols = c("state","month_num")` so that every index is computed relative to the long-term climatology of each state in each calendar month.

The user must supply column names for:

- precipitation (`rain_col`)
- maximum temperature (`tmax_col`), optional
- minimum temperature (`tmin_col`), optional

Columns that are `NULL` are simply skipped and not added to the output.

Value

The original `data` with additional columns appended:

`RAI`, `RAI_class` Rainfall Anomaly Index + label

`MRAI`, `MRAI_class` Modified RAI + label

`SRAI`, `SRAI_class` Standardized RAI + label

`SSPI`, `SSPI_class` Simplified SPI + label

`SPI`, `SPI_class` Standardized Precipitation Index + label

`tmax_anomaly`, `tmax_anom_class` Tmax z-score + label (if `tmax_col` supplied)

`tmin_anomaly`, `tmin_anom_class` Tmin z-score + label (if `tmin_col` supplied)

`tavg_c` Mean of the tmax and tmin columns (if both T columns supplied)

`tavg_anomaly`, `tavg_anom_class` Tavg z-score + label (if both T columns supplied)

References

Van Rooy, M.P. (1965). Notos, 14, 97–104.
Ekpetere, K.O. (2025). J. Env. Mgmt., 375, 124160. doi:10.1016/j.jenvman.2025.124160
Raziei, T. (2021). J. Hydrology, 602, 126761. doi:10.1016/j.jhydrol.2021.126761
McKee, T.B. et al. (1993). 8th Conf. Applied Climatology, AMS, 179–184.

See Also

`calc_rai`, `calc_mrai`, `calc_srai`, `calc_sspi`, `calc_spi`, `calc_temp_anomaly`

Examples

```
# --- Example with built-in sample dataset ---
data(india_monthly)

result <- calc_all_indices(
  data       = india_monthly,
  group_cols = c("state", "month_num"),
  rain_col   = "rainfall_mm",
  tmax_col   = "tmax_mean_c",
```

```
  tmin_col   = "tmin_mean_c"
)

# View first few rows for one state
subset(result, state == "Maharashtra" & year >= 2015,
       select = c("state","year","month_num","rainfall_mm",
                  "RAI","MRAI","SPI","tmax_anomaly"))

# --- Compute only RAI and SPI (skip temp) ---
result2 <- calc_all_indices(
  data       = india_monthly,
  group_cols = c("state", "month_num"),
  rain_col   = "rainfall_mm",
  tmax_col   = NULL,
  tmin_col   = NULL,
  indices    = c("RAI", "SPI")
)
```

`calc_mrai` *Modified Rainfall Anomaly Index (MRAI)*

Description

Computes the Modified Rainfall Anomaly Index (MRAI) proposed by Ekpetere (2025). Unlike RAI, MRAI uses the *absolute* minimum and maximum of the full record as reference thresholds, removing the arbitrary choice of the top/bottom 10 values and ensuring the index always lies within $[-3, +3]$.

Usage

```
calc_mrai(x)
```

Arguments

`x`	Numeric vector of precipitation values for a single group.

Details

$$MRAI = \begin{cases} +3\,\dfrac{P_n - \bar{P}}{P_{\max} - \bar{P}} & \text{if } P_n \geq \bar{P} \\ -3\,\dfrac{P_n - \bar{P}}{P_{\min} - \bar{P}} & \text{if } P_n < \bar{P} \end{cases}$$

Value

Numeric vector of MRAI values in $[-3, +3]$.

References

Ekpetere, K.O. (2025). Development and evaluation of the modified and standardized rainfall anomaly indices for extreme variability analysis. *Journal of Environmental Management*, 375, 124160. doi:10.1016/j.jenvman.2025.124160

See Also

calc_rai, calc_srai

Examples

```
set.seed(42)
rain <- c(120, 85, 200, 60, 150, 95, 170, 40, 110, 130,
          75, 220, 90, 160, 50, 140, 100, 180, 70, 115)
mrai_values <- calc_mrai(rain)
data.frame(rain = rain, MRAI = round(mrai_values, 3))
```

---

calc_rai *Rainfall Anomaly Index (RAI)*

Description

Computes the Rainfall Anomaly Index (RAI) introduced by Van Rooy (1965). The index ranks positive and negative precipitation anomalies through a normalisation that uses the mean of the `n_extreme` highest values ($\bar{M}$) and the mean of the `n_extreme` lowest values ($\bar{X}$) as reference thresholds.

Usage

```
calc_rai(x, n_extreme = 10L)
```

Arguments

`x`	Numeric vector of precipitation values for a single group (e.g. one station and one calendar month over all years).
`n_extreme`	Integer. Number of extreme values used to compute the upper ($\bar{M}$) and lower ($\bar{X}$) thresholds. Van Rooy (1965) used 10; automatically capped at `floor(length(x) / 2)`. Default `10`.

Details

$$RAI = \begin{cases} +3\,\dfrac{N-\bar{N}}{\bar{M}-\bar{N}} & \text{if } N \geq \bar{N} \\ -3\,\dfrac{N-\bar{N}}{\bar{X}-\bar{N}} & \text{if } N < \bar{N} \end{cases}$$

where N is the current value, $\bar{N}$ is the long-term mean, $\bar{M}$ is the mean of the `n_extreme` highest values, and $\bar{X}$ is the mean of the `n_extreme` lowest values.

Value

Numeric vector of RAI values (same length and order as `x`).

References

Van Rooy, M.P. (1965). A rainfall anomaly index independent of time and space. *Notos*, 14, 97–104.

See Also

`calc_mrai`, `calc_srai`, `calc_all_indices`

Examples

```
set.seed(42)
rain <- c(120, 85, 200, 60, 150, 95, 170, 40, 110, 130,
          75, 220, 90, 160, 50, 140, 100, 180, 70, 115)
rai_values <- calc_rai(rain)
data.frame(rain = rain, RAI = round(rai_values, 3))
```

`calc_spi` *Standardized Precipitation Index (SPI)*

Description

Computes the Standardized Precipitation Index (SPI) of McKee et al. (1993). A Gamma distribution is fitted via maximum-likelihood estimation to the non-zero precipitation values; zero-inflation is handled explicitly through the mixed probability $H(x) = q + (1 - q) \cdot F_\Gamma(x)$. The resulting cumulative probability is converted to a standard normal z-score, which is the SPI value.

Usage

```
calc_spi(x)
```

Arguments

`x`	Numeric vector of precipitation values for a single group.

Details

If fewer than 4 non-zero observations are available (e.g. an arid month with almost no rain), the function falls back to a simple z-score $(x - \bar{x})/s$.

Value

Numeric vector of SPI values (standard normal scores).

References

McKee, T.B., Doesken, N.J., & Kleist, J. (1993). The relationship of drought frequency and duration to time scales. *Proceedings of the 8th Conference on Applied Climatology*, 17–22 January 1993, Anaheim, CA. American Meteorological Society, pp. 179–184.

See Also

calc_sspi, calc_all_indices

Examples

```
set.seed(42)
rain <- c(120, 85, 200, 60, 150, 95, 170, 40, 110, 130,
          75, 220, 90, 160, 50, 140, 100, 180, 70, 115)
spi_values <- calc_spi(rain)
data.frame(rain = rain, SPI = round(spi_values, 3))
```

---

calc_srai — *Standardized Rainfall Anomaly Index (SRAI)*

Description

Computes the Standardized Rainfall Anomaly Index (SRAI) introduced by Ekpetere (2025). SRAI incorporates the standard deviation (σ) of the series to better detect extreme rainfall events relative to average conditions. Output is clamped to $[-3, +3]$.

Usage

```
calc_srai(x, clamp = TRUE)
```

Arguments

x	Numeric vector of precipitation values for a single group.
clamp	Logical. If TRUE (default), values are clamped to $[-3, +3]$ as intended by the index design.

Details

$$SRAI = \begin{cases} +3\,\dfrac{P_n - \sigma}{P_{\max} - \sigma} & \text{if } P_n \geq \bar{P} \\ -3\,\dfrac{P_n - \sigma}{P_{\min} - \sigma} & \text{if } P_n < \bar{P} \end{cases}$$

Value

Numeric vector of SRAI values.

References

Ekpetere, K.O. (2025). Development and evaluation of the modified and standardized rainfall anomaly indices for extreme variability analysis. *Journal of Environmental Management*, 375, 124160. doi:10.1016/j.jenvman.2025.124160

See Also

calc_mrai, calc_rai

Examples

```
set.seed(42)
rain <- c(120, 85, 200, 60, 150, 95, 170, 40, 110, 130,
          75, 220, 90, 160, 50, 140, 100, 180, 70, 115)
srai_values <- calc_srai(rain)
data.frame(rain = rain, SRAI = round(srai_values, 3))
```

---

calc_sspi — *Simplified Standardized Precipitation Index (SSPI)*

Description

Computes the Simplified Standardized Precipitation Index (SSPI) as proposed by Raziei (2021). SSPI is designed as a non-parametric alternative to SPI that handles zero-dominated precipitation series (arid/semi-arid climates) without fitting a probability distribution.

Usage

```
calc_sspi(x, eps = 1e-06)
```

Arguments

x	Numeric vector of precipitation values for a single group.
eps	Small positive constant used in the denominator to prevent division by zero in zero-dominated series. Default 1e-6.

Details

The algorithm follows Equation (2) of Raziei (2021):

1. Compute the probability of zero precipitation (PZP).
2. Reduce skewness of the series:
   - If skewness > 0.5: apply cube-root transformation ($x^{1/3}$).
   - If skewness < -0.5: apply cube transformation (x^3).
   - Otherwise: no transformation.
3. Compute anomaly $\Delta_i = P_i^* - \bar{P}^*$ in the transformed domain.
4. Derive the 5th (P_B) and 95th (P_T) percentiles of the ranked transformed data.
5. Apply the appropriate SSPI formula based on the sign of Δ_i and whether PZP $\geq 40\%$.

Value

Numeric vector of SSPI values.

References

Raziei, T. (2021). Revisiting the Rainfall Anomaly Index to serve as a Simplified Standardized Precipitation Index. *Journal of Hydrology*, 602, 126761. doi:10.1016/j.jhydrol.2021.126761

See Also

`calc_spi`, `calc_all_indices`

Examples

```
set.seed(42)
rain <- c(120, 85, 200, 60, 150, 95, 170, 40, 110, 130,
          75, 220, 90, 160, 50, 140, 100, 180, 70, 115)
sspi_values <- calc_sspi(rain)
data.frame(rain = rain, SSPI = round(sspi_values, 3))
```

`calc_temp_anomaly` *Standardised Temperature Anomaly*

Description

Computes the standardised temperature anomaly (z-score) for a single group:

Usage

```
calc_temp_anomaly(x)
```

Arguments

`x`	Numeric vector of temperature values for a single group.

Details

$$Z_T = \frac{T_i - \bar{T}}{s_T}$$

where $\bar{T}$ is the long-term mean temperature for the group and s_T is its sample standard deviation. The grouping is typically *location* $\times$ *calendar month* so that, for example, every January at a given station is compared only against other Januaries.

Value

Numeric vector of standardised anomaly values (z-scores).

Examples

```
# Tmax values for one station, all Januaries 1980-2020
set.seed(7)
tmax_jan <- rnorm(41, mean = 28, sd = 2)
z <- calc_temp_anomaly(tmax_jan)
summary(z)
```

`classify_rai` *Classify RAI / MRAI / SRAI values*

Description

Assigns a drought/wet severity class label to a numeric vector of RAI, MRAI, or SRAI values using the classification scheme of Van Rooy (1965) and Raziei (2021).

Usage

```
classify_rai(x)
```

Arguments

`x`	Numeric vector of RAI (or MRAI/SRAI) values.

Details

Range	Class
>= 3.00	Extremely Wet
2.00 to 2.99	Very Wet
1.00 to 1.99	Moderately Wet
0.50 to 0.99	Slightly Wet
-0.49 to 0.49	Near Normal
-0.99 to -0.50	Slightly Dry
-1.99 to -1.00	Moderately Dry
-2.99 to -2.00	Very Dry
<= -3.00	Extremely Dry

Value

Character vector of class labels (same length as `x`).

References

Van Rooy, M.P. (1965). Notos, 14, 97–104. Raziei, T. (2021). Journal of Hydrology, 602, 126761.

Examples

```
vals <- c(-3.5, -2.1, -0.8, 0.1, 0.7, 1.5, 2.5, 3.2)
classify_rai(vals)
```

---

classify_spi *Classify SPI / SSPI values*

Description

Assigns a drought/wet severity class label using the standard SPI classification (McKee et al., 1993).

Usage

```
classify_spi(x)
```

Arguments

x	Numeric vector of SPI or SSPI values.

Details

Range	Class
>= 2.00	Extremely Wet
1.50 to 1.99	Severely Wet
1.00 to 1.49	Moderately Wet
0.50 to 0.99	Mildly Wet
-0.49 to 0.49	Near Normal
-0.99 to -0.50	Mildly Dry
-1.49 to -1.00	Moderately Dry
-1.99 to -1.50	Severely Dry
<= -2.00	Extremely Dry

Value

Character vector of class labels.

References

McKee, T.B., Doesken, N.J., & Kleist, J. (1993). Proceedings of the 8th Conference on Applied Climatology, AMS, pp. 179–184.

Examples

```
vals <- c(-2.5, -1.6, -1.2, -0.7, 0.0, 0.6, 1.1, 1.7, 2.3)
classify_spi(vals)
```

---

classify_temp_anomaly *Classify temperature anomaly values*

Description

Assigns a temperature departure class label to standardised temperature anomaly z-scores.

Usage

```
classify_temp_anomaly(x)
```

Arguments

x	Numeric vector of temperature anomaly z-scores.

Details

Range	Class
>= 2.0	Extremely Warm
1.0 to 1.99	Warm
0.5 to 0.99	Slightly Warm
-0.49 to 0.49	Near Normal
-0.99 to -0.50	Slightly Cool
-1.99 to -1.00	Cool
<= -2.0	Extremely Cool

Value

Character vector of class labels.

Examples

```
vals <- c(-2.5, -1.2, -0.6, 0.1, 0.7, 1.3, 2.1)
classify_temp_anomaly(vals)
```

`india_monthly` *Sample monthly climate data for Indian states (1976–2026)*

Description

A subset of monthly state-level rainfall and temperature records for India, included as a demonstration dataset for the **ClimateAnomaly** package.

Usage

```
india_monthly
```

Format

A data frame with columns:

state Character. State/territory name.

year Integer. Year (1976–2026).

month_num Integer. Calendar month (1 = January, 12 = December).

month Character. Month label in `"YYYY-MM"` format.

rainfall_mm Numeric. Monthly total rainfall (mm).

rainy_days Integer. Number of rainy days in the month.

tmax_mean_c Numeric. Mean daily maximum temperature (degrees Celsius).

tmin_mean_c Numeric. Mean daily minimum temperature (degrees Celsius).

tmax_peak_c Numeric. Peak daily maximum temperature (degrees Celsius).

tmin_low_c Numeric. Lowest daily minimum temperature (degrees Celsius).

complete Logical. Whether the month has complete data coverage.

source Character. Data source identifier.

Source

Open-Meteo historical climate API (open-meteo.com).

Examples

```
data(india_monthly)
head(india_monthly)
table(india_monthly$state)
```

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