streamflow-example

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Contents

Introduction

Summary

This notebook demonstrates the workflow used to compute, analyse, and visualize streamflow indicators from daily discharge data within the *PIRAGUA* project. It presents the main functions implemented in `functions.R`, which provide a standardized framework to summarize hydrological behaviour at different temporal scales, assess trends, and produce basic graphical and tabular outputs. All functions are part of a custom R package developed within the PIRAGUA project to standardize hydrological analyses of observed and modelled streamflows in the Pyrenees, but can be used with other streamflow data. All computations are based on xts time series objects, ensuring temporal consistency and easy handling of missing data."

Functions overview

knitr::kable(data.frame(Function = c("piragua_annual", "piragua_monthly", "piragua_trend", "piragua_plot"), Purpose = c("Compute annual streamflow indices", "Compute monthly streamflow indices", "Estimate trends (Yue–Pilon method)", "Generate integrated summary plots")), caption = "Overview of main PIRAGUA streamflow functions.")

The function `piragua_annual()` calculates a comprehensive set of **annual indicators** describing central tendency, dispersion, extremes, and distributional shape of daily streamflow or precipitation. These include the mean, standard deviation, quantiles (`q10`–`q90`), inter- and decile-based skewness and kurtosis, low-flow indices (`vcn3`, `vcn7`), and counts or volumes of exceedances above or below key thresholds.

The function `piragua_monthly()` extends these computations to the **monthly scale**, preserving the same set of statistics for finer temporal resolution. The function `piragua_trend()` applies the **Yue–Pilon prewhitening** method and **Sen's slope estimator** to detect and quantify monotonic trends in each indicator, while `piragua_plot()` generates **integrated visual summaries** combining daily, monthly, and annual patterns, empirical flow distributions, and trend diagnostics for each gauging station.

Together, these routines provide a **reproducible toolkit** for streamflow characterization, trend analysis, and reporting of hydrological changes across the Pyrenean basin.

Main streamflow indicators

- **mean**, **sd** – mean and standard deviation of daily streamflow.
- **max**, **min** – maximum and minimum daily discharge.
- **q10**, **q25**, **q50**, **q75**, **q90** – quantiles representing low, median, and high-flow conditions.
- **iqr**, **idr** – inter-quartile (`q75-q25`) and inter-decile (`q90-q10`) ranges, measuring flow variability.
- **qsk**, **dsk**, **dku** – quantile skewness, decile skewness, and decile kurtosis, describing asymmetry and peakedness of the flow distribution.
- **vcn3**, **vcn7** – 3- and 7-day minimum flow indices (baseflow proxies).
- **n_q10–n_q90** – number of days below or above each quantile threshold.
- **v_q10–v_q90** – cumulative volumes of flow below or above each quantile threshold (in hm^3 or mm, depending on area specification).
- **rl20** – estimated discharge corresponding to a 20-year return period.
- **na**, **na_3**, **na_5** – counts of missing data and of consecutive missing-day periods (3 or 5 days).
- *(for precipitation data)*: **nrainy**, **total**, **meanrainy**, **sdrainy** describe the frequency, totals, and variability of rainy days.

Unless specified, discharge values are expressed in m^3s^{-1}; when area is provided, results are converted to relative units ($mm \equiv kg\ m^{-2}$).

Hydrological year convention

All analyses follow a **hydrological year definition**, which runs from **October to September**. This convention ensures that winter and spring high-flow periods are grouped within the same annual cycle, improving the interpretation of seasonal flow dynamics.

Streamflow trend analysis at one gauging station

The following sections demonstrate the full workflow using daily streamflow data from the Gállego River at Anzánigo (station 2203), located in the central Spanish Pyrenees.

Data preparation

We first load the daily discharge series and convert it into an `xts` time-series object for further analysis.

Also, create a time series of NA values to indicate missing data in plots.

```
dat <- read.table("../data/Anzanigo.csv", sep = ",", skip = 11)
dat <- xts::xts(dat[, 2], order.by = as.Date(dat[, 1], format = "%d/%m/%Y"))
dat.na <- xts::xts(ifelse(is.na(dat), 1, NA), order.by = time(dat))
```

Daily streamflow series

The following plot shows the full daily record, with red bars indicating missing values.

```
plot(dat,
  ylab = "m3 s-1",
  main = "Gállego en Anzánigo",
  sub = "Daily streamflow"
)
points(dat.na, pch = "|", cex = 0.5, col = "red")
```

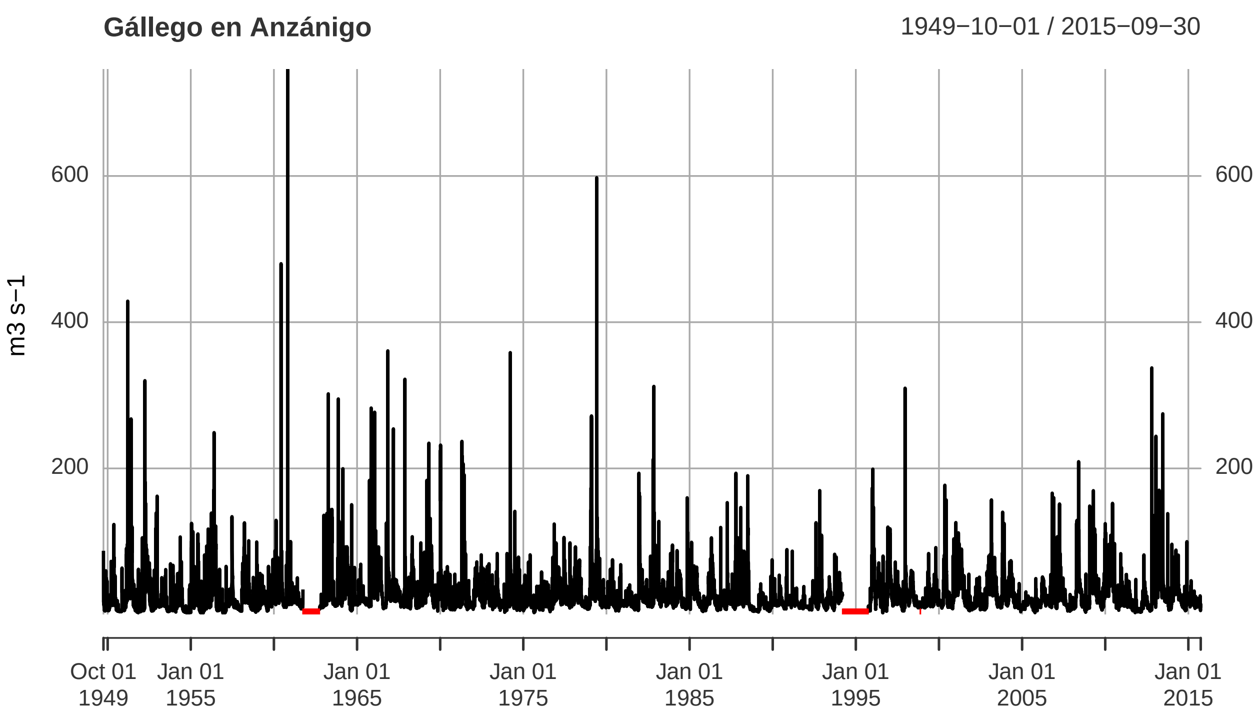

Figure 1: Daily streamflow at Gállego in Anzánigo ($m^3 s^{-1}$)

Empirical flow distribution (ECDF)

This plot shows the empirical cumulative distribution of daily discharge, highlighting the skewed distribution typical of mountain rivers.

```r
colnames(dat) <- "value"
lims <- signif(quantile(dat$value, c(0.002, 0.999), na.rm = TRUE), 1)
lims[1] <- max(lims[1], 0.01)
ggplot(dat, aes(x = value)) +
  stat_ecdf(pad = FALSE) +
  ggtitle(
    label = "ECDF of daily streamflow",
    subtitle = "(Gállego River at Anzánigo)") +
  ylab("Frequency") +
  xlab(expression(m^{3} ~ s^{-1})) +
  scale_y_continuous(breaks = c(0.10, 0.25, 0.5, 0.75, 0.9)) +
  scale_x_continuous(trans = "log10", limits = lims,
                     guide = guide_axis(check.overlap = TRUE)) +
  theme_bw()
```

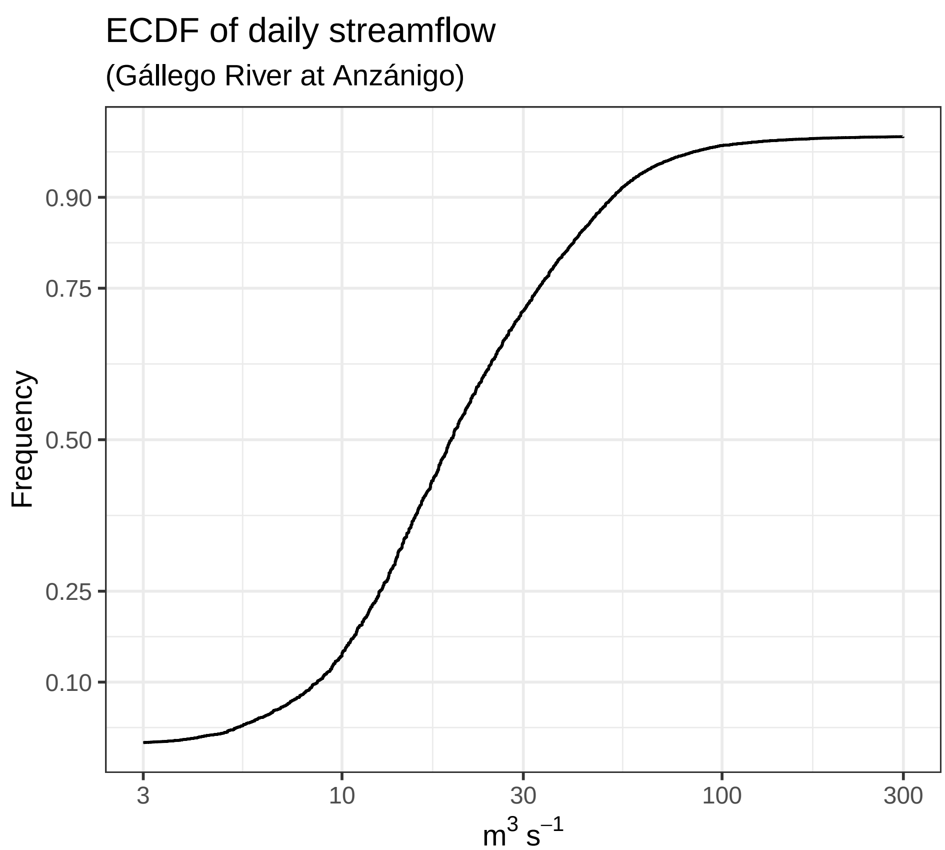

Figure 2: Empirical Cumulative Distribution Function (ECDF) of daily streamflow at Gállego in Anzánigo.

Annual streamflow indicators

The following plot displays the annual evolution of all computed indices, illustrating interannual variability and long-term hydrological behaviour.

```r
annual <- piragua_annual(x = dat)
plot(zoo::as.zoo(annual[, -1]),
  xlab = "",
  main = ""
)
```

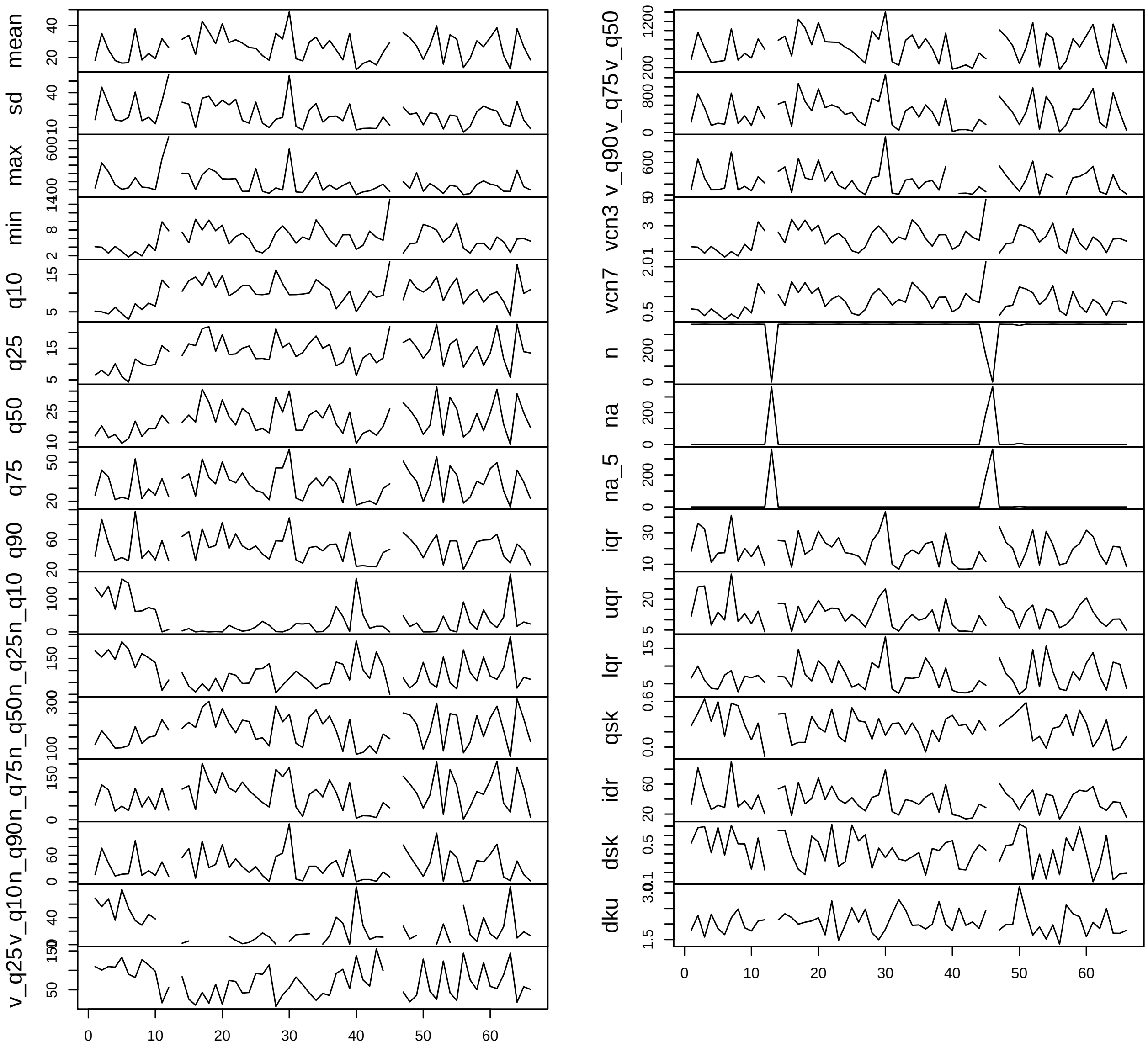

Figure 3: Annual time series of daily streamflow indicators at Gállego in Anzánigo ($m^3 s^{-1}$).

When the catchment area is provided, streamflow is expressed as an equivalent depth of water (mm), enabling comparison across basins of different size.

```
annual_rel <- piragua_annual(dat, area = 1391)
plot(zoo::as.zoo(annual_rel[, -1]),
  xlab = "",
  main = ""
)
```

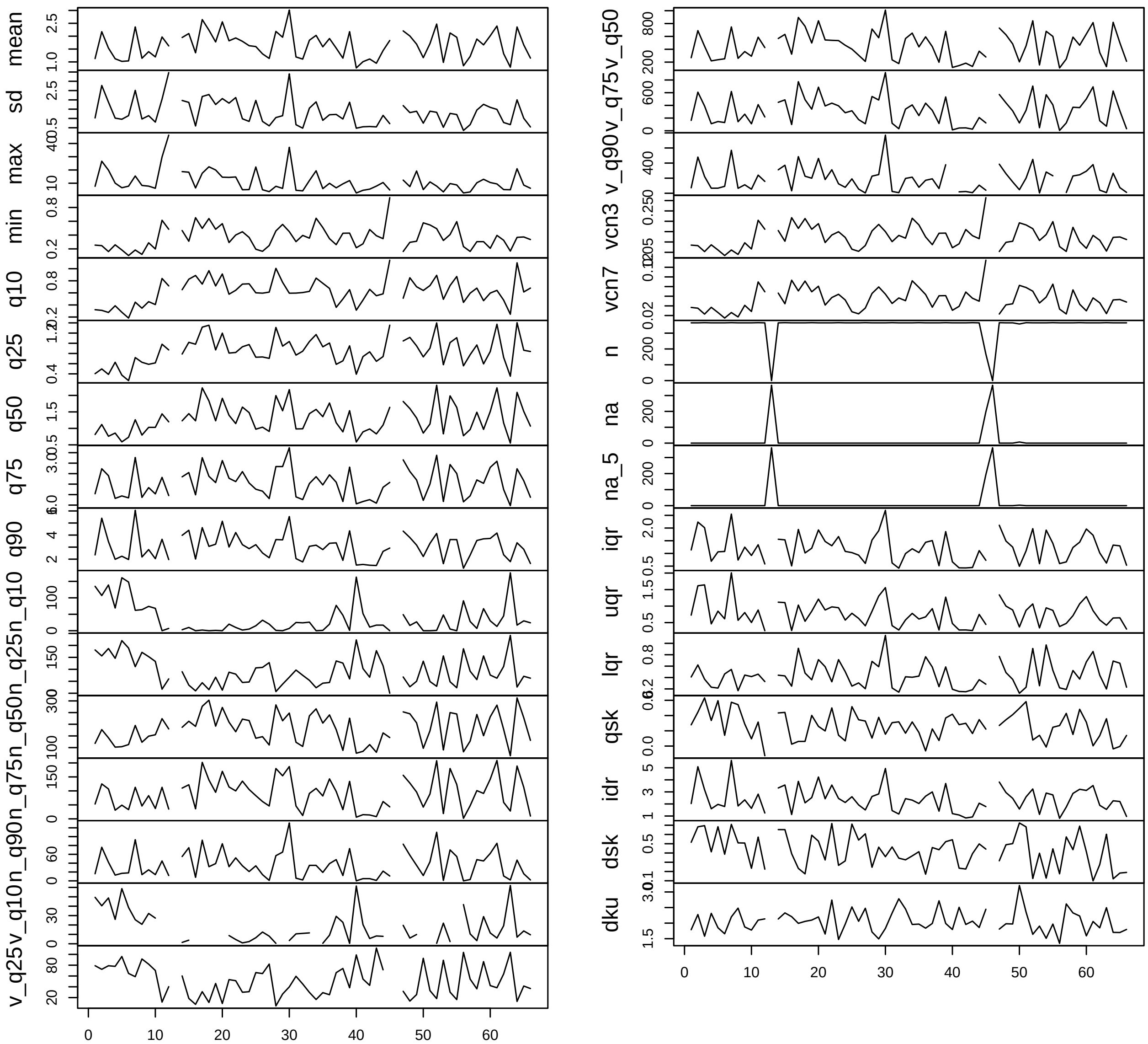

Figure 4: Annual time series of daily streamflow indicators at Gállego in Anzánigo (mm).

Monthly streamflow indicators

Monthly statistics provide a more detailed view of intra-annual dynamics, allowing identification of seasonal changes in flow regimes.

```r
monthly <- piragua_monthly(x = dat) # , area=1391
plot(zoo::as.zoo(monthly[, -c(1, 2)]),
  xlab = "",
  main = ""
)
```

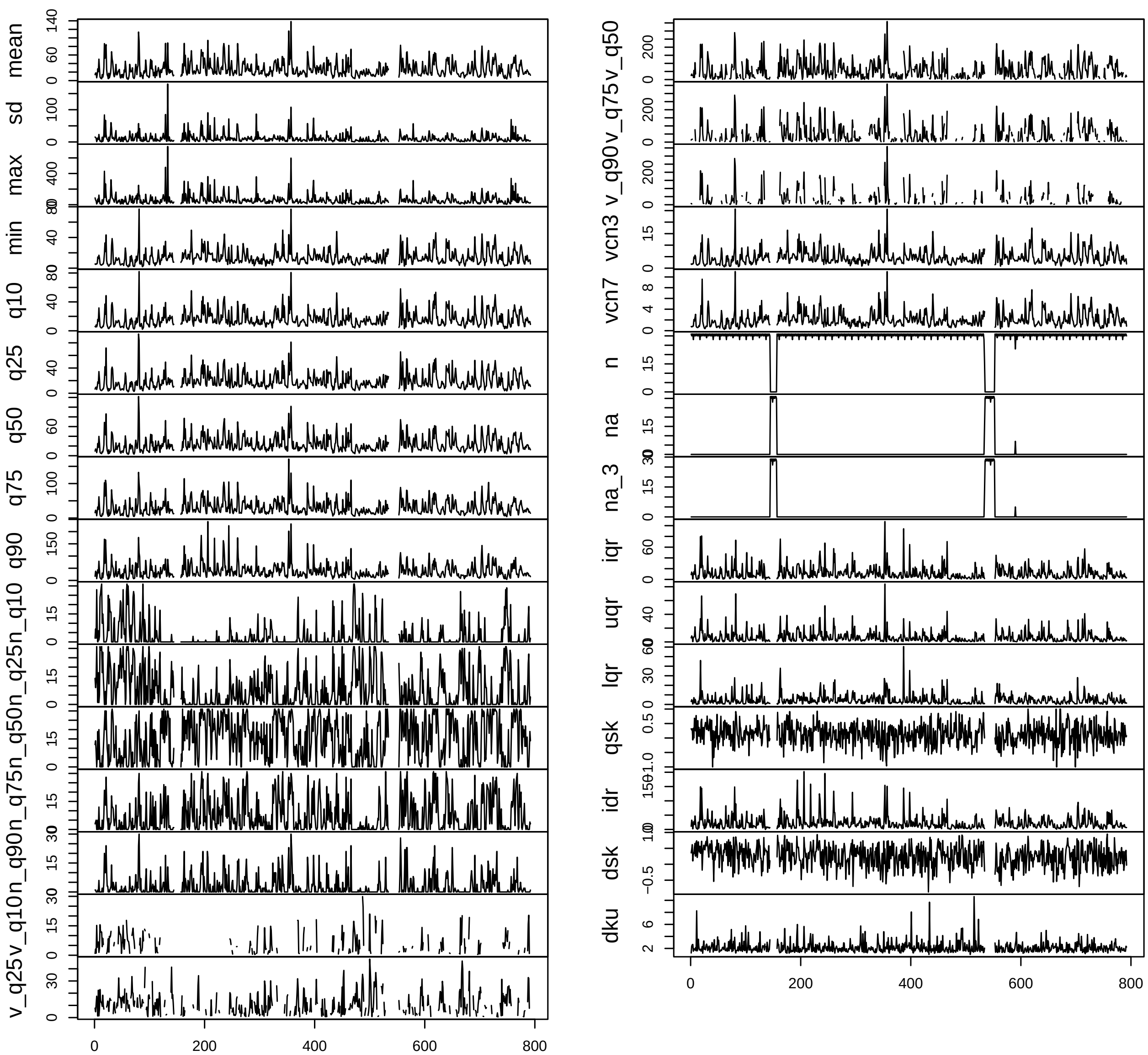

Figure 5: Monthly time series of daily streamflow indicators at Gállego in Anzánigo ($m^3 s^{-1}$).

Annual trend analysis

The following table summarizes the estimated long-term trends in each annual indicator, computed using the Yue–Pilon prewhitening and Sen's slope method.

```r
trend_y <- piragua_trend(annual)
kableExtra::kbl(trend_y, digits = 2, booktabs = TRUE, longtable = TRUE,
                caption = "Streamflow indices annual trends (m3 s-1)") |>
  kableExtra::kable_styling(latex_options = "hold_position", font_size = 8) |>
  kableExtra::row_spec(0, angle = 90)
```

Table 1: Streamflow indices annual trends (m3 s-1)

	lbound	trend	trendp	trendd	trend_r	trendp_r	trendd_r	ubound	tau	sig	nruns	autocor	valid_frac	linear	intercept
mean	-0.15	-0.02	-1.19	-0.19	-0.07	-4.41	-0.69	0.09	-0.03	0.71	1	0.03	1	-0.01	26.90
sd	-0.32	-0.18	-11.74	-1.83	-0.71	-45.63	-7.13	-0.04	-0.21	0.02	1	0.05	1	-0.20	25.72
max	-3.22	-1.70	-108.72	-16.99	-0.91	-58.05	-9.07	-0.39	-0.21	0.01	1	0.13	1	-2.39	187.28
min	-0.02	0.01	0.58	0.09	0.23	14.91	2.33	0.04	0.06	0.49	1	0.25	1	0.01	3.91
q10	-0.01	0.03	1.98	0.31	0.47	30.03	4.69	0.08	0.12	0.15	1	0.26	1	0.04	6.59
q25	-0.01	0.06	3.56	0.56	0.58	36.91	5.77	0.11	0.15	0.09	1	0.17	1	0.06	9.65
q50	-0.04	0.06	3.56	0.56	0.33	21.06	3.29	0.16	0.10	0.25	1	0.07	1	0.07	16.90
q75	-0.17	-0.04	-2.51	-0.39	-0.11	-7.14	-1.12	0.16	-0.04	0.63	1	0.00	1	-0.01	35.14
q90	-0.38	-0.11	-7.19	-1.12	-0.20	-12.64	-1.98	0.14	-0.07	0.41	1	-0.07	1	-0.14	56.87
vcn3	-0.01	0.00	0.26	0.04	0.30	19.29	3.01	0.02	0.06	0.51	1	0.22	1	0.01	1.37
vcn7	0.00	0.00	0.10	0.02	0.28	17.67	2.76	0.01	0.05	0.53	1	0.22	1	0.00	0.59
iqr	-0.19	-0.06	-3.65	-0.57	-0.28	-17.72	-2.77	0.07	-0.08	0.33	1	-0.01	1	-0.07	20.61
uqr	-0.16	-0.06	-3.88	-0.61	-0.43	-27.36	-4.28	0.02	-0.13	0.15	1	-0.01	1	-0.08	14.19
lqr	-0.05	0.00	-0.06	-0.01	-0.01	-0.83	-0.13	0.06	0.00	0.97	1	0.01	1	0.01	6.67
qsk	-0.01	0.00	-0.15	-0.02	-0.68	-43.56	-6.81	0.00	-0.16	0.07	1	0.05	1	0.00	0.35
idr	-0.39	-0.15	-9.61	-1.50	-0.33	-20.82	-3.25	0.12	-0.10	0.25	1	-0.08	1	-0.18	46.15
dsk	-0.01	0.00	-0.21	-0.03	-0.58	-36.85	-5.76	0.00	-0.20	0.02	1	-0.06	1	0.00	0.58
dku	-0.01	0.00	-0.17	-0.03	-0.12	-7.69	-1.20	0.00	-0.08	0.34	1	-0.08	1	0.00	2.26
rl20	NA	-4.97	NA	-49.73	-0.77	NA	-7.69	NA	NA	0.01	NA	NA	NA	NA	646.29

Trends are here expressed in relative terms (mm), facilitating the comparison of trend magnitudes among basins of varying catchment size.

```r
trend_y <- piragua_trend(annual_rel)
kableExtra::kbl(trend_y, digits = 2, booktabs = TRUE, longtable = TRUE,
                caption = "Streamflow indices annual trends (mm)") |>
  kableExtra::kable_styling(latex_options = "hold_position", font_size = 8) |>
  kableExtra::row_spec(0, angle = 90)
```

Table 2: Streamflow indices annual trends (mm)

	lbound	trend	trendp	trendd	trend_r	trendp_r	trendd_r	ubound	tau	sig	nruns	autocor	valid_frac	linear	intercept
mean	-0.01	0.00	-0.07	-0.01	-0.07	-4.41	-0.69	0.01	-0.03	0.71	1	0.03	1	0.00	1.67
sd	-0.02	-0.01	-0.73	-0.11	-0.71	-45.63	-7.13	0.00	-0.21	0.02	1	0.05	1	-0.01	1.60
max	-0.20	-0.11	-6.75	-1.06	-0.91	-58.05	-9.07	-0.02	-0.21	0.01	1	0.13	1	-0.15	11.63
min	0.00	0.00	0.04	0.01	0.23	14.91	2.33	0.00	0.06	0.49	1	0.25	1	0.00	0.24
q10	0.00	0.00	0.12	0.02	0.47	30.03	4.69	0.00	0.12	0.15	1	0.26	1	0.00	0.41
q25	0.00	0.00	0.22	0.03	0.58	36.91	5.77	0.01	0.15	0.09	1	0.17	1	0.00	0.60
q50	0.00	0.00	0.22	0.03	0.33	21.06	3.29	0.01	0.10	0.25	1	0.07	1	0.00	1.05
q75	-0.01	0.00	-0.16	-0.02	-0.11	-7.14	-1.12	0.01	-0.04	0.63	1	0.00	1	0.00	2.18
q90	-0.02	-0.01	-0.45	-0.07	-0.20	-12.64	-1.98	0.01	-0.07	0.41	1	-0.07	1	-0.01	3.53
vcn3	0.00	0.00	0.02	0.00	0.30	19.29	3.01	0.00	0.06	0.51	1	0.22	1	0.00	0.09
vcn7	0.00	0.00	0.01	0.00	0.28	17.67	2.76	0.00	0.05	0.53	1	0.22	1	0.00	0.04
iqr	-0.01	0.00	-0.23	-0.04	-0.28	-17.72	-2.77	0.00	-0.08	0.33	1	-0.01	1	0.00	1.28
uqr	-0.01	0.00	-0.24	-0.04	-0.43	-27.36	-4.28	0.00	-0.13	0.15	1	-0.01	1	0.00	0.88
lqr	0.00	0.00	0.00	0.00	-0.01	-0.83	-0.13	0.00	0.00	0.97	1	0.01	1	0.00	0.41
qsk	-0.01	0.00	-0.15	-0.02	-0.68	-43.56	-6.81	0.00	-0.16	0.07	1	0.05	1	0.00	0.35
idr	-0.02	-0.01	-0.60	-0.09	-0.33	-20.82	-3.25	0.01	-0.10	0.25	1	-0.08	1	-0.01	2.87
dsk	-0.01	0.00	-0.21	-0.03	-0.58	-36.85	-5.76	0.00	-0.20	0.02	1	-0.06	1	0.00	0.58
dku	-0.01	0.00	-0.17	-0.03	-0.12	-7.69	-1.20	0.00	-0.08	0.34	1	-0.08	1	0.00	2.26
rl20	NA	-0.31	NA	-3.09	-0.77	NA	-7.69	NA	NA	0.01	NA	NA	NA	NA	40.13

Monthly trend analysis

Monthly trend estimates reveal the seasonality of changes in streamflow indicators. Here, results are shown for October as an example.

```r
trend_m <- piragua_trend(monthly)
kableExtra::kbl(trend_m["October", , ], digits = 2, booktabs = TRUE, longtable = TRUE,
                caption = "Streamflow indices trends for October (m3 s-1)") |>
  kableExtra::kable_styling(latex_options = "hold_position", font_size = 8) |>
  kableExtra::row_spec(0, angle = 90)
```

Table 3: Streamflow indices trends for October (m3 s-1)

	lbound	trend	trendp	trendd	trend_r	trendp_r	trendd_r	ubound	tau	sig	nruns	autocor	valid_frac	linear	intercept
mean	-0.11	0.01	0.73	0.11	0.08	5.05	0.79	0.12	0.01	0.87	1	0.02	1	-0.01	14.55
sd	-0.05	0.04	2.67	0.42	0.72	46.20	7.22	0.14	0.09	0.30	1	-0.07	1	-0.03	5.79
max	-0.38	0.11	6.78	1.06	0.28	17.66	2.76	0.57	0.04	0.65	1	-0.08	1	-0.05	38.42
min	-0.09	-0.04	-2.78	-0.43	-0.68	-43.70	-6.83	0.00	-0.16	0.07	1	0.28	1	-0.03	6.36
q10	-0.11	-0.04	-2.66	-0.42	-0.55	-35.27	-5.51	0.02	-0.12	0.17	1	0.24	1	-0.03	7.55
q25	-0.11	-0.04	-2.41	-0.38	-0.44	-28.14	-4.40	0.02	-0.09	0.31	1	0.22	1	-0.02	8.56
q50	-0.11	-0.03	-1.64	-0.26	-0.22	-14.21	-2.22	0.08	-0.04	0.66	1	0.13	1	0.00	11.56
q75	-0.10	0.02	1.48	0.23	0.16	10.27	1.60	0.16	0.03	0.75	1	0.04	1	0.06	14.45
q90	-0.09	0.09	5.86	0.92	0.51	32.95	5.15	0.29	0.09	0.29	1	0.03	1	0.08	17.78
vcn3	-0.03	-0.02	-0.96	-0.15	-0.67	-42.85	-6.69	0.00	-0.15	0.09	1	0.29	1	-0.01	2.25
vcn7	-0.01	-0.01	-0.33	-0.05	-0.50	-31.91	-4.99	0.00	-0.12	0.17	1	0.27	1	0.00	1.03
iqr	0.00	0.06	4.10	0.64	1.59	102.02	15.94	0.13	0.17	0.05	1	-0.06	1	0.09	4.02
uqr	0.01	0.05	2.91	0.45	2.25	144.00	22.50	0.09	0.19	0.03	1	-0.11	1	0.06	2.02
lqr	-0.02	0.01	0.64	0.10	0.78	50.16	7.84	0.03	0.07	0.39	1	0.10	1	0.03	1.27
qsk	0.00	0.00	0.18	0.03	3.06	196.11	30.64	0.01	0.07	0.39	1	0.07	1	0.00	0.09
idr	0.01	0.13	8.53	1.33	1.61	103.15	16.12	0.29	0.17	0.04	1	-0.02	1	0.11	8.27
dsk	0.00	0.00	0.10	0.02	0.61	39.19	6.12	0.01	0.04	0.62	1	0.16	1	0.00	0.25
dku	-0.01	0.00	-0.19	-0.03	-0.18	-11.33	-1.77	0.01	-0.05	0.55	1	0.16	1	0.00	1.64
rl20	NA	1.01	NA	10.13	0.46	NA	4.59	NA	NA	0.10	NA	NA	NA	NA	220.49

This table summarizes trends for the 50th percentile (median flow), allowing direct comparison of central tendency changes through the hydrological year. Similar tables can be generated for any other index by modifying the code below.

```
kableExtra::kbl(trend_m[, "q50", ], digits = 2, booktabs = TRUE, longtable = TRUE,
                caption = "50th quantile (median) monthly trends (m3 s-1)") |>
  kableExtra::kable_styling(latex_options = "hold_position", font_size = 8) |>
  kableExtra::row_spec(0, angle = 90)
```

Table 4: 50th quantile (median) monthly trends (m3 s-1)

	lbound	trend	trendp	trendd	trend_r	trendp_r	trendd_r	ubound	tau	sig	nruns	autocor	valid_frac	linear	intercept
October	-0.11	-0.03	-1.64	-0.26	-0.22	-14.21	-2.22	0.08	-0.04	0.66	1	0.13	1	0.00	11.56
November	-0.15	-0.02	-0.98	-0.15	-0.12	-7.38	-1.15	0.12	-0.02	0.85	1	0.15	1	-0.01	13.25
December	-0.11	0.07	4.24	0.66	0.42	26.69	4.17	0.23	0.06	0.48	1	0.08	1	0.10	15.89
January	-0.08	0.07	4.44	0.71	0.58	36.37	5.77	0.24	0.08	0.37	1	0.16	1	0.16	12.21
February	-0.16	0.01	0.45	0.07	0.04	2.56	0.40	0.19	0.01	0.93	1	0.16	1	0.06	17.72
March	-0.21	-0.03	-2.17	-0.34	-0.13	-8.57	-1.34	0.13	-0.03	0.70	1	-0.09	1	-0.04	25.33
April	-0.10	0.12	7.57	1.20	0.50	31.47	5.00	0.35	0.09	0.30	1	0.09	1	0.11	24.05
May	-0.25	-0.02	-1.49	-0.24	-0.06	-3.78	-0.60	0.22	-0.02	0.84	1	-0.05	1	-0.08	39.47
June	-0.42	-0.16	-10.22	-1.62	-0.40	-25.22	-4.00	0.04	-0.14	0.11	1	-0.07	1	-0.25	40.51
July	-0.07	0.04	2.44	0.39	0.19	11.97	1.90	0.14	0.06	0.47	1	-0.14	1	0.06	20.39
August	0.06	0.13	7.97	1.26	1.51	95.35	15.14	0.19	0.32	0.00	1	0.16	1	0.13	8.36
September	-0.02	0.05	3.11	0.49	0.52	32.78	5.20	0.11	0.13	0.15	1	0.13	1	0.06	9.49

The following table reports the p-values of the trend tests for all months and indices, identifying where trends are statistically significant ($p \leq 0.05$).

```r
kableExtra::kbl(trend_m[, , "sig"], digits = 2, booktabs = TRUE, longtable = TRUE,
                caption = "Monthly streamflow indices trends (significance)") |>
  kableExtra::kable_styling(latex_options = "hold_position", font_size = 8) |>
  kableExtra::row_spec(0, angle = 90)
```

Table 5: Monthly streamflow indices trends (significance)

	mean	sd	max	min	q10	q25	q50	q75	q90	vcn3	vcn7	iqr	uqr	lqr	qsk	idr	dsk	dku
October	0.87	0.30	0.65	0.07	0.17	0.31	0.66	0.75	0.29	0.09	0.17	0.05	0.03	0.39	0.39	0.04	0.62	0.55
November	0.90	0.77	0.64	0.81	0.99	0.76	0.85	0.88	0.78	0.85	0.83	0.99	0.91	0.92	0.86	0.64	0.65	0.16
December	0.54	0.93	0.78	0.19	0.28	0.14	0.48	0.59	0.70	0.24	0.20	0.78	0.97	0.87	0.62	0.76	0.41	0.52
January	0.51	0.35	0.67	0.07	0.09	0.15	0.37	0.53	0.86	0.07	0.05	0.62	0.89	0.36	0.49	0.55	0.59	0.58
February	0.70	0.01	0.04	0.34	0.48	0.51	0.93	0.60	0.41	0.41	0.46	0.03	0.02	0.11	0.09	0.09	0.03	0.55
March	0.21	0.16	0.12	0.64	0.82	0.76	0.70	0.22	0.05	0.64	0.63	0.35	0.11	0.65	0.24	0.07	0.11	0.76
April	0.44	0.84	0.32	0.72	0.38	0.27	0.30	0.78	0.90	0.66	0.47	0.38	0.07	0.58	0.01	0.48	0.02	0.49
May	0.72	0.52	0.69	1.00	0.90	0.99	0.84	0.62	0.77	0.92	0.63	0.75	0.64	0.42	0.63	0.54	0.35	0.87
June	0.04	0.03	0.02	0.10	0.15	0.24	0.11	0.10	0.02	0.11	0.27	0.21	0.36	0.09	0.22	0.06	0.54	0.52
July	0.72	0.01	0.11	0.03	0.01	0.01	0.47	0.19	0.13	0.05	0.09	0.01	0.02	0.15	0.16	0.01	0.05	0.03
August	0.00	0.62	0.98	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.88	0.89	0.58	0.73	0.65	0.34	0.90
September	0.69	0.05	0.20	0.28	0.23	0.17	0.15	0.68	0.78	0.11	0.14	0.14	0.01	0.52	0.01	0.12	0.00	0.54

Conclusions

This notebook provides a reproducible workflow to compute hydrological indicators, detect trends, and visualize the behaviour of daily streamflow data using the `piragua_*` functions. The approach is adaptable to multiple gauging stations and can be extended to other hydroclimatic variables such as precipitation and temperature.

Session information

```r
sessionInfo()
```

```
## R version 4.4.3 (2025-02-28)
## Platform: aarch64-apple-darwin20
## Running under: macOS 26.0.1
##
## Matrix products: default
## BLAS:   /System/Library/Frameworks/Accelerate.framework/Versions/A/Frameworks/vecLib.framework/Versi
## LAPACK: /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRlapack.dylib;  LAPACK ve
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: Europe/Madrid
## tzcode source: internal
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
##  [1] piragua_0.1.0  abind_1.4-8    evd_2.3-7.1    ismev_1.42
##  [5] mgcv_1.9-1     nlme_3.1-167   zyp_0.11-1     Kendall_2.2.1
##  [9] ggplot2_3.5.1  devtools_2.4.5 usethis_3.1.0
##
## loaded via a namespace (and not attached):
##  [1] tidyselect_1.2.1  viridisLite_0.4.2 farver_2.1.2
##  [4] dplyr_1.1.4       fastmap_1.2.0     promises_1.3.2
##  [7] digest_0.6.37     timechange_0.3.0  mime_0.12
## [10] lifecycle_1.0.4   ellipsis_0.3.2    processx_3.8.6
## [13] magrittr_2.0.3    compiler_4.4.3    rlang_1.1.5
## [16] tools_4.4.3       yaml_2.3.10       knitr_1.49
## [19] askpass_1.2.1     htmlwidgets_1.6.4 sp_2.2-0
## [22] pkgbuild_1.4.6    xml2_1.3.7        pkgload_1.4.0
## [25] miniUI_0.1.1.1    withr_3.0.2       purrr_1.0.4
## [28] sys_3.4.3         desc_1.4.3        grid_4.4.3
## [31] roxygen2_7.3.2    urlchecker_1.0.1  profvis_0.4.0
## [34] xts_0.14.1        xtable_1.8-4      colorspace_2.1-1
## [37] scales_1.3.0      tinytex_0.56      cli_3.6.4
## [40] rmarkdown_2.29    generics_0.1.3    remotes_2.5.0
## [43] rstudioapi_0.17.1 commonmark_1.9.2  sessioninfo_1.2.3
## [46] cachem_1.1.0      stringr_1.5.1     splines_4.4.3
## [49] vctrs_0.6.5       boot_1.3-31       Matrix_1.7-3
## [52] callr_3.7.6       credentials_2.0.2 systemfonts_1.2.3
## [55] testthat_3.2.3    glue_1.8.0        ps_1.9.0
## [58] lubridate_1.9.4   stringi_1.8.4     gtable_0.3.6
## [61] later_1.4.1       munsell_0.5.1     tibble_3.2.1
## [64] pillar_1.10.1     htmltools_0.5.8.1 brio_1.1.5
## [67] openssl_2.3.2     R6_2.6.1          textshaping_1.0.0
## [70] gert_2.1.4        rprojroot_2.0.4   evaluate_1.0.3
## [73] shiny_1.10.0      kableExtra_1.4.0  lattice_0.22-6
## [76] memoise_2.0.1     httpuv_1.6.15     Rcpp_1.0.14
## [79] svglite_2.2.1     gridExtra_2.3     whisker_0.4.1
```

```
## [82] xfun_0.51          fs_1.6.5           zoo_1.8-13
## [85] pkgconfig_2.0.3
```