Package 'RiverLoad'

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Type Package

Title Load Estimation of River Compounds with Different Methods

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Description Implements several of the most popular load estimation procedures, including averaging methods, ratio estimators and regression methods. The package provides an easy-to-use tool to rapidly calculate the load for various compounds and to compare different methods. The package also supplies additional functions to easily organize and analyze the data.

License GPL (>= 2)

Encoding UTF-8

LazyData true

Depends R (>= 2.10)

Imports graphics, grDevices, stats, imputeTS

RoxygenNote 7.1.2

NeedsCompilation no

Repository CRAN

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R topics documented:

`annual.mean` *Annual mean of flow records*

Description

The function returns the annual arithmetic mean of flow records. It is also possible to obtain the standard deviation.

Usage

```
annual.mean(flow.data, standev)
```

Arguments

`flow.data`	A dataframe with a first column with DateTime information in standard format(yyyy-mm-dd HH:MM:SS) labeled "datetime" and a second column with flow records labelede "flow".
`standev`	An optional argument. If the user specifies "sd", the function will return the value of the standard deviation for each row.

Value

A data frame with two columns: the first with the years (labeled "year") and the second with annual mean flow data (labeled "flow"). If the user has specified "sd", there is a third column with standard deviation value for each row (labeled "sd").

Author(s)

Veronica Nava

See Also

daily.mean monthly.mean monthly.year.mean

Examples

```
data("flow.data1")
annual.mean(flow.data1)
annual.mean(flow.data1, "sd")
```

---

beale.period *Load estimation with Beale ratio estimator based on monthly or annual relationship*

Description

Estimate the load using the Beale ratio methods (Quilbe' et al., 2006). The bias correction factor and the subsequent load estimation are calculated monthly or annually based on the user's specification in the 'period' argument.

Usage

```
beale.period(db, ncomp, period)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with continuous flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.
period	A mandatory argument that specify the time period in which the regression relationship must be calculated. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load.

Value

A matrix with the estimated load for the different compounds. If the optional argument is equal to "month", the load values are reported by month in different rows. If the optional argument is equal to "year", the load values are reported by year in different rows. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Quilbe', R., Rousseau, A. N., Duchemin, M., Poulin, A., Gangbazo, G., & Villeneuve, J. P. (2006). Selecting a calculation method to estimate sediment and nutrient loads in streams: Application to the Beaurivage River (Quebec, Canada). Journal of Hydrology, 326(1-4), 295-310. https://doi.org/10.1016/j.jhydrol.2005.11.

See Also

db.union beale.ratio

Examples

```
data("flow.data1","conc.data1")
union<-db.union(flow.data1, conc.data1)
beale.periodM<-beale.period(union, 2, "month")
beale.periodY<-beale.period(union, 2, "year")
```

---

beale.ratio *Load estimation with Beale ratio method*

Description

Estimate the load using the Beale ratio methods (Quilbe' et al., 2006). The estimation is performed on the time period spanned by flow records. It is also possible to estimate the load monthly or annually specifying optional argument. However, the bias correction factor is still calculated over the entire period.

Usage

```
beale.ratio(db, ncomp, period)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with continuous flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.
period	Optional argument. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load. If it misses, the calculation is performed on the time period spanned by the streamflow data.

Value

A matrix with the estimated load with Beale ratio for the different compounds. If the optional argument 'period' misses, the matrix will have only one row with the load estimation done throughout the time period spanned by streamflow data. Otherwise, if the period is specified, the load is estimated in the different months/year and the load values are returned in different rows, named with the month/year considered. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Quilbe', R., Rousseau, A. N., Duchemin, M., Poulin, A., Gangbazo, G., & Villeneuve, J. P. (2006). Selecting a calculation method to estimate sediment and nutrient loads in streams: Application to the Beaurivage River (Quebec, Canada). Journal of Hydrology, 326(1-4), 295-310. https://doi.org/10.1016/j.jhydrol.2005.11.

See Also

db.union

Examples

```
data("flow.data1", "conc.data1")
union<-db.union(flow.data1, conc.data1)
beale<-beale.ratio(union, 2)
beale.month<-beale.ratio(union, 2, "month")
beale.year<-beale.ratio(union, 2, "year")
```

---

conc.data1 *Concentration dataset of Kaskaskia River*

Description

Scattered concentration data of nitrite plus nitrate ("NOx") and soluble reactive phosphorus ("SRP") of Kaskaskia River, IL. The data are expressed in mg/L and covered a two-year period from January 2016 to December 2017.

Usage

```
data("conc.data1")
```

Format

A data frame with 130 observations on the following 3 variables.

`datetime` a POSIXct

`NOx` a numeric vector

`SRP` a numeric vector

Source

https://waterdata.usgs.gov/usa/nwis/uv?05595000

References

USGS, United States Geological Survey

Examples

```
data("conc.data1")
str(conc.data1)
summary(conc.data1)
```

---

conc.data2 *Concentration dataset of Sandusky River*

Description

Scattered concentration data of total phosphorus ("TP") of Sandusky River, Ohio. The data are expressed in mg/L and covered a one-year period from January 2017 to December 2017.

Usage

```
data("conc.data2")
```

Format

A data frame with 104 observations on the following 2 variables.

`datetime` a POSIXct

`TP` a numeric vector

Source

https://ncwqr.org/monitoring/

References

Heidelberg Tributary Loading Program (HTLP) and USGS, United States Geological Survey

Examples

```
data("conc.data2")
str(conc.data2)
summary(conc.data2)
```

conc.data3 *Dataset with faked concentration records of Adda River*

Description

Scattered concentration data of Total Nitrogen ("TN") in mg/L. The data were made up for explanatory purpouse. The dataset covers a one-year period, from January 2017 to December 2017.

Usage

```
data("conc.data3")
```

Format

A data frame with 43 observations on the following 2 variables.

`datetime` a POSIXct

`TN` a numeric vector

Examples

```
data("conc.data3")
str(conc.data3)
```

CQregression *Relationship between concentration and flow*

Description

Calculate the R^2 of the relationship between concentration and flow. Statistically significant correlation between concentration and flow is mandatory to perform analysis using regression methods (Quilbe' et al., 2006; Aulenbach et al., 2016).

Usage

```
CQregression(db, ncomp)
```

Arguments

`db`	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with continuous flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output data frame of the function db.union.
`ncomp`	Number of compounds in the input data frame for which the load must be estimated.

Value

A matrix with R^2 for each compound.

Author(s)

Veronica Nava

References

Quilbe', R., Rousseau, A. N., Duchemin, M., Poulin, A., Gangbazo, G., & Villeneuve, J. P. (2006). Selecting a calculation method to estimate sediment and nutrient loads in streams: Application to the Beaurivage River (Quebec, Canada). Journal of Hydrology, 326(1-4), 295-310. https://doi.org/10.1016/j.jhydrol.2005.11.
Aulenbach, B. T., Burns, D. A., Shanley, J. B., Yanai, R. D., Bae, K., Wild, A. D.,...,Yi, D. (2016). Approaches to stream solute load estimation for solutes with varying dynamics from five diverse small watersheds. Ecosphere, 7(6), 1-22. https://doi.org/10.1002/ecs2.1298

See Also

`db.union` `rating` `ferguson`

Examples

```
data("flow.data1","conc.data1")
union<-db.union(flow.data1, conc.data1)
reg.relationship<-CQregression(union, 2)
```

`daily.mean` *Daily mean of flow records*

Description

The function returns the daily arithmetic mean of flow records.

Usage

```
daily.mean(flow.data, standev)
```

Arguments

`flow.data`	A dataframe with a first column with DateTime information in standard format(yyyy-mm-dd HH:MM:SS) labeled "datetime" and a second column with flow records labelede "flow".
`standev`	An optional argument. If the user specifies "sd", the function will return the standard deviation for each row.

Value

A data frame with two columns: the first with the day and the second with annual mean flow data (labeled "flow"). If the user has specified "sd", there is a third column with standard deviation value for each row (labeled "sd").

Author(s)

Veronica Nava

See Also

`annual.mean` `monthly.mean` `monthly.year.mean`

Examples

```
data("flow.data1")
daily.mean(flow.data1)
daily.mean(flow.data1, "sd")
```

`db.intersect` *Intersection of flow and concentration data in a unique data frame*

Description

Flow and concentration data are merged in a unique data frame on the basis of DateTime information. The function pairs the data maintaining the rows in which both the concentration and the flow records are available. None 'NA' value is reported

Usage

```
db.intersect(flow.data, conc.data)
```

Arguments

`flow.data`	A dataframe with a first column with DateTime information in standard format(yyyy-mm-dd HH:MM:SS) labeled "datetime" and a second column with continuous flow records labelede "flow".
`conc.data`	A dataframe with a first column with DateTime information in standard format (yyyy-mm-dd HH:MM:SS) and the following columns with concentration of different compounds in milligram per litre.

Value

A dataframe with three columns: the first column with DateTime in standard format (yyyy-mm-dd HH:MM:SS), the second column with flow records, and the third column with concentration data, paired on the basis of datetime column. Only the rows in which both concentration and flow data are available are maintened.

Author(s)

Veronica Nava

See Also

db.union

Examples

```
data("flow.data2","conc.data2")
intersect<-db.intersect(flow.data2, conc.data2)
summary<-db.intersect
```

---

db.union *Union of flow and concentration data in a unique data frame*

Description

This function allows merging the data maintaining all the available flow records with the scattered concentration values on the basis of DateTime information

Usage

```
db.union(flow.data, conc.data)
```

Arguments

flow.data	A dataframe with a first column with DateTime information in standard format(yyyy-mm-dd HH:MM:SS) labeled "datetime" and a second column with continuous flow records labelede "flow".
conc.data	A dataframe with a first column with DateTime information in standard format (yyyy-mm-dd HH:MM:SS) and the following columns with concentration of different compounds in milligram per litre.

Value

A dataframe with three columns: the first column with DateTime in standard format (yyyy-mm-dd HH:MM:SS), the second column with continuous flow records, and the third column with scattered concentration data, paired on the basis of datetime column. All the flow data are mainteined. For the DateTime in which concentration data are not available, 'NA' is reported.

Author(s)

Veronica Nava

See Also

db.intersect

Examples

```
data("flow.data2", "conc.data2")
intersect<-db.intersect(flow.data2, conc.data2)
summary<-db.intersect
```

`ferguson` *Load estimation with Ferguson rating curve*

Description

Estimate the load using a log-log rating curve between concentration and streamflow values at the time of sampling. The load value were then multiplied by a correction factor to get an unbiased estimator(Quilbe' et al., 2006; Worrall, Howden, & Burt, 2013). The estimation is performed on the time period spanned by flow records. It is also possible to estimate the load monthly or annually specifying optional argument.

Usage

```
ferguson(db, ncomp, period)
```

Arguments

`db`	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with continuous flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
`ncomp`	Number of compounds in the input data frame for which the load must be estimated.
`period`	Optional argument. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load. If it misses, the calculation is performed on the time period spanned by the streamflow data.

Value

A matrix with the estimated load for the different compounds. If the optional argument 'period' misses, the matrix will have only one row with the load estimation done throughout the time period spanned by streamflow data. Otherwise, if the period is specified, the load is estimated in the different months/year and the load values are returned in different rows, named with the month/year considered. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Quilbe', R., Rousseau, A. N., Duchemin, M., Poulin, A., Gangbazo, G., & Villeneuve, J. P. (2006). Selecting a calculation method to estimate sediment and nutrient loads in streams: Application to the Beaurivage River (Quebec, Canada). Journal of Hydrology, 326(1-4), 295-310. https://doi.org/10.1016/j.jhydrol.2005.11.
Worrall, F., Howden, N. J. K., & Burt, T. P. (2013). Assessment of sample frequency bias and precision in fluvial flux calculations - An improved low bias estimation method. Journal of Hydrology, 503, 101–110. https://doi.org/10.1016/j.jhydrol.2013.08.048

See Also

db.union CQregression

Examples

```
data("flow.data2", "conc.data2")
union<-db.union(flow.data2, conc.data2)
CQregression(union,1)
ferg<-ferguson(union, 1)
ferg.month<-ferguson(union, 1, "month")
ferg.year<-ferguson(union, 1, "year")
```

---

ferguson.period *Load estimation with Ferguson method based on monthly or annual relationship*

Description

Estimate the load using a a monthly or annual based log-log rating curve between values of concentration and river flow at the time of sampling (multiple regression analyses are performed monthly/annually). The load value were then multiplied by a correction factor to get an unbiased estimator(Quilbe' et al., 2006; Worrall, Howden, & Burt, 2013).

Usage

```
ferguson.period(db, ncomp, period)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with continuous flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.
period	A mandatory argument that specify the time period in which the regression relationship must be calculated. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load.

Value

A matrix with the estimated load for the different compounds. If the optional is equal to "month", the load values are reported by month in different rows. If the optional argument is equal to "year", the load values are reported by year in different rows. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Quilbe', R., Rousseau, A. N., Duchemin, M., Poulin, A., Gangbazo, G., & Villeneuve, J. P. (2006). Selecting a calculation method to estimate sediment and nutrient loads in streams: Application to the Beaurivage River (Quebec, Canada). Journal of Hydrology, 326(1-4), 295-310, https://doi.org/10.1016/j.jhydrol.2005.11.0
Worrall, F., Howden, N. J. K., & Burt, T. P. (2013). Assessment of sample frequency bias and precision in fluvial flux calculations - An improved low bias estimation method. Journal of Hydrology, 503, 101–110, https://doi.org/10.1016/j.jhydrol.2013.08.048.

See Also

db.union ferguson rsquared.period

Examples

```
data("flow.data2","conc.data2")
union<-db.union(flow.data2, conc.data2)
fer.periodM<-ferguson.period(union, 1, "month")
fer.periodY<-ferguson.period(union, 1, "year")
```

---

flow.data1 *Dataset of flow record of Kaskskia River*

Description

Dataframe with two columns: a first column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime" and a second column with flow records labeled "flow". These latter are expressed in cubic metre per second. The dataset covers a two-year period with flow records every 1 day.

Usage

```
data(flow.data1)
```

Format

A data frame with 731 observations on the following 2 variables.

`datetime` a POSIXct

`flow` a numeric vector

Source

https://waterdata.usgs.gov/usa/nwis/uv?05595000

References

USGS, United States Geological Survey

Examples

```
data("flow.data1")
summary(flow.data1)
```

---

flow.data2 *Dataset of flow record of Sandusky River*

Description

Dataframe with two columns: a first column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime" and a second column with flow records labeled "flow". These latter are expressed in cubic metre per second. The dataset covers a one-year period with flow records every 1 day.

Usage

```
data("flow.data2")
```

Format

A data frame with 365 observations on the following 2 variables.

`datetime` a POSIXct

`flow` a numeric vector

Source

https://ncwqr.org/monitoring/

References

Heidelberg Tributary Loading Program (HTLP) and USGS, United States Geological Survey

Examples

```
data(flow.data2)
summary(flow.data2)
```

`flow.data3` *Flow record dataset of Adda River*

Description

Dataframe with two colmns: a first column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime" and a second column with flow records labeled "flow". These latter are expressed in cubic metre per second. The dataset covers a one-year period with flow records every 12 hours.

Usage

```
data("flow.data3")
```

Format

A data frame with 728 observations on the following 2 variables.

`datetime` a POSIXct

`flow` a numeric vector

Source

http://www.arpalombardia.it/siti/arpalombardia/meteo/richiesta-dati-misurati/Pagine/RichiestaDatiMisurati.aspx

References

ARPA-Lombardia, Italian Environmental Protection Agency

Examples

```
data("flow.data3")
str(flow.data3)
```

`method1` *Load estimation with time-weighted flow and concentration method*

Description

Estimate the load based on the time-weighted flow and concentration method (Moatar & Meybeck, 2005). The estimation is performed on the time period spanned by flow records. It is possible to estimate the load also monthly or annually.

Usage

```
method1(db, ncomp, period)
```

Arguments

`db`	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
`ncomp`	Number of compounds in the input data frame for which the load must be estimated.
`period`	Optional argument. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load. If it misses, the calculation is performed on the time period spanned by the streamflow data.

Value

A matrix with the estimated load with time-weighted flow and concentration method for the different compounds. If the optional argument 'period' misses, the matrix will have only one row with the load estimation done throughout the time period spanned by streamflow data. Otherwise, if the period is specified, the load is estimated in the different months/year and the load values are returned in different rows, named with the month/year considered. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Moatar, F., & Meybeck, M. (2005). Compared performances of different algorithms for estimating annual nutrient loads discharged by the eutrophic River Loire. Hydrological Processes, 19(2), 429-444. https://doi.org/10.1002/hyp.5541

See Also

`db.union`

Examples

```
data("flow.data1","conc.data1")
union<-db.union(flow.data1, conc.data1)
met1<-method1(union, 2)
met1.month<-method1(union, 2, "month")
met1.year<-method1(union, 2, "year")
```

`method2` *Load estimation with discharge-weighted concentration method*

Description

Estimate the load based on the discharge-weighted concentration method (Moatar & Meybeck, 2005). The estimation is performed on the time period spanned by flow records.It is possible to estimate the load also monthly or annually.

Usage

```
method2(db, ncomp, period)
```

Arguments

`db`	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
`ncomp`	Number of compounds in the input data frame for which the load must be estimated.
`period`	Optional argument. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load. If it misses, the calculation is performed on the time period spanned by the streamflow data.

Value

A matrix with the estimated load with discharge-weighted concentration method for the different compounds. If the optional argument 'period' misses, the matrix will have only one row with the load estimation done throughout the time period spanned by streamflow data. Otherwise, if the period is specified, the load is estimated in the different months/year and the load values are returned in different rows, named with the month/year considered. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Moatar, F., & Meybeck, M. (2005). Compared performances of different algorithms for estimating annual nutrient loads discharged by the eutrophic River Loire. Hydrological Processes, 19(2), 429-444. https://doi.org/10.1002/hyp.5541

See Also

db.union

Examples

```
data("flow.data1", "conc.data1")
union<-db.union(flow.data1, conc.data1)
met2<-method2(union, 2)
met2.month<-method2(union, 2, "month")
met2.year<-method2(union, 2, "year")
```

---

method3 *Load estimation with mean discharge-weighted concentration method*

Description

Estimate the load with the mean discharge-weighted concentration method (Moatar & Meybeck, 2005). The estimation is performed on the time period spanned by flow records. It is possible to estimate the load also monthly or annually.

Usage

```
method3(db, ncomp, period)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.
period	Optional argument. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load. If it misses, the calculation is performed on the time period spanned by the streamflow data.

Value

A matrix with the estimated load with mean discharge-weighted concentration method for the different compounds. If the optional argument 'period' misses, the matrix will have only one row with the load estimation done throughout the time period spanned by streamflow data. Otherwise, if the period is specified, the load is estimated in the different months/year and the load values are returned in different rows, named with the month/year considered. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Moatar, F., & Meybeck, M. (2005). Compared performances of different algorithms for estimating annual nutrient loads discharged by the eutrophic River Loire. Hydrological Processes, 19(2), 429-444. https://doi.org/10.1002/hyp.5541

See Also

db.union

Examples

```
data("flow.data1", "conc.data1")
union<-db.union(flow.data1, conc.data1)
met3<-method3(union, 2)
met3.month<-method3(union, 2, "month")
met3.year<-method3(union, 2, "year")
```

---

method4 *Load estimation with time-weighted concentration method*

Description

Estimate the load with the time-weighted concentration method (Moatar & Meybeck, 2005; Worrall, Howden, & Burt, 2013). The estimation is performed on the time period spanned by flow records. It is also possible to estimate the load monthly or annually.

Usage

```
method4(db, ncomp, period)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.
period	Optional argument. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load. If it misses, the calculation is performed on the time period spanned by the streamflow data.

Value

A matrix with the estimated load with time-weighted concentration method for the different compounds. If the optional argument 'period' misses, the matrix will have only one row with the load estimation done throughout the time period spanned by streamflow data. Otherwise, if the period is specified, the load is estimated in the different months/year and the load values are returned in different rows, named with the month/year considered. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Moatar, F., & Meybeck, M. (2005). Compared performances of different algorithms for estimating annual nutrient loads discharged by the eutrophic River Loire. Hydrological Processes, 19(2), 429–444. https://doi.org/10.1002/hyp.5541. Worrall, F., Howden, N. J. K., & Burt, T. P. (2013). Assessment of sample frequency bias and precision in fluvial flux calculations - An improved low bias estimation method. Journal of Hydrology, 503, 101–110. https://doi.org/10.1016/j.jhydrol.2013.08.048.

See Also

db.union

Examples

```
data("flow.data1", "conc.data1")
union<-db.union(flow.data1, conc.data1)
met4<-method4(union, 2)
met4.month<-method4(union, 2, "month")
met4.year<-method4(union, 2, "year")
```

method5 *Load estimation with time and discharge weighted method*

Description

Estimate the load with the time and discharge weighted concentration method (Moatar & Meybeck, 2005; Worrall, Howden, & Burt, 2013). The estimation is performed on the time period spanned by flow records. It is also possible to estimate the load monthly or annually specifying an optional argument.

Usage

```
method5(db, ncomp, period)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.
period	Optional argument. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load. If it misses, the calculation is performed on the time period spanned by the streamflow data.

Value

A matrix with the estimated load with time and discharge weighted concentration method for the different compounds. If the optional argument 'period' misses, the matrix will have only one row with the load estimation done throughout the time period spanned by streamflow data. Otherwise, if the period is specified, the load is estimated in the different months/year and the load values are returned in different rows, named with the month/year considered. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Moatar, F., & Meybeck, M. (2005). Compared performances of different algorithms for estimating annual nutrient loads discharged by the eutrophic River Loire. Hydrological Processes, 19(2), 429–444. https://doi.org/10.1002/hyp.5541. Worrall, F., Howden, N. J. K., & Burt, T. P. (2013). Assessment of sample frequency bias and precision in fluvial flux calculations - An improved low bias estimation method. Journal of Hydrology, 503, 101–110. https://doi.org/10.1016/j.jhydrol.2013.08.048.

See Also

db.union

Examples

```
data("flow.data1", "conc.data1")
union<-db.union(flow.data1, conc.data1)
met5<-method5(union, 2)
met5.month<-method5(union, 2, "month")
met5.year<-method5(union, 2, "year")
```

---

method6 *Load estimation based on linear interpolation of concentration*

Description

Estimate the load linearly interpolating the concentration data and then multipling the values obtained by the flow records (Moatar & Meybeck, 2005). The estimation is performed on the time period spanned by flow records. It is also possible to estimate the load monthly or annually specifying optional argument.

Usage

```
method6(db, ncomp, period)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.
period	Optional argument. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load. If it misses, the calculation is performed on the time period spanned by the streamflow data.

Value

A matrix with the estimated load with linear interpolation of concentration method for the different compounds. If the optional argument 'period' misses, the matrix will have only one row with the load estimation done throughout the time period spanned by streamflow data. Otherwise, if the period is specified, the load is estimated in the different months/year and the load values are returned in different rows, named with the month/year considered. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Moatar, F., & Meybeck, M. (2005). Compared performances of different algorithms for estimating annual nutrient loads discharged by the eutrophic River Loire. Hydrological Processes, 19(2), 429-444. https://doi.org/10.1002/hyp.5541

Examples

```
data("flow.data1", "conc.data1")
union<-db.union(flow.data1, conc.data1)
met6<-method6(union, 2)
met6.month<-method6(union, 2, "month")
met6.year<-method6(union, 2, "year")
```

---

monthly.mean *Monthly mean of flow records not differentiated by year*

Description

The function returns the monthly arithmetic mean of continuous flow records.The mean is not differentiated by year,therefore if more year of flow records are reported, the mean refers to all flow records of the same month in the different years. It is also possible to obtain the standard deviation.

Usage

```
monthly.mean(flow.data, standev)
```

Arguments

flow.data	A dataframe with a first column with DateTime information in standard format(yyyy-mm-dd HH:MM:SS) labeled "datetime" and a second column with continuous flow records labelede "flow".
standev	An optional argument. If the user specifies "sd", the function will return the standard deviation for each row

Value

A data.frame with a first column with the months (labeled "month") and a second column with monthly mean flow (labeled "flow"). If the user has specified "sd", there is a third column with standard deviation value for each row (labeles "sd").

Author(s)

Veronica Nava

See Also

daily.mean monthly.year.mean annual.mean

Examples

```
data("flow.data2")
mon<-monthly.mean(flow.data2)
mon.sd<-monthly.mean(flow.data2, "sd")
```

---

monthly.year.mean *Monthly mean of flow records differentiated by year*

Description

The function returns the monthly arithmetic mean of flow records. The mean is differentiated by year,therefore if more years of flow records are reported, the function returns separately the mean for every single month of each year. It is also possible to obtain the standard deviation.

Usage

```
monthly.year.mean(flow.data, standev)
```

Arguments

flow.data	A dataframe with a first column with DateTime information in standard format(yyyy-mm-dd HH:MM:SS) labeled "datetime" and a second column with flow records labelede "flow".
standev	An optional argument. If the user specifies "sd", the function will return the standard deviation for each row

Value

A data.frame with a first column with the months (labeled "month") and a second column with monthly mean flow (labeled "flow"). If the user has specified "sd", there is a third column with standard deviation value for each row (labeles "sd").

Author(s)

Veronica Nava

Examples

```
data("flow.data1")
mon<-monthly.mean(flow.data1)
mon.sd<-monthly.mean(flow.data1, "sd")
```

`rating` *Load estimation with log log rating curve*

Description

Estimate the load using a log-log rating curve between values of concentration and river flow at the time of sampling (Quilbe' et al., 2006). The estimation is performed on the time period spanned by flow records. It is also possible to estimate the load monthly or annually specifying optional argument.

Usage

```
rating(db, ncomp, period)
```

Arguments

`db`	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
`ncomp`	Number of compounds in the input data frame for which the load must be estimated.
`period`	Optional argument. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load. If it misses, the calculation is performed on the time period spanned by the streamflow data.

Value

A matrix with the estimated load with regression method for the different compounds. If the optional argument 'period' misses, the matrix will have only one row with the load estimation done throughout the time period spanned by streamflow data. Otherwise, if the period is specified, the load is estimated in the different months/year and the load values are returned in different rows, named with the month/year considered. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Quilbe', R., Rousseau, A. N., Duchemin, M., Poulin, A., Gangbazo, G., & Villeneuve, J. P. (2006). Selecting a calculation method to estimate sediment and nutrient loads in streams: Application to the Beaurivage River (Quebec, Canada). Journal of Hydrology, 326(1-4), 295-310. https://doi.org/10.1016/j.jhydrol.2005.11.

See Also

`db.union` `CQregression`

Examples

```
data("flow.data1","conc.data1")
union<-db.union(flow.data1, conc.data1)
CQregression(union,1)
reg<-rating(union, 2)
reg.month<-rating(union, 2, "month")
reg.year<-rating(union, 2, "year")
```

`rating.period` *Load estimation with log log rating curve based on monthly or annual relationship*

Description

Estimate the load using a monthly or annual based log-log rating curve between values of concentration and river flow at the time of sampling (Quilbe' et al., 2006). Multiple regression analyses are performed. The estimation is performed on the time period spanned by flow records.

Usage

```
rating.period(db, ncomp, period)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.
period	A mandatory argument that specify the time period in which the regression relationship must be calculated. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load.

Value

A matrix with the estimated load for the different compounds. If the optional argument is equal to "month", the load values are reported by month in different rows. If the optional argument is equal to "year", the load values are reported by year in different rows. The load is expressed in gram per period of estimation.

Author(s)

Veronica Nava

References

Quilbe', R., Rousseau, A. N., Duchemin, M., Poulin, A., Gangbazo, G., & Villeneuve, J. P. (2006). Selecting a calculation method to estimate sediment and nutrient loads in streams: Application to the Beaurivage River (Quebec, Canada). Journal of Hydrology, 326(1-4), 295-310. https://doi.org/10.1016/j.jhydrol.2005.11.

See Also

db.union rating rsquared.period

Examples

```
data("flow.data2","conc.data2")
union<-db.union(flow.data2, conc.data1)
reg.periodM<-rating.period(union, 1, "month")
reg.periodY<-rating.period(union, 1, "year")
```

---

reg.inspection *Parameters of regression analysis between flow and concentration*

Description

Calculate regression analysis parameters. The output returns the slope and intercept coefficients and their related p-value, the R^2, the adjusted R^2, and the residual degrees-of-freedom

Usage

```
reg.inspection(db, ncomp)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.

Value

A matrix with the slope coefficient, the slope p-value, the intercept coefficient, the intercept p-value, the R^2, and the residual degrees-of-freedom for each compound.

Author(s)

Veronica Nava

See Also

db.union rating ferguson

Examples

```
data("flow.data3", "conc.data3")
union<-db.union(flow.data3, conc.data3)
reg.parametrs<-reg.inspection(union, 1)
```

---

residual.plot *Residual plots of one selected component*

Description

Obtain the diagnostic plots returned by plot.lm: a plot of residuals against fitted values, a Scale-Location plot of squared root of absolute value of residuals against fitted values, a Normal Q-Q plot, a plot of residuals against leverages.

Usage

```
residual.plot(db, numbercomponent, filepath)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
numbercomponent	The position number of the specific compounds for which the user would obtain the plots, as the function returns the graphs for one compound at time.
filepath	An optional argument. The user can directly specify the path in which the plot must be saved. If this argument misses, the plot is showed in R window.

Value

A graphical ouput with plots of residuals against fitted values, a Scale-Location plot of squared root of absolute value of residuals against fitted values, a Normal Q-Q plot, a plot of residuals against leverages.

Author(s)

Veronica Nava

See Also

db.union rating ferguson

Examples

```
data("flow.data1","conc.data1")
union<-db.union(flow.data1, conc.data1)
residual.plot(union, 1)
```

`rsquared.period` *Coefficient of determination for period based regression analyses*

Description

Return the coefficient of determination (R^2) to inspect the relationship between concentration and flow. It is a useful tool for the function rating.period and ferguson.period.

Usage

```
rsquared.period(db, ncomp, period)
```

Arguments

db	An input data frame with at least three column. A column with DateTime in standard format (yyyy-mm-dd HH:MM:SS) labeled "datetime", a column with flow records in cubic meter per second labeled "flow", and columns with scattered concentration data in milligram per litre. Alternatively, it can be used the output matrix of the function db.union.
ncomp	Number of compounds in the input data frame for which the load must be estimated.
period	A mandatory argument that specify the time period in which the regression relationship must be calculated. It can be "month" for a monthly estimation of load, or it can be "year" for annual estimation of load.

Value

A matrix with the R^2 value for the different compiunds.

Author(s)

Veronica Nava

See Also

`db.union` `rating.period` `ferguson.period`

Examples

```
data("flow.data3","conc.data3")
union<-db.union(flow.data3, conc.data3)
rsquared.period(union,1, "month")
rsquared.period(union,1, "year")
```

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