OGC-biomass

Climate Data Analyses

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Contents

```r
## Read in data
climate.data <- read_csv("data/OGC_final_biomass_data.csv", show_col_types = FALSE) %>%
    select(UID, Year, Season, Period, CaCO, Carbon, Conductivity, DO, pH, Water_Temperature,
                 Air_Temperature, Precipitation, Mean_Discharge)

## Set variables as factors
climate.data$UID            <- as_factor(climate.data$UID)
climate.data$Year           <- as_factor(climate.data$Year)
climate.data$Season         <- as_factor(climate.data$Season)
climate.data$Period         <- as_factor(climate.data$Period)
```

USGS Discharge Data

We obtained average daily discharge (m^3 s^{-1}) and water chemistry metrics from the United States Geological Survey (USGS, gage 02202500) to calculate the average discharge over a two-week period preceding each sampling date. Discharge data were downloaded using the `waterData` package.

```r
## List of start dates
start.dates <- c("1981-12-02", "1982-01-09", "1982-02-15", "1982-03-09",
                 "1982-04-02", "1982-04-30", "1982-05-25", "1982-06-26",
                 "1982-07-23", "1982-08-19", "1982-09-15", "1982-10-15",
                 "1982-11-18", "1982-12-24", "1983-01-22", "1983-02-18",
                 "1983-03-25", "1983-04-23", "1983-05-20", "1983-06-17",
                 "1983-07-15", "1983-08-13", "1983-09-09", "1983-10-08",
                 "1983-11-04",
                 "2015-06-26", "2015-07-27", "2015-08-29", "2015-10-02",
                 "2015-11-06", "2015-12-03", "2016-01-21", "2016-02-24",
                 "2016-03-30", "2016-04-27", "2016-05-31", "2016-08-03",
                 "2016-09-05", "2016-10-05", "2016-11-02", "2016-11-30",
                 "2017-01-06", "2017-02-10", "2017-03-08", "2017-04-12",
                 "2017-05-03", "2017-05-29", "2017-07-05", "2017-08-08")

## List of end dates
end.dates <- c("1981-12-16", "1982-01-23", "1982-03-01", "1982-03-23",
               "1982-04-16", "1982-05-14", "1982-06-08", "1982-07-10",
               "1982-08-06", "1982-09-02", "1982-09-29", "1982-10-29",
               "1982-12-02", "1983-01-07", "1983-02-05", "1983-03-04",
               "1983-04-08", "1983-05-07", "1983-06-03", "1983-07-01",
               "1983-07-29", "1983-08-27", "1983-09-23", "1983-10-22",
               "1983-11-18",
               "2015-07-10", "2015-08-10", "2015-09-12", "2015-10-16",
               "2015-11-20", "2015-12-17", "2016-02-04", "2016-03-09",
               "2016-04-13", "2016-05-11", "2016-06-14", "2016-08-17",
               "2016-09-19", "2016-10-19", "2016-11-16", "2016-12-14",
               "2017-01-20", "2017-02-24", "2017-03-22", "2017-04-26",
               "2017-05-17", "2017-06-12", "2017-07-19", "2017-08-22")

## Bind start and end dates into a single dataframe
flow.dates <- as.data.frame(cbind(start.dates, end.dates))

## Add UID identifier to flow dates
flow.dates$UID <- climate.data$UID
```

```r
## Empty dataframe for discharge data
discharge.data <- tibble(data.frame(matrix(0, nrow = 15, ncol = 49)))

## Append data for all dates
for(x in 1:49){
  require(waterData)
  bin.1 <- importDVs(staid = "02202500", code = "00060", stat = "00003",
                     sdate = flow.dates[x, 1],
                     edate = flow.dates[x, 2])
  bin.2 <- cleanUp(bin.1, task = "fix", replace = 0.001)
  bin.3 <- fillMiss(bin.1, block = 2, pmiss = 5, model = "trend",
                    smooth = FALSE, log = "y")
  bin.4 <- bin.3[, c(2, 3)]
  colnames(bin.4) <- c(flow.dates[x, 3])
  discharge.data[, x] <- bin.4[, 1]
}
```

```r
## Calculate two week mean & convert from ft3 to m3
mean.discharge <- sapply(discharge.data, mean)
metric.shift   <- (mean.discharge / 35.315)

## Create mean discharge dataframe
metric.shift            <- tibble(mean.discharge)
metric.shift$UID        <- climate.data$UID
```

Climate Data Management

We obtained historical USGS discharge data from 1969 to 2018 to determine average daily discharge for the winter-spring season (i.e., flood-prone months) of each year. Water temperature data collected from 1974 until 2018 were also obtained from the USGS water quality dataset. Precipitation data from 1970 until 2018 were obtained from the National Weather Service Forecast Office in Louisville, GA.

```r
## Read in 50-year climate data
climate.data <- read.csv("data/OGC_long_term_climate_data.csv")

## Subset data by season
winter.spring.data <- climate.data %>%
    filter(Season_String == "WinterSpring")
summer.fall.data   <- climate.data %>%
    filter(Season_String == "SummerFall")

## Vector of sampling period info
winter.spring.sampling.info <- winter.spring.data[, 1:4]
summer.fall.sampling.info   <- summer.fall.data[, 1:4]
```

```r
## Aggregate mean values by year for the winter-spring data

## Winter-spring discharge
winter.spring.discharge <- aggregate(
    Mean_Discharge ~ Year,
    data = winter.spring.data,
    FUN = mean
    )

## Winter-spring precipitation
winter.spring.precipitation <- aggregate(
    Precipitation ~ Year,
    data = winter.spring.data,
    FUN = mean
    ) %>%
    na.omit()

## Winter-spring air temperature
winter.spring.air.temperature <- aggregate(
    Air_Temperature ~ Year,
    data = winter.spring.data,
    FUN = mean
    ) %>%
    na.omit()

## Winter-spring water temperature
winter.spring.water.temperature <- aggregate(
    Water_Temperature ~ Year,
    data = winter.spring.data,
    FUN = mean
    ) %>%
    na.omit()
```

```r
## Aggregate mean values by year for the summer-fall data

## Summer-fall discharge
summer.fall.discharge <- aggregate(
    Mean_Discharge ~ Year,
    data = summer.fall.data,
    FUN = mean
    )

## Summer-fall precipitation
summer.fall.precipitation <- aggregate(
    Precipitation ~ Year,
    data = summer.fall.data,
    FUN = mean
    ) %>%
    na.omit()

## Summer-fall air temperature
summer.fall.air.temperature <- aggregate(
    Air_Temperature ~ Year,
    data = summer.fall.data,
    FUN = mean
    ) %>%
    na.omit()

## Summer-fall water temperature
summer.fall.water.temperature <- aggregate(
    Water_Temperature ~ Year,
    data = summer.fall.data,
    FUN = mean
    ) %>%
    na.omit()
```

Discharge & Climate Mann-Kendall Tests

We assessed temporal trends in discharge, precipitation, water temperature, and air temperature using autocorrelation function estimation and Mann-Kendall tests for each of the Winter-Spring and Summer-Fall flooding seasons. We calculated monthly averages for each variable, and then assessed a shift in the time series using `MannKendall()`.

Winter-Spring

```
MannKendall(winter.spring.discharge$Mean_Discharge)
# tau = -0.248, P = 0.012
```

```
MannKendall(winter.spring.precipitation$Precipitation)
# tau = -0.087, P = 0.384
```

```
MannKendall(winter.spring.air.temperature$Air_Temperature)
# tau = -0.11, P = 0.270
```

```
MannKendall(winter.spring.water.temperature$Water_Temperature)
# tau = 0.442, P < 0.001
```

Summer-Fall

```
MannKendall(summer.fall.discharge$Mean_Discharge)
# tau = -0.179, P = 0.072
```

```
MannKendall(summer.fall.precipitation$Precipitation)
# tau = -0.014, P = 0.897
```

```
MannKendall(summer.fall.air.temperature$Air_Temperature)
# tau = -0.1, P = 0.313
```

```
MannKendall(summer.fall.water.temperature$Water_Temperature)
# tau = 0.212, P = 0.044
```

Discharge & Climate ANOVAs

Description goes here.

ANOVAs were conducted for discharge and each climate parameter, testing the effect of period, season, and the interaction with Type II sums-of-squares [`Anova()`]. ANOVA assumptions were inspected graphically using `check_model()`, and effect sizes for the ANOVAs were calculated as η^2_P using `eta_squared()`.

```
## Filter long-term climate data to only include the sampling periods
# Select rows for the 1980s and 2010s sampling period
sampling.period.climate.data <- climate.data[c(145:168, 548:571), ]

# Add vector of sampling period to aid in later analyses
sampling.period.climate.data$Period <- c(rep("1980s", times = 24), rep("2010s", times = 24))
```

Discharge

```
discharge.anova <- lm(
    log(Mean_Discharge) ~ Period * Season, data = sampling.period.climate.data
    )
```

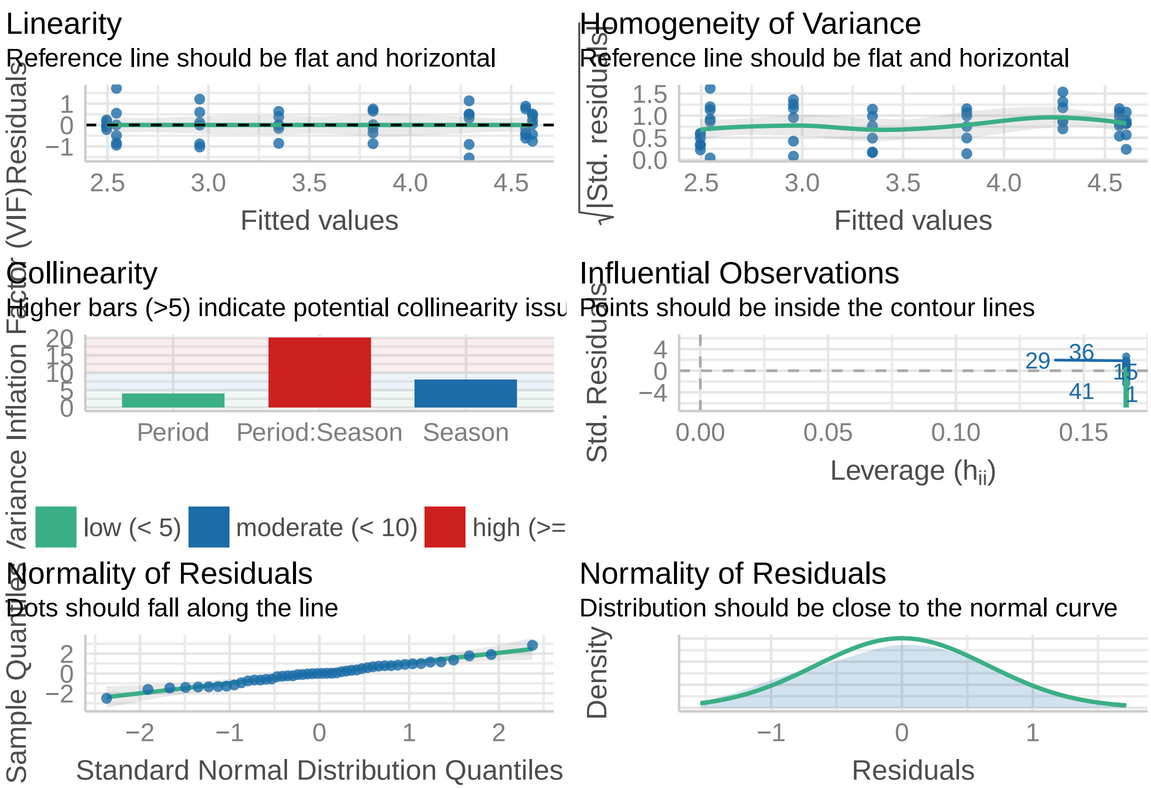

Figure 1: Diagnostic plots of the discharge ANOVA.

Table 1: ANOVA results for discharge by period, season, and the interaction.

	Sums-of-Squares	df	F	P-value
Period	0.462	1	0.899	0.349
Season	27.134	3	17.598	0.000
Period:Season	4.126	3	2.676	0.060
Residuals	20.558	40	NA	NA

```r
## Calculating partial eta-squared for each factor in the discharge ANOVA
discharge.anova.eta.squared <- eta_squared(
    Anova(discharge.anova, type = "II"),
    partial = TRUE
    )
```

Table 2: Table of the effect sizes in the predator biomass ANOVA.

Term	Eta-squared	CI	CI_Low	CI_High
Period	0.022	0.95	0.000	1
Season	0.569	0.95	0.379	1
Period:Season	0.167	0.95	0.000	1

Precipitation

```
precipitation.anova <- lm(
    Precipitation ~ Period * Season, data = sampling.period.climate.data
    )
```

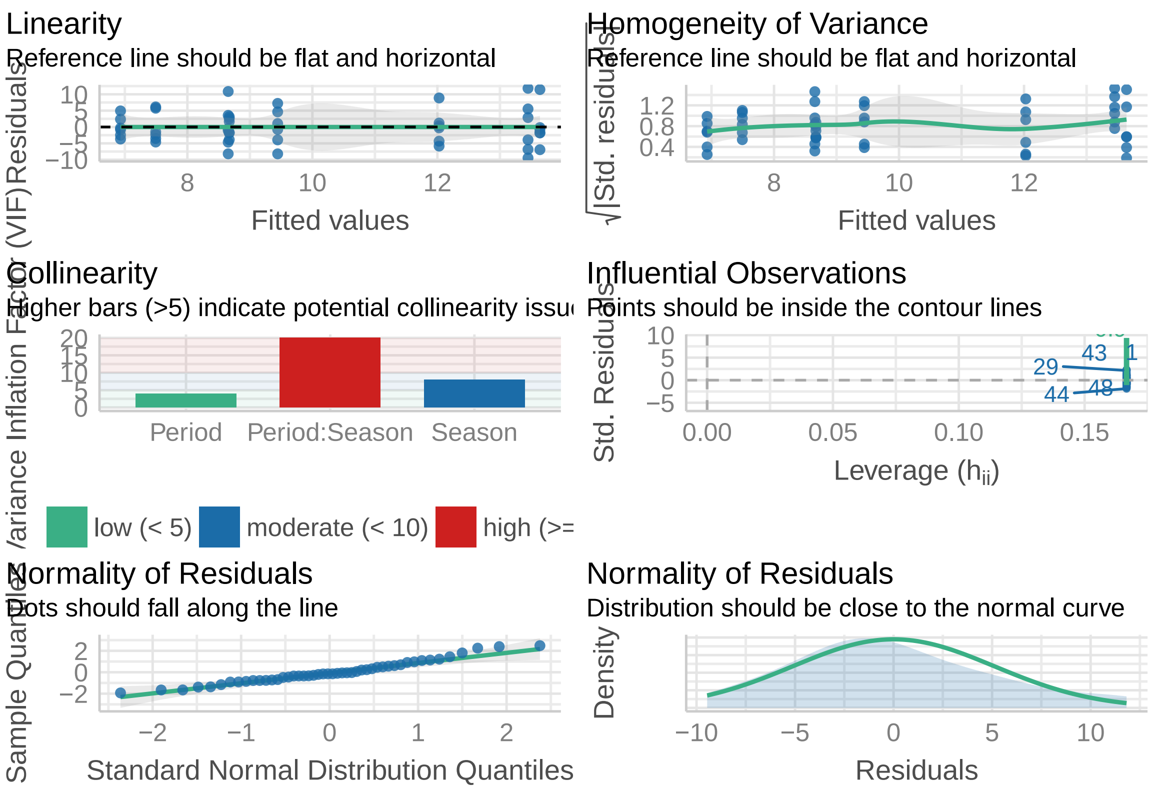

Figure 2: Diagnostic plots of the precipitation ANOVA.

Table 3: ANOVA results for precipitation by period, season, and the interaction.

	Sums-of-Squares	df	F	P-value
Period	2.462	1	0.080	0.779
Season	236.146	3	2.558	0.069
Period:Season	54.462	3	0.590	0.625
Residuals	1230.761	40	NA	NA

```
## Calculating partial eta-squared for each factor in the precipitation ANOVA
precipitation.anova.eta.squared <- eta_squared(
    Anova(precipitation.anova, type = "II"),
    partial = TRUE
    )
```

Table 4: Table of the effect sizes in the predator biomass ANOVA.

Term	Eta-squared	CI	CI_Low	CI_High
Period	0.002	0.95	0	1
Season	0.161	0.95	0	1
Period:Season	0.042	0.95	0	1

Air Temperature

```
air.temperature.anova <- lm(
    Air_Temperature ~ Period * Season, data = sampling.period.climate.data
    )
```

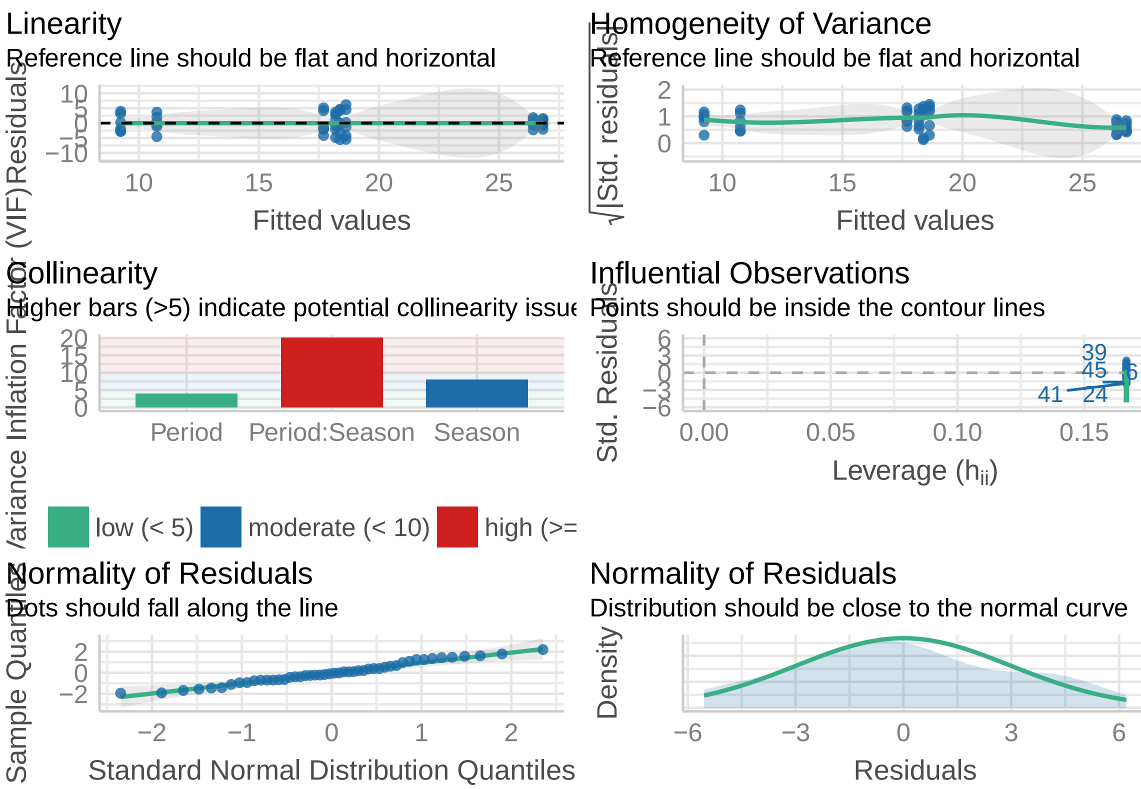

Figure 3: Diagnostic plots of the air temperature ANOVA.

Table 5: ANOVA results for air.temperature by period, season, and the interaction.

	Sums-of-Squares	df	F	P-value
Period	5.333	1	0.511	0.479
Season	1662.167	3	53.036	0.000
Period:Season	2.936	3	0.094	0.963
Residuals	417.874	40	NA	NA

```r
## Calculating partial eta-squared for each factor in the air temperature ANOVA
air.temperature.anova.eta.squared <- eta_squared(
    Anova(air.temperature.anova, type = "II"),
    partial = TRUE
    )
```

Table 6: Table of the effect sizes in the predator biomass ANOVA.

Term	Eta-squared	CI	CI_Low	CI_High
Period	0.013	0.95	0.000	1
Season	0.799	0.95	0.699	1
Period:Season	0.007	0.95	0.000	1

Water Temperature

```
water.temperature.anova <- lm(
    Water_Temperature ~ Period * Season, data = sampling.period.climate.data
    )
```

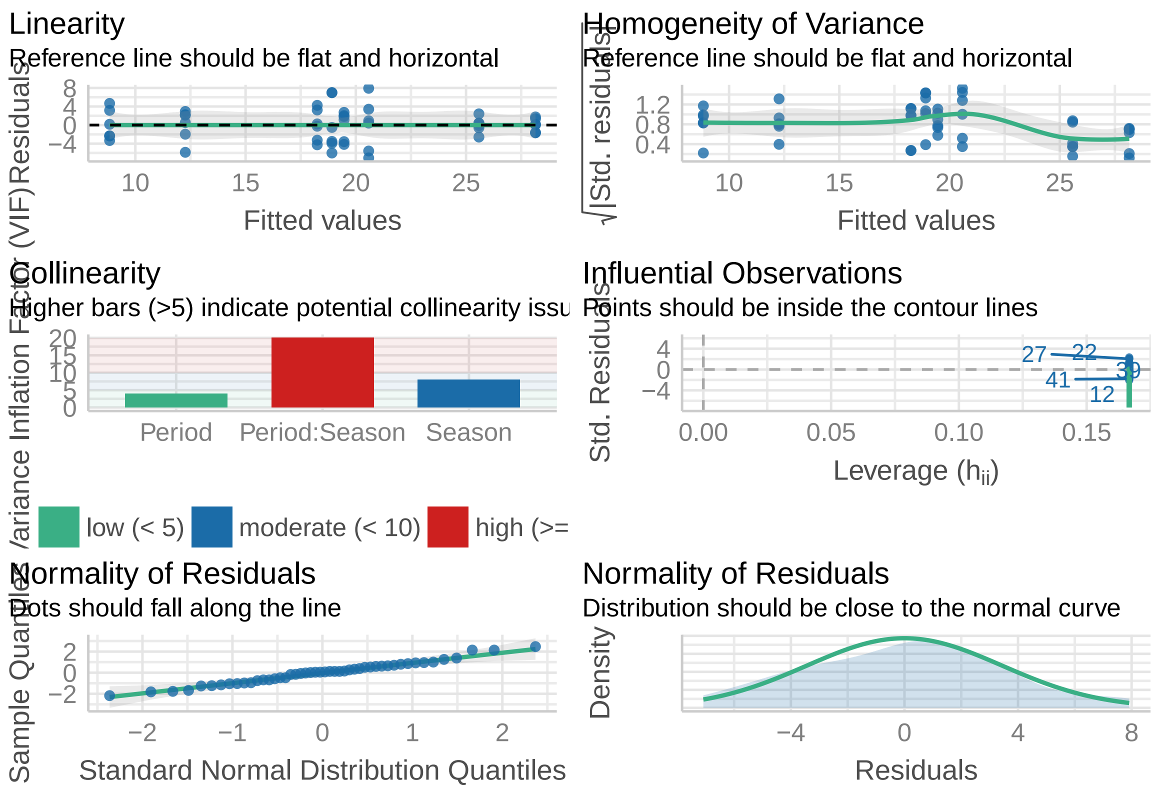

Figure 4: Diagnostic plots of the water temperature ANOVA.

Table 7: ANOVA results for water.temperature by period, season, and the interaction.

	Sums-of-Squares	df	F	P-value
Period	23.102	1	1.661	0.205
Season	1606.432	3	38.507	0.000
Period:Season	44.799	3	1.074	0.371
Residuals	556.235	40	NA	NA

```r
## Calculating partial eta-squared for each factor in the water temperature ANOVA
water.temperature.anova.eta.squared <- eta_squared(
    Anova(water.temperature.anova, type = "II"),
    partial = TRUE
    )
```

Table 8: Table of the effect sizes in the predator biomass ANOVA.

Term	Eta-squared	CI	CI_Low	CI_High
Period	0.040	0.95	0.000	1
Season	0.743	0.95	0.617	1
Period:Season	0.075	0.95	0.000	1

R Session Information

Table 9: R session information for transparency and reproducing results.

Setting	Value
version	R version 4.1.2 (2021-11-01)
os	macOS Big Sur 10.16
system	x86_64, darwin17.0
ui	X11
language	(EN)
collate	en_CA.UTF-8
ctype	en_CA.UTF-8
tz	America/New_York
date	2022-01-03
pandoc	2.14.0.3 @ /Applications/RStudio.app/Contents/MacOS/pandoc/ (via rmarkdown)

Table 10: Packages for data management and analysis.

Package	Loaded Version	Date
bayestestR	0.11.5	2021-10-30
car	3.0-12	2021-11-06
carData	3.0-4	2020-05-22
correlation	0.7.1	2021-10-06
datawizard	0.2.1	2021-10-04
dplyr	1.0.7	2021-06-18
easystats	0.4.3	2021-11-07
effectsize	0.5	2021-10-04
forcats	0.5.1	2021-01-27
ggplot2	3.3.5	2021-06-25
insight	0.14.5	2021-10-16
kableExtra	1.3.4	2021-02-20
Kendall	2.2	2011-05-18
knitr	1.37	2021-12-16
modelbased	0.7.0.1	2021-11-17
parameters	0.15.0	2021-10-18
performance	0.8.0	2021-10-01
purrr	0.3.4	2020-04-17
readr	2.1.1	2021-11-30
report	0.4.0	2021-09-30
see	0.6.8	2021-10-03
stringr	1.4.0	2019-02-10
tibble	3.1.6	2021-11-07
tidyr	1.1.4	2021-09-27
tidyverse	1.3.1	2021-04-15
waterData	1.0.8	2017-04-28