Package 'seawaveQ'

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LazyLoad yes

Description
A model and utilities for analyzing trends in chemical concentrations in streams with a seasonal wave (seawave) and adjustment for streamflow (Q) and other ancillary variables

Depends R (>= 3.0.0)

Imports survival, NADA, lubridate, rms

Suggests waterData

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NeedsCompilation no

R topics documented:

`seawaveQ-package` *A model and utilities for analyzing trends in chemical concentrations in streams with a seasonal wave (seawave) and adjustment for streamflow (Q) and other ancillary variables (Q) and other ancillary variables*

Description

An R package for the U.S. Geological Survey seawaveQ model, a parametric regression model specifically designed for analyzing seasonal- and flow-related variability and trends in pesticide concentrations. See Vecchia and others (2008) for the original description of the model and see Sullivan and others (2009), Vecchia and others (2009), Ryberg and others (2010), Ryberg and others (2014), Ryberg and Gilliom (2015), and Oelsner and others (2017) and for applications of the model.

Details

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Author(s)

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References

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Ryberg, K.R. and Gilliom, R.J., 2015, Trends in pesticide concentrations and use for major rivers of the United States: Science of The Total Environment, v. 538, p. 431–444, https://doi.org/10.1016/j.scitotenv.2015.06.095

Ryberg, K.R. and Vecchia, A.V., 2013, seawaveQ–An R package providing a model and utilities for analyzing trends in chemical concentrations in streams with a seasonal wave (seawave) and adjustment for streamflow (Q) and other ancillary variables: U.S. Geological Survey Open-File Report 2013–1255, 13 p., with 3 appendixes, http://dx.doi.org/10.3133/ofr20131255.

#' Ryberg, K.R., Vecchia, A.V., Gilliom, R.J., and Martin, J.D., 2014, Pesticide trends in major rivers of the United States, 1992-2010: U.S. Geological Survey Scientific Investigations Report 2014–5135, 74 p., http://pubs.er.usgs.gov/publication/sir20145135.

Ryberg, K.R., Vecchia, A.V., Martin, J.D., Gilliom, R.J., 2010, Trends in pesticide concentrations in urban streams in the United States, 1992-2008: U.S. Geological Survey Scientific Investigations Report 2010-5139, 101 p., http://pubs.usgs.gov/sir/2010/5139/.

Sullivan, D.J., Vecchia, A.V., Lorenz, D.L., Gilliom, R.J., Martin, J.D., 2009, Trends in pesticide concentrations in corn-belt streams, 1996-2006: U.S. Geological Survey Scientific Investigations Report 2009-5132, 75 p. http://pubs.usgs.gov/sir/2009/5132/.

Vecchia, A.V., Gilliom, R.J., Sullivan, D.J., Lorenz, D.L., and Martin, J.D., 2009, Trends in concentrations and use of agricultural herbicides for Corn Belt rivers, 1996-2006: Environmental Science and Technology, v. 43, p. 9,096-9,102.

Vecchia, A.V., Martin, J.D., and Gilliiom, R.J., 2008, Modeling variability and trends in pesticide concentrations in streams: Journal of the American Water Resources Association, v. 44, no. 5, p. 1308-1324, http://dx.doi.org/10.1111/j.1752-1688.2008.00225.x.

`cenScatPlot` *Scatter plot of water-quality data*

Description

Function to generate a scatter plot that indicates censored and estimated water-quality concentrations.

Usage

```
cenScatPlot(data, datescol = "dates", pname, qwcols = c("R", "P"),
  site = "", xlabel = "", ylabel = "Concentration", legpos = "topright",
  legcex = 1, ...)
```

Arguments

`data`	is the dataset with columns that begin with P followed by alphanumeric characters indicating concentration data and columns that begin with R followed by alphanumeric characters that match those of the concentration data indicating qualification codes. See example datasets for more information about the data format, see `IllRivValleyCty` and `qwMoRivOmaha`.
`datescol`	is the column label for the dates column.
`pname`	is the the column heading (paramenter name) for the particular water-quality constituent to be plotted (omit the the starting character, for example for sulfate data indicated by P00945, enter "00945").

qwcols	is a character vector with the beginning of the column headers for remarks code (default is R), and beginning of column headers for concentration data (default is P for parameter).
site	is a label for the plot title indicating the site where the water-quality samples were collected.
xlabel	is the label for the x-axis, defaults to no label.
ylabel	is the label for the y-axis.
legpos	is the position of the legend, see legend.
legcex	is a numerical value giving the amount by which the legend text and symbols should be magnified relative to the default, 1.
...	arguments to be passed to plot method.

Details

This function uses the qualification, or remark, column associated with water-quality concentration values to indicate which samples are unqualified, which are estimated, and which are censored. A blank remark field or an "_" indicates that the concentration value is not qualified; an "E" indicates the values has been estimated; and a less than symbol, "<", indicates the value has been censored as less than a minimum reporting level. See Oblinger Childress (1999) for information on the minimum reporting level and the definition of "E" for U.S. Geological Survey data. Other users may have a different definition of the minimum reporting level, but censored values need to be qualified with a "<". Using the "E" code is optional.

Value

a scatter plot

Author(s)

Karen R. Ryberg

References

Oblinger Childress, C.J., Foreman, W.T., Connor, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations for interpretations of water-quality data provided by the U.S. Geological Survey: U.S. Geological Survey Open-File Report 99–193, 19 p., http://water.usgs.gov/owq/OFR_99-193/index.html.

Examples

```
data(swData)
# scatter plot of Simazine concentrations
cenScatPlot(IllRivValleyCty, pname = "04035")
# scatter plot with many additional plotting arguments
par(las = 1, tcl = 0.5)
cenScatPlot(IllRivValleyCty, pname = "04035",
            site = "05586100 Illinois River at Valley City, IL",
            ylabel = "Simazine concentration, in micrograms per liter",
            legcex = 0.7, ylim = c(0, 0.4), yaxs = "i", cex.lab = 0.9,
            cex.axis = 0.9, xlim = c(as.Date("1996-01-01", "%Y-%m-%d"),
            as.Date("2012-01-01", "%Y-%m-%d")), xaxs = "i", xaxt = "n")
axdates <- c("1996-01-01", "2000-01-01", "2004-01-01", "2008-01-01",
           "2012-01-01")
```

```
axis(1, as.Date(axdates, "%Y-%m-%d"),
     labels = c("1996", "2000", "2004", "2008", "2012"), cex.axis = 0.9)
```

`combineData` *Combine water-quality sample data and continuous ancillary variables*

Description

Function to combine water-quality sample data and continuous (daily) ancillary variables and drop unnecessary columns.

Usage

```
combineData(qwdat, cqwdat, qwcols = c("staid", "dates", "R", "P"))
```

Arguments

`qwdat`	is the dataset containing water-quality sample data with columns that begin with a P (or other user-defined indicator) followed by alphanumeric characters. These columns are concentration data. In addition there need to be columns that begin with an R (or other user- defined indicator) followed by alphanumeric characters that match those of the associated concentration data. The R columns contain data qualification codes. See example datasets for more information about the data format, IllRivValleyCty and qwMoRivOmaha.
`cqwdat`	is the dataset containing variables that can be used as explanatory variables for the seawaveQ model. See example dataset for more information about the data format cqwMoRivOmaha. These are daily values with no missing values allowed between the first and the last date in the dataset.
`qwcols`	is a character vector with column headings for a station (location) identifier, a dates column identifier, beginning of column headers for remarks code (default is R), and beginning of column headers for concentration data (default is P for parameter).

Format

a dataframe with the number of rows equal to the number of rows in the dataframe indicated by qwdat. The number of columns depend on the two input data frames. Minimally there will be a station identification column, a dates column, a column of qualification codes, and a column of water-quality data.

Value

a dataframe

Note

The columns indicated by qwcols[1:2] are used to combined the datasets. The first column is the station identifier and the second column is the date column. These two column headings must be the same in the two datasets being combined and the dates in the datasets being combined must be for the class Date and be in the same format.

Author(s)

Karen R. Ryberg and Aldo V. Vecchia

Examples

```
data(swData)
MoRivOmaha <- combineData(qwdat = qwMoRivOmaha, cqwdat = cqwMoRivOmaha,
qwcols = c("staid", "dates", "R", "P"))
```

`compwaveconv` *Seasonal Wave Computation*

Description

Function to compute seasonal wave.

Usage

```
compwaveconv(cmaxt, jmod, hlife)
```

Arguments

`cmaxt`	is the time of the maximum chemical concentration, decimal time in years.
`jmod`	is the choice of model or pulse input function, an integer 1 through 14.
`hlife`	is the model half-life in months, 1 to 4 months

Value

a numeric vector of size 361 with discrete values of the seasonal wave for decimal season `seq(0,1,1/360)`.

Note

The seasonal wave is a dimensionless, periodic function of time with an annual cycle, similar to a mixture of sine and cosine functions often used to model seasonality in concentration data. However, the seasonal wave is better suited for modeling seasonal behavior of pesticide data than a mixture of sines and cosines. The pulse input function, represented by jmod, has either one or two distinct application seasons (when pesticides may be transported to the stream) of lengths from 1 to 6 months. Therefore, 56 (14x4) choices for the wave function are available. The numeric vector is a discrete approximation of the continuous wave function defined on the interval 0 to 1.

Author(s)

Aldo V. Vecchia

References

Vecchia, A.V., Martin, J.D. and Gilliom, R.J., 2008, Modeling variability and trends in pesticide concentrations in streams: JAWRA Journal of the American Water Resources Association, v. 44, p. 1308–1324, http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2008.00225.x/abstract.

Examples

```
# evaluate seasonal wave for specified decimal seasons
# these example decimal dates represent days at points 0.25, 0.5, and
# 0.75 percent of the way through the year and the end of the year
dseas <- c(0.25, 0.5, 0.75, 1)
swave <- compwaveconv(cmaxt = 0.483, jmod = 2, hlife = 4)
swave[floor(360 * dseas)]
plot(seq(0, 1, 1/360), swave, typ = "l")
```

`cqwMoRivOmaha` *Continuously monitored (daily) data for 06610000 Missouri River at Omaha, Neb.*

Description

Continuously monitored (daily) streamflow and sediment data for U.S. Geological Survey streamgage 06610000 Missouri River at Omaha, Neb., and streamflow and sediment anomalies.

Usage

```
cqwMoRivOmaha
```

Format

A data frame containing 2,922 daily observations of two hydrologic variables, streamflow and sediment, and streamflow and sediment anomalies. There are eight variables.

staid	character	USGS Station identification number
dates	date	date water-quality sample collected
dflow	numeric	daily mean streamflow, cubic feet per second
flowa30	numeric	30-day streamflow anomaly
flowa1	numeric	1-day streamflow anomaly
dsed	numeric	daily mean sediment concentration, milligrams per liter
seda30	numeric	30-day sediment anomaly
seda1	numeric	1-day sediment anomaly

Details

The streamflow and sediment anomalies were generated using the R package waterData (Ryberg and Vecchia, 2012).

Note

See Ryberg and Vecchia (2012) for more information on calculating the anomalies and for additional references documenting the use of streamflow anomalies in water-quality trend analysis studies.

Source

Data provided by Patrick Phillips, U.S. Geological Survey, New York Water Science Center.

References

Ryberg, K.R. and Vecchia, A.V., 2012, waterData—An R package for retrieval, analysis, and anomaly calculation of daily hydrologic time series data, version 1.0.0: U.S. Geological Survey Open-File Report 2012–1168, 8 p. (Also available at http://pubs.usgs.gov/of/2012/1168/.)

Examples

```
data(swData)

# summary of water-quality concentrations
apply(cqwMoRivOmaha[,3:8], 2, summary)
```

`examplecavdat` *Example continuous ancillary variable data.*

Description

This is an example of the continuous ancillary data that is passed internally to subfunctions of `fitswavecav`. It is provided here for use with examples of internal functions.

Usage

```
examplecavdat
```

Format

A data frame containing 2,893 data variables and 30-day and 1-day streamflow anomalies (Ryberg and Vecchia, 2012).

yrx	numeric	Year
mox	numeric	Month
dax	numeric	Day
jdayx	numeric	Julian day from first day water year for start year in `fitswavecav`
flowa30	numeric	30-day streamflow anomaly
flowa1	numeric	1-day streamflow anomaly

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                      tanm="myexample", pnames=c("04041"), yrstart=1995,
                      yrend=2003, tndbeg=1995, tndend=2003,
                      iwcav=c("flowa30","flowa1"), dcol="dates",
                      qwcols=c("R","P"))
```

References

Ryberg, K.R., and Vecchia, A.V., 2012, waterData–An R package for retrieval, analysis, and anomaly calculation of daily hydrologic time series data, version 1.0: U.S. Geological Survey Open-File Report 2012–1168, 8 p. (Also available at http://pubs.usgs.gov/of/2012/1168/.)

Examples

```
data(swData)
head(examplecavdat)
```

---

examplecavmat *Example continuous ancillary variable matrix.*

Description

This is an example of the continuous ancillary matrix that is passed internally to subfunctions of fitswavecav. It is provided here for use with examples of internal functions.

Usage

```
examplecavmat
```

Format

A matrix containing 115 30-day and 1-day streamflow anomalies (Ryberg and Vecchia, 2012).

flowa30	numeric	30-day streamflow anomaly
flowa1	numeric	1-day streamflow anomaly

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

Examples

```
data(swData)
head(examplecavmat)
```

---

examplecdatsub *Example water-quality data.*

Description

This is an example of the water-quality data that is passed internally to subfunctions of fitswavecav. It is provided here for use with examples of internal functions.

Usage

```
examplecdatsub
```

Format

A data frame containing 115 observations of 10 variables. The date variables were internally calculated. The columns R04041 and P04041 are a subset of qwMoRivOmaha and the 30-day and 1-day streamflow and sediment anomalies are a subset of cqwMoRivOmaha.

yrc	numeric	Year
moc	numeric	Month
dac	numeric	Day
jdayc	numeric	Julian day from first day of start year in fitswavecav
flowa30	numeric	30-day streamflow anomaly
flowa1	numeric	1-day streamflow anomaly
seda30	numeric	30-day sediment anomaly
seda1	numeric	1-day sediment anomaly

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

See Also

qwMoRivOmaha cqwMoRivOmaha

Examples

```
data(swData)
head(examplecdatsub)
```

---

examplecentmp *Example logical vector.*

Description

This is an example of data that is passed internally to subfunctions of link{fitswavecav}. This logical vector indicates which water-quality values are censored. It is provided here for use with examples of the internal functions.

Usage

```
examplecentmp
```

Format

A logical vector of 115 observations.

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

Examples

```
data(swData)
examplecentmp
```

`exampleclog` *Example of logarithmically transformed concentration data.*

Description

This is an example of data that is used internally by fitMod and passed to its subfunction `seawaveQPlots`. This numeric vector represents the base-10 logarithm of the water-quality concentrations. It is provided here for use with examples of the internal functions.

Usage

```
exampleclog
```

Format

A numeric vector of 115 observations.

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

Examples

```
data(swData)
exampleclog
```

exampleqwcols *Example data indicators.*

Description

This is an example of the character vector used to indicate which columns represent qualification codes and which represent water-quality concentration data. It is provided here for use with examples of the internal functions.

Usage

```
exampleqwcols
```

Format

A numeric vector of 115 observations.

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

See Also

prepData fitMod

Examples

```
data(swData)
exampleqwcols
```

examplestpars *Example matrix for internal use.*

Description

This is an example of data that is passed internally to subfunctions of fitswavecav. It is provided here for use with examples of the internal functions.

Usage

```
examplestpars
```

Format

A numeric matrix of two rows and 14 columns.
column description
1 mclass, model class has not been implemented yet and is equal to 1
2 model chosen (a number 1-56), this number represents both the pulse input function and the half-life
3 is the scale factor from the `survreg.object` 4 is the likelihood for the model chosen
5 is the coefficient for the model intercept
6 is the coefficient for the seasonal wave component of the model
7 is the coefficient for the trend component of the model
8 is the coefficient for the 30-day flow anomaly
9 is the coefficient for the 1-day flow anomaly
10 is the standard error for the intercept term
11 is the standard error for the seasonal wave term
12 is the standard error for the trend term
13 is the standard error for the 30-day flow anomaly term
14 is the standard error for the 1-day flow anomaly term
15 is cmaxt, the decimal season of maximum concentration
16 is the p-value for the trend line

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

See Also

`fitswavecav`

Examples

```
data(swData)
examplestpars
```

`exampletndlin` *Example numeric vector used internally.*

Description

This is an example of data that is passed internally to `seawaveQPlots`. This numeric vector contains trend coefficients for the water-quality samples. It is provided here for use with examples of the internal functions.

Usage

```
exampletndlin
```

Format

A numeric vector of 115 observations.

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

Examples

```
data(swData)
head(exampletndlin)
```

`exampletndlinpr` *Example numeric vector used internally.*

Description

This is an example of data that is passed internally to `seawaveQPlots`. This numeric vector contains trend coefficients for a continous water-quality prediction based on the continuous ancillary variables. It is provided here for use with examples of the internal functions.

Usage

```
exampletndlinpr
```

Format

A numeric vector of 2,893 observations.

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

Examples

```
data(swData)
head(exampletndlinpr)
```

`exampletseas` *Example numeric vector used internally.*

Description

This is an example of data that is passed internally to `seawaveQPlots`. This numeric vector contains decimal seasonal (0-1) values for the water-quality samples. It is provided here for use with examples of the internal functions.

Usage

```
exampletseas
```

Format

A numeric vector of 115 observations.

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

Examples

```
data(swData)
head(exampletseas)
```

`exampletseaspr` *Example numeric vector used internally.*

Description

This is an example of data that is passed internally to `seawaveQPlots`. This numeric vector contains decimal seasonal (0-1) values for the continuous ancillary data. It is provided here for use with examples of the internal functions.

Usage

```
exampletseaspr
```

Format

A numeric vector of 2,893 observations.

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

Examples

```
data(swData)
head(exampletseaspr)
```

---

exampletyr *Example numeric vector used internally.*

Description

This is an example of data that is passed internally to seawaveQPlots. This numeric vector contains decimal dates for the water-quality samples. It is provided here for use with examples of the internal functions.

Usage

```
exampletyr
```

Format

A numeric vector of 115 observations.

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

Examples

```
data(swData)
head(exampletyr)
```

exampletyrpr *Example numeric vector used internally.*

Description

This is an example of data that is passed internally to seawaveQPlots. This numeric vector contains decimal dates for continuous ancillary variables. It is provided here for use with examples of the internal functions.

Usage

```
exampletyrpr
```

Format

A numeric vector of 2,893 observations.

Source

Internal data captured from the following function call:

```
fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
                        tanm="myexample", pnames=c("04041"), yrstart=1995,
                        yrend=2003, tndbeg=1995, tndend=2003,
                        iwcav=c("flowa30","flowa1"), dcol="dates",
                        qwcols=c("R","P"))
```

Examples

```
data(swData)
head(exampletyrpr)
```

fitMod *Internal function that fits the seawaveQ model.*

Description

fitMod is called from within fitswavecav but can be invoked directly. It fits the seawaveQ model and returns the results.

Usage

```
fitMod(cdatsub, cavdat, yrstart, yrend, tndbeg, tndend, tanm, pnames, qwcols,
  mclass = 1)
```

Arguments

cdatsub	is the concentration data
cavdat	is the continuous (daily) ancillary data
yrstart	is the starting year of the analysis (treated as January 1 of that year).
yrend	is the ending year of the analysis (treated as December 31 of that year).
tndbeg	is the beginning (in whole or decimal years) of the trend period.
tndend	is the end (in whole or decimal years) of the trend period.
tanm	is a character identifier that names the trend analysis run. It is used to label output files.
pnames	is the parameter (water-quality constituents) to analyze (if using USGS parameters, omit the the starting 'P', such as "00945" for sulfate).
qwcols	is a character vector with the beginning of the column headers for remarks code (default is R), and beginning of column headers for concentration data (default is P for parameter).
mclass	indicates the class of model one wants to use. A class 1 model is the the traditional SEAWAVE-Q model that has a linear time tredn. A class 2 model is a newer option for longer trend periods that uses a set of restricted cubic splines on the time variable to provide a more flexible model.

Value

a pdf file containing plots (see seawaveQPlots), a text file showing the best model survival regression call and results, and a list. The first element of the list contains information about the data and the model(s) selected (see examplestpars). The second element of the list contains the summary of the survival regression call. The third element of the list is itself a list containing the observed concentrations (censored and uncensored) and the predicted concentrations used by seawaveQPlots to generate the plots.

Author(s)

Aldo V. Vecchia and Karen R. Ryberg

References

Allison, P.D. 1995: Survival analysis using the SAS system—A practical guide: Cary, North Carolina, SAS Publishing, 304 p.

Examples

```
data(swData)
myRes <- fitMod(cdatsub=examplecdatsub, cavdat=examplecavdat,
yrstart=1995, yrend=2003, tndbeg=1995, tndend=2003, tanm="myfit3",
pnames=c("04041"), qwcols=c("R", "P"))
```

`fitMod2` *Internal function that fits the seawaveQ model with restricted cubic splines.*

Description

fitMod2 is called from within fitswavecav but can be invoked directly. It fits the seawaveQ model and with restricted cubic splines on tim variable returns the model results.

Usage

```
fitMod2(cdatsub, cavdat, yrstart, yrend, tndbeg, tndend, tanm, pnames, qwcols,
  mclass = 2, numknots = 4)
```

Arguments

`cdatsub`	is the concentration data
`cavdat`	is the continuous (daily) ancillary data
`yrstart`	is the starting year of the analysis (treated as January 1 of that year).
`yrend`	is the ending year of the analysis (treated as December 31 of that year).
`tndbeg`	is the beginning (in whole or decimal years) of the trend period.
`tndend`	is the end (in whole or decimal years) of the trend period.
`tanm`	is a character identifier that names the trend analysis run. It is used to label output files.
`pnames`	is the parameter (water-quality constituents) to analyze (if using USGS parameters, omit the the starting 'P', such as "00945" for sulfate).
`qwcols`	is a character vector with the beginning of the column headers for remarks code (default is R), and beginning of column headers for concentration data (default is P for parameter).
`mclass`	indicates the class of model one wants to use. A class 1 model is the the traditional SEAWAVE-Q model that has a linear time tredn. A class 2 model is a newer option for longer trend periods that uses a set of restricted cubic splines on the time variable to provide a more flexible model.
`numknots`	is the number of knots in the restricted cubic spline model. The default is 4, and the recommended number is 3–7.

Value

a pdf file containing plots (see `seawaveQPlots`), a text file showing the best model survival regression call and results, and a list. The first element of the list contains information about the data and the model(s) selected (see `examplestpars`). The second element of the list contains the summary of the survival regression call. The third element of the list is itself a list containing the observed concentrations (censored and uncensored) and the predicted concentrations used by `seawaveQPlots` to generate the plots.

Author(s)

Karen R. Ryberg and Aldo V. Vecchia

References

Allison, P.D. 1995: Survival analysis using the SAS system—A practical guide: Cary, North Carolina, SAS Publishing, 304 p.

Examples

```
data(swData)
myRes <- fitMod2(cdatsub = examplecdatsub, cavdat = examplecavdat,
yrstart = 1995, yrend = 2003, tndbeg = 1995, tndend = 2003,
tanm = "myfit3", pnames = c("04041"), qwcols = c("R", "P"),
mclass = 2, numknots = 4)
```

`fitswavecav` *Fit seasonal wave and continuous ancillary data for trend analysis*

Description

Function to prepare data and fit the seawaveQ model.

Usage

```
fitswavecav(cdat, cavdat, tanm = "trend1", pnames,
  yrstart = 0, yrend = 0, tndbeg = 0, tndend = 0,
  iwcav = c("none"), dcol = "dates",
  qwcols = c("R", "P"), mclass = 1)
```

Arguments

`cdat`	is the concentration data
`cavdat`	is the continuous (daily) ancillary data
`tanm`	is a character identifier that names the trend analysis run. It is used to label output files.
`pnames`	are the parameters (water-quality constituents) to analyze (omit the the starting character, for example for sulfate data indicated by P00945, enter "00945").
`yrstart`	is the starting year of the analysis (treated as January 1 of that year). Zero means the start date will be determined by the start date of cavdat, the continuous ancillary data.
`yrend`	is the ending year of the analysis (treated as December 31 of that year). Zero means the end date will be determined by the end date of cavdat, the continuous ancillary data.
`tndbeg`	is the beginning (in whole or decimal years) of the trend period. Zero means the begin date will be the beginning of the concentration data, cdat.
`tndend`	is the end of the trend (treated as December 31 of that year). Zero means the end date will be the end of the concentration data, cdat.
`iwcav`	is a character vector indicating which continuous ancillary variables to include, if none are used for analysis, use iwcav=c("none").
`dcol`	is the column name for the dates, should be the same for both cdat and cavdat
`qwcols`	is a character vector with the beginning of the column headers for remarks code (default is R), and beginning of column headers for concentration data (default is P for parameter).
`mclass`	has not been implemented yet but will provide additional model options.

Format

The data frame returned has one row for each parameter analyzed and the number of columns depend on the number of continuous ancillary variables used. The general format is as follows:

pname	character	Parameter analyzed
mclass	numeric	Currently a value of 1
jmod	numeric	The choice of pulse input function, an integer 1–14.
hlife	numeric	the model half-life in months, an integer, 1 to 4 months
cmaxt	numeric	the decimal season of maximum concentration
scl	numeric	the scale factor from the `survreg.object`
loglik	numeric	the log-likelihood for the model
cint	numeric	coefficient for model intercept
cwave	numeric	coefficient for the seasonal wave
ctnd	numeric	coefficient for the trend component of model
c[alphanumeric]	numeric	0 or more coefficients for the continuous ancillary variables
seint	numeric	standard error for the intercept
sewave	numeric	standard error for the seasonal wave
setnd	numeric	standard error for the trend
se[alphanumeric]	numeric	0 or more standard errors for the continuous ancillary variables
pvaltnd	numeric	the p-value for the trend line

Details

Fits the seawaveQ model (Vecchia and others, 2008) using a seasonal wave and continuous ancillary variables (streamflow anomalies and other continuous variables such as conductivity or sediment) to model water quality.

Value

a pdf file containing plots of the data and modeled concentration, a text file containing a summary of the survival regression call for each model selected, and a list. The first element of the list is a data frame described under format. The second element of the list is the summary of the survival regression call. The third element is the observed concentration data (censored and uncensored). The fourth element is the concentration data predicted by the model. The fifth element provides summary statistics for the predicted concentrations.

Note

The assumed data format is one with columns for water-quality concentration values and a related column for qualification of those values, such as in the case of left-censored values less than a particular value. For example, a water-quality sample was collected and the laboratory analysis indicated that the concentration was less than 0.01 micrograms per liter. The USGS parameter code for simazine is 04035 (U.S. Geological Survey, 2013b). When the data are retrieved through the National Water Information System: Web Interface (`http://waterdata.usgs.gov/nwis`; U.S. Geological Survey, 2013a), the concentration values are in a column labeled P04035 and the qualification information, or remark codes, are in a column labeled R04035. To use this function, the argument pnames would be the unique identifier for simazine values and qualifications, 04035, and the qwcols argument would be c("R", "P") to indicate that the qualification column starts with an R and the values column starts with a P.

Other users may have data in different format that can be changed to use with this function. For example, a user may have concentration values and qualification codes in one column, such as a

column labeled simzaine with the values 0.05, 0.10, <0.01, <0.01, and 0.90. In this case, the less thans and any other qualification codes should be placed in a separate column. The column names for the qualification codes and the concentration values should be the same with the exception of different beginning letters to indicate which column is which. The columns could be named Rsimazine and Psimazine. Then the argument pnames = "simazine" and the argument qwcols = c("R", "P").
Users should exercise caution when their water-quality data have multiple censoring limits and may want to recensor the data to a single censoring level. Censoring and recensoring issues are discussed in the text and Appendix 1 of Ryberg and others (2010).

Author(s)

Aldo V. Vecchia and Karen R. Ryberg

References

Ryberg, K.R., Vecchia, A.V., Martin, J.D., and Gilliom, R.J., 2010, Trends in pesticide concentrations in urban streams in the United States, 1992–2008: U.S. Geological Survey Scientific Investigations Report 2010-5139, 101 p. (Also available at http://pubs.usgs.gov/sir/2010/5139/.)

U.S. Geological Survey, 2013a, National Water Information System: Web Interface, accessed Febaruary 26, 2013, at http://waterdata.usgs.gov.

U.S. Geological Survey, 2013b, Parameter code definition: National Water Information System: Web Interface, accessed Febaruary 26, 2013, at http://nwis.waterdata.usgs.gov/usa/nwis/pmcodes.

Vecchia, A.V., Martin, J.D., and Gilliiom, R.J., 2008, Modeling variability and trends in pesticide concentrations in streams: Journal of the American Water Resources Association, v. 44, no. 5, p. 1308-1324, http://dx.doi.org/10.1111/j.1752-1688.2008.00225.x.

See Also

The functions that `fitswavecav` calls internally:
`prepData` and `fitMod`.

Examples

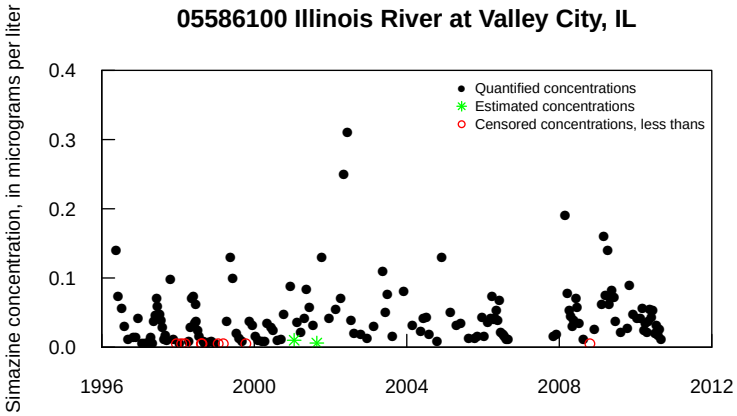
```
data(swData)
modMoRivOmaha<-combineData(qwdat=qwMoRivOmaha, cqwdat=cqwMoRivOmaha)
myfit1 <- fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
tanm="myfit1", pnames=c("04035", "04037", "04041"), yrstart=1995,
yrend=2003, tndbeg=1995, tndend=2003, iwcav=c("flowa30","flowa1"),
dcol="dates", qwcols=c("R","P"))
 ## Not run:
myfit2 <- fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
tanm="myfit2", pnames=c("04035", "04037", "04041"), yrstart=1995,
yrend=2003, tndbeg=1995, tndend=2003, iwcav=c("seda30","seda1"),
dcol="dates", qwcols=c("R","P"))
myfit3 <- fitswavecav(cdat=modMoRivOmaha, cavdat=cqwMoRivOmaha,
tanm="myfit3", pnames=c("04035", "04037", "04041"), yrstart=1995,
yrend=2003, tndbeg=1995, tndend=2003, iwcav=c("flowa30","flowa1",
"seda30", "seda1"), dcol="dates", qwcols=c("R","P"))

## End(Not run)
# trend model results
myfit1[[1]]
```

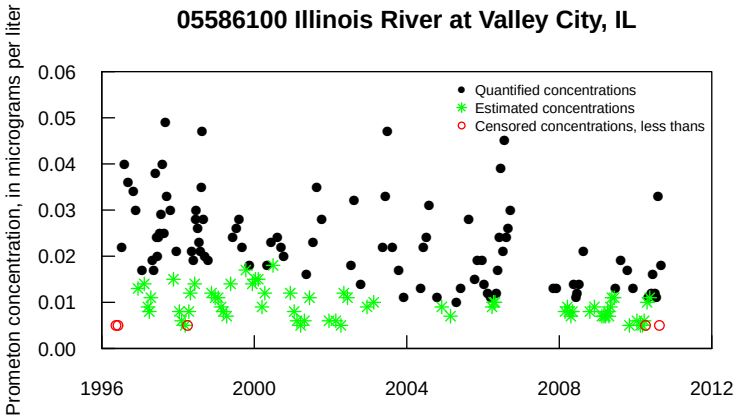
```
# example regression call
myfit1[[2]][[1]]
# first few lines of observed concentrations
head(myfit1[[3]])
# first few lines of predicted concentrations
head(myfit1[[4]])
# summary statistics for predicted concentrations
head(myfit1[[5]])
```

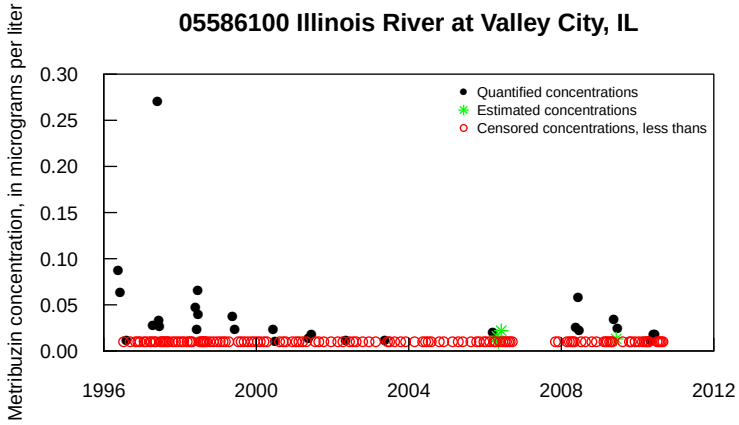
`IllRivValleyCty` *Water-quality data for 05586100 Illinois River at Valley City, Ill.*

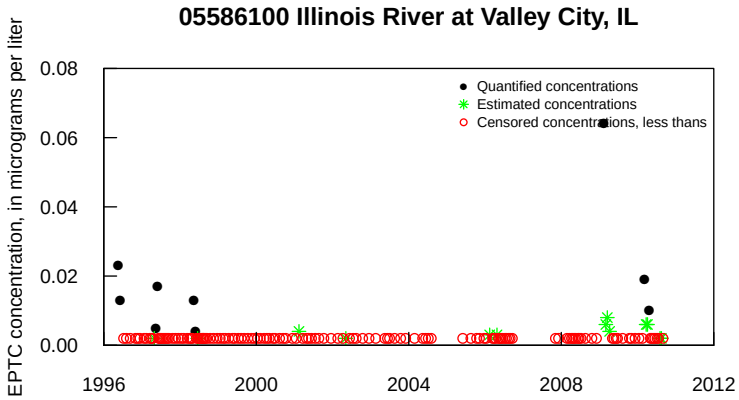
Description

Scatterplots of water-quality data for 05586100 Illinois River at Valley City, Ill.

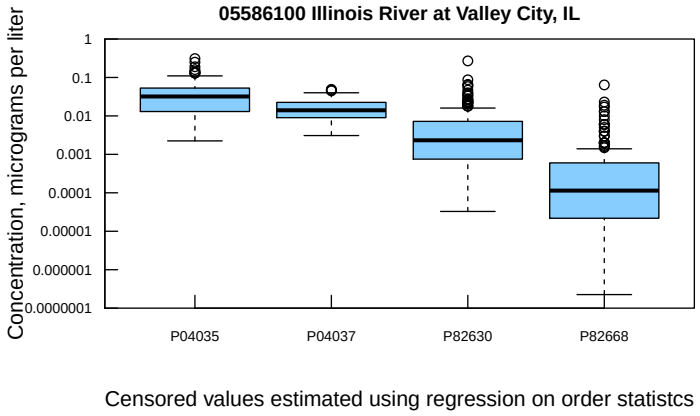








Boxplot of data using regression on order statistics (Helsel, 2005; Lee, 2010) to estimate censored values.



Censored values estimated using regression on order statistcs

Usage

```
IllRivValleyCty
```

Format

A data frame containing 168 water-quality samples for 4 constituents. There are 20 variables.

site	character	Site abbreviation for study
staid	character	USGS Station identification number
dates	date	Date water-quality sample collected
yrc	numeric	Year
moc	numeric	Month
dac	numeric	Day
jdayc	numeric	Julian day from first day of associated streamflow data used
R04035	character	Remark code (blank, _, <, or E)
P04035	numeric	Simazine, water, filtered, recoverable, micrograms per liter
R04037	character	Remark code (blank, _, <, or E)
P04037	numeric	Prometon, water, filtered, recoverable, micrograms per liter
R82630	character	Remark code (blank, _, <, or E)
P82630	numeric	Metribuzin, water, filtered, recoverable, micrograms per liter
R82668	character	Remark code (blank, _, <, or E)
P82668	numeric	EPTC, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
dflow	numeric	Streamflow, cubic feet per second
flowa30	numeric	30-day streamflow anomaly
flowa1	numeric	1-day streamflow anomaly
dsed	numeric	Sediment concentration, milligrams per liter
seda30	numeric	30-day sediment anomaly
seda1	numeric	1-day sediment anomaly

Details

Chemical concentration data are in the columns that start with a P and are followed by a number. Qualification codes for the concentration data are in the columns that start with an R followed by the same numbers as the associated concentration data. For example, column P04035 indicates simazine data, 04035, being the U.S. Geological Survey parameter code for simazine. The qualification codes for the simazine concentrations are found in the column R04035, indicating a U.S. Geological Survey remark code. Remark codes include _ or nothing, indicating no qualification of the value in the associated concentration field; <, indicating a censored value that is less than the number reported in the associated concentration field; and E, indicating that the value has been estimated. See Oblinger Childress and others (1999) for information on the remark codes used by the U.S. Geological Survey. The streamflow and sediment anomalies were generated using the R package waterData (Ryberg and Vecchia, 2012).

Source

Data provided by Patrick Phillips, U.S. Geological Survey, New York Water Science Center.

References

Oblinger Childress, C.J., Foreman, W.T., Connor, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations for interpretations of water-quality data provided by the U.S. Geological Survey Open-File Report 99–193, 19 p. (Also available at http://water.usgs.gov/owq/OFR_99-193/index.html.)

Examples

```
data(swData)

# summary of water-quality concentrations
apply(IllRivValleyCty[,grep("P[[:digit:]]",
dimnames(IllRivValleyCty)[[2]])], 2, summary)

# simple boxplot of water-quality concentrations
rosBoxPlot(IllRivValleyCty)

# same boxplot function with many additional plotting arguments
rosBoxPlot(IllRivValleyCty,
           site="05586100 Illinois River at Valley City, Ill.", log="y",
           yaxt="n", ylim=c(0.0000001, 1), qwcols=c("R", "P"),
           ylab=c("Concentration, micrograms per liter"), col="skyblue1",
           cex.axis=0.7, cex.sub=0.8, par(tcl=0.5, las=1,
                                                    yaxs="i",
                                                    mgp=c(3,0.5,0),
                                                    mar=c(5,5,2,2),
                                                    cex.main=0.9))
axis(2, at=c(0.0000001, 0.000001, 0.00001, 0.0001, 0.001, 0.01, 0.1, 1),
     labels=c("0.0000001", "0.000001", "0.00001", "0.0001", "0.001", "0.01",
              "0.1", "1"), cex.axis=0.7)

# scatter plot of simazine concentrations
cenScatPlot(IllRivValleyCty, pname="04035")

# scatter plot with many additional plotting arguments
par(las=1, tcl=0.5)
cenScatPlot(IllRivValleyCty, pname="04035",
            site="05586100 Illinois River at Valley City, Ill.",
            ylabel="Simazine concentration, in micrograms per liter",
            legcex=0.7,
            ylim=c(0,0.4), yaxs="i", cex.lab=0.9, cex.axis=0.9,
            xlim=c(as.Date("1996-01-01"), as.Date("2012-01-01")),
            xaxs="i", xaxt="n")
axdates<-c("1996-01-01", "2000-01-01", "2004-01-01", "2008-01-01",
           "2012-01-01")
axis(1, as.Date(axdates), labels=c("1996", "2000", "2004", "2008",
                                   "2012"), cex.axis=0.9)

# Prometon scatter plot
cenScatPlot(IllRivValleyCty, pname="04037",
            site="05586100 Illinois River at Valley City, Ill.",
            ylabel="Prometon concentration, in micrograms per liter",
            legcex=0.7,
            ylim=c(0,0.06), yaxs="i", cex.lab=0.9, cex.axis=0.9,
            xlim=c(as.Date("1996-01-01"),
                   as.Date("2012-01-01")), xaxs="i",
            xaxt="n")
axdates<-c("1996-01-01", "2000-01-01", "2004-01-01", "2008-01-01",
           "2012-01-01")
axis(1, as.Date(axdates), labels=c("1996", "2000", "2004", "2008",
                                              "2012"), cex.axis=0.9)

# Metribuzin scatter plot
```

```
cenScatPlot(IllRivValleyCty, pname="82630",
            site="05586100 Illinois River at Valley City, Ill.",
            ylabel="Metribuzin concentration, in micrograms per liter",
            legcex=0.7,
            ylim=c(0,0.3), yaxs="i", cex.lab=0.9, cex.axis=0.9,
            xlim=c(as.Date("1996-01-01"),
                   as.Date("2012-01-01")), xaxs="i",
            xaxt="n")
axdates<-c("1996-01-01", "2000-01-01", "2004-01-01", "2008-01-01",
           "2012-01-01")
axis(1, as.Date(axdates), labels=c("1996", "2000", "2004", "2008",
                                                    "2012"), cex.axis=0.9)
# EPTC scatter plot
cenScatPlot(IllRivValleyCty, pname="82668",
            site="05586100 Illinois River at Valley City, Ill.",
            ylabel="EPTC concentration, in micrograms per liter",
            legcex=0.7, ylim=c(0,0.08), yaxs="i", cex.lab=0.9,
            cex.axis=0.9, xlim=c(as.Date("1996-01-01"),
                   as.Date("2012-01-01")), xaxs="i", xaxt="n")
axdates<-c("1996-01-01", "2000-01-01", "2004-01-01", "2008-01-01",
           "2012-01-01")
axis(1, as.Date(axdates), labels=c("1996", "2000", "2004", "2008","2012"),
     cex.axis=0.9)
```

`prepData` *Prepares concentration data and continuous ancillary data*

Description

prepData is usually called from within fitswavecav but can be invoked directly. It performs some date calculations, removes rows with missing values for concentration or continous variables, and returns the the concentration and continuous ancillary data to be used by fitswavecav and its other internal functions.

Usage

```
prepData(cdat, cavdat, yrstart, yrend, dcol, pnames, iwcav, qwcols)
```

Arguments

`cdat`	is the concentration data.
`cavdat`	is the continuous (daily) ancillary data.
`yrstart`	is the starting year of the analysis (treated as January 1 of that year). Zero means the start date will be determined by the start date of cavdat, the continuous ancillary data.
`yrend`	is the ending year of the analysis (treated as December 31 of that year). Zero means the end date will be determined by the end date of cavdat, the continuous ancillary data.
`dcol`	is the column name for the dates, should be the same for both cdat and cavdat.
`pnames`	are the parameters (water-quality constituents) to analyze (if using USGS parameters, omit the the starting 'P', such as "00945" for sulfate).

iwcav	is a character variable indicating which continuous ancillary variables to include, if none use iwcav=c("none").
qwcols	is a character vector with the beginning of the column headers for remarks code (default is R), and beginning of column headers for concentration data (default is P for parameter).

Value

a list. The first element is the concentration data with additional date information, missing values removed, and extra columns removed. The second element is the continuous ancillary data with additional date information, missing values removed, and extra columns removed.

Author(s)

Aldo V. Vecchia and Karen R. Ryberg

Examples

```
data(swData)
modMoRivOmaha<-combineData(qwdat=qwMoRivOmaha, cqwdat=cqwMoRivOmaha)
preppedDat <- prepData(modMoRivOmaha, cqwMoRivOmaha, yrstart=1995,
yrend=2003, dcol="dates", pnames=c("04035", "04037", "04041"),
iwcav=c("flowa30","flowa1"), qwcols=c("R","P"))
```

---

rosBoxPlot *Boxplot of water-quality data*

Description

Function to create boxplots of water-quality data that include censored values.

Usage

```
rosBoxPlot(data, site = "", qwcols = c("R", "P"), ...)
```

Arguments

data	is the dataset with columns that begin with P followed by a number indicating concentration data and columns that begin with R followed by numbers that match those of the concentration data indicating qualification codes. See example data sets for more information about the data format, IllRivValleyCty and qwMoRivOmaha.
site	is a label for the plot title indicating the site where the water-quality samples were collected.
qwcols	is a character vector with the beginning of the column headers for remarks code (default is R), and beginning of column headers for concentration data (default is P for parameter).
...	arguments to be passed to plot method.

Details

This function determines the columns within the data set that have concentration data, based on them having column headings that start with P (or a user-specificed indicater in the second element of the qwcols argument) followed by a number. The function determines the associated remark, or qualification columns, based on them having column headings that start with R (or a user-specificed indicater in the first element of the qwcols argument) followed by numbers that match the associated concentration data. Then it determines which values are censored, indicated by a less than symbol in the R columns, performs regression on order statistics, ros, using the NADA package, and estimates values for the censored concentrations for constituents with less than 90-percent censoring. The water-quality concentrations are then depicted by boxplots.

Value

a boxplot

Note

The regression on order statistics function in R package NADA (Lee, 2012), ros, is an implementation of a regression on order statistics designed for multiply-censored analytical-chemistry data (Helsel, 2005). The method assumes data contains zero to many left-censored (less-than) values. For highly censored data, ros may produce a warning message. Such as,

```
Warning messages:
1: In ros(my.list$obs, my.list$cen) :
 Input > 80% censored -- Results are tenuous.
```

The boxplot will still be generated, but the user should consider the warning message when interpreting the plots. See Oblinger Childress and others (1999) for information on the remark codes used by the U.S. Geological Survey.

Author(s)

Karen R. Ryberg

References

Helsel, D.R., 2005, Nondetects and data analysis: New York, John Wiley and Sons.

Lee, Lopaka, 2012, Nondetects and data analysis for environmental data: R package version 1.5-4, http://CRAN.R-project.org/package=NADA.

Oblinger Childress, C.J., Foreman, W.T., Connor, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations for interpretations of water-quality data provided by the U.S. Geological Survey: U.S. Geogolical Survey Open-File Report 99–193, 19 p. (Also available at http://water.usgs.gov/owq/OFR_99-193/index.html.)

Examples

```
data(swData)
# summary of water-quality concentrations
apply(IllRivValleyCty[, grep("P[[:digit:]]",
      dimnames(IllRivValleyCty)[[2]])], 2, summary)
# simple boxplot of water-quality concentrations
rosBoxPlot(IllRivValleyCty)
# same boxplot function with many additional plotting arguments
```

```
rosBoxPlot(IllRivValleyCty,
           site="05586100 Illinois River at Valley City, IL",
           log="y", yaxt="n", ylim=c(0.0000001, 1), qwcols=c("R", "P"),
           ylab=c("Concentration, micrograms per liter"),
           col="skyblue1", cex.axis=0.7, cex.sub=0.8,
           par(tcl=0.5, las=1, yaxs="i", mgp=c(3, 0.5, 0),
               mar=c(5, 5, 2, 2),cex.main=0.9))
axis(2,
     at=c(0.0000001, 0.000001, 0.00001, 0.0001, 0.001, 0.01, 0.1, 1),
     labels=c("0.0000001", "0.000001","0.00001", "0.0001", "0.001",
              "0.01", "0.1", "1"), cex.axis=0.7)
```

`seawaveQPlots` *Internal function that generates plots of data and model results.*

Description

seawaveQPlots is usually called from within `fitMod` but can be invoked directly. It generates plots of data and model results, as well as diagnostic plots, and returns the observed and predicted concentrations so that users may plot the concentrations using their own functions.

Usage

```
seawaveQPlots(stpars, cmaxt, tseas, tseaspr, tndlin, tndlinpr, cdatsub, cavdat,
  cavmat, clog, centmp, yrstart, yrend, tyr, tyrpr, pnames, tanm, mclass = 1)
```

Arguments

`stpars`	is a matrix of information about the best seawaveQ model for the concentration data, see `examplestpars`.
`cmaxt`	is the decimal season of maximum chemical concentration.
`tseas`	is the decimal season of each concentration value in cdatsub.
`tseaspr`	is the decimal season date used to model concentration using the continuous data set cavdat.
`tndlin`	is the decimal time centered on the midpoint of the trend for the sample data, cdatasub.
`tndlinpr`	is is the decimal time centered on the midpoint of the trend for the continuous data, cavdat.
`cdatsub`	is the concentration data
`cavdat`	is the continuous (daily) ancillary data
`cavmat`	is a matrix containing the continuous ancillary variables.
`clog`	is a vector of the base-10 logarithms of the concentration data.
`centmp`	is a logical vector indicating which concentration values are censored.
`yrstart`	is the starting year of the analysis (treated as January 1 of that year).
`yrend`	is the ending year of the analysis (treated as December 31 of that year).
`tyr`	is a vector of decimal dates for the concentration data
`tyrpr`	is a vector of decimal dates for the continuous ancillary varaibles.

pnames	is the parameter (water-quality constituents) to analyze (if using USGS parameters, omit the the starting 'P', such as "00945" for sulfate).
tanm	is an a character identifier that names the trend analysis run. It is used to label output files.
mclass	has not been implemented yet, but will provide additional model options.

Value

a pdf file containing plots of the data and modeled concentrations and regression diagnostic plots and a list containing the observed concentrations (censored and uncensored) and the predicted concentrations used for the plot.

Note

The plotting position used for representing censored values in the plots produced by seawaveQPlots is an important consideration for interpreting model fit. Plotting values obtained by using the censoring limit, or something smaller such as one-half of the censoring limit, produce plots that are difficult to interpret if there are a large number of censored values. Therefore, to make the plots more representative of diagnostic plots used for standard (non-censored) regression, a method for substituting randomized residuals in place of censored residuals was used. If a log-transformed concentration is censored at a particular limit, `logC < L`, then the residual for that concentration is censored as well, `logC - fitted(logC) < L - fitted(logC) = rescen`. In that case, a randomized residual was generated from a conditional normal distribution

```
resran  <-  scl * qnorm(runif(1) * pnorm(rescen / scl)),
```

where scl is the scale parameter from the survival regression model, `pnorm` is the R function for computing cumulative normal probabilities, `runif` is the R function for generating a random variable from the uniform distribution, and `qnorm` is the R function for computing quantiles of the normal distribution. Under the assumption that the model residuals are uncorrelated, normally distributed random variables with mean zero and standard deviation scl, the randomized residuals generated in this manner are an unbiased sample of the true (but unknown) residuals for the censored data. This is an application of the probability integral transform (Mood and others, 1974) to generate random variables from continuous distributions. The plotting position used a censored concentration is `fitted(logC) + resran`. Note that each time a new model fit is performed, a new set of randomized residuals is generated and thus the plotting positions for censored values can change.

Author(s)

Aldo V. Vecchia and Karen R. Ryberg

References

Mood, A.M., Graybill, F.A., and Boes, D.C., 1974, Introduction to the theory of statistics (3d ed.): New York, McGraw-Hill, Inc., 564 p.

Examples

```
data(swData)
myPlots <- seawaveQPlots(stpars=examplestpars, cmaxt=0.4808743,
tseas=exampletseas, tseaspr=exampletseaspr, tndlin=exampletndlin,
tndlinpr=exampletndlinpr, cdatsub=examplecdatsub, cavdat=examplecavdat,
```

```
cavmat=examplecavmat, clog=exampleclog, centmp=examplecentmp,
yrstart=1995, yrend=2003, tyr=exampletyr, tyrpr=exampletyrpr,
pnames=c("04041"), tanm="examplePlots04041")
```

---

seawaveQPlots2 *Internal function that generates plots of data and model results.*

Description

seawaveQPlots2 is usually called from within fitMod2 but can be invoked directly. It generates plots of data and model results, as well as diagnostic plots, and returns the observed and predicted concentrations so that users may plot the concentrations using their own functions. This is the version for models that use restricted cubic splines

Usage

```
seawaveQPlots2(stpars, cmaxt, tseas, tseaspr, tndlin, tndlinpr, tndrcs,
  tndrcspr, cdatsub, cavdat, cavmat, clog, centmp, yrstart, yrend, tyr, tyrpr,
  pnames, tanm, mclass = 2, numknots)
```

Arguments

stpars	is a matrix of information about the best seawaveQ model for the concentration data, see examplestpars.
cmaxt	is the decimal season of maximum chemical concentration.
tseas	is the decimal season of each concentration value in cdatsub.
tseaspr	is the decimal season date used to model concentration using the continuous data set cavdat.
tndlin	is the decimal time centered on the midpoint of the trend for the sample data, cdatasub.
tndlinpr	is is the decimal time centered on the midpoint of the trend for the continuous data, cavdat.
cdatsub	is the concentration data
cavdat	is the continuous (daily) ancillary data
cavmat	is a matrix containing the continuous ancillary variables.
clog	is a vector of the base-10 logarithms of the concentration data.
centmp	is a logical vector indicating which concentration values are censored.
yrstart	is the starting year of the analysis (treated as January 1 of that year).
yrend	is the ending year of the analysis (treated as December 31 of that year).
tyr	is a vector of decimal dates for the concentration data
tyrpr	is a vector of decimal dates for the continuous ancillary varaibles.
pnames	is the parameter (water-quality constituents) to analyze (if using USGS parameters, omit the the starting 'P', such as "00945" for sulfate).
tanm	is an a character identifier that names the trend analysis run. It is used to label output files.
mclass	has not been implemented yet, but will provide additional model options.

Value

a pdf file containing plots of the data and modeled concentrations and regression diagnostic plots and a list containing the observed concentrations (censored and uncensored) and the predicted concentrations used for the plot.

Note

The plotting position used for representing censored values in the plots produced by seawaveQPlots2 is an important consideration for interpreting model fit. Plotting values obtained by using the censoring limit, or something smaller such as one-half of the censoring limit, produce plots that are difficult to interpret if there are a large number of censored values. Therefore, to make the plots more representative of diagnostic plots used for standard (non-censored) regression, a method for substituting randomized residuals in place of censored residuals was used. If a log-transformed concentration is censored at a particular limit, `logC < L`, then the residual for that concentration is censored as well, `logC - fitted(logC) < L - fitted(logC) = rescen`. In that case, a randomized residual was generated from a conditional normal distribution

```
resran  <-  scl * qnorm(runif(1) * pnorm(rescen / scl)),
```

where scl is the scale parameter from the survival regression model, `pnorm` is the R function for computing cumulative normal probabilities, `runif` is the R function for generating a random variable from the uniform distribution, and `qnorm` is the R function for computing quantiles of the normal distribution. Under the assumption that the model residuals are uncorrelated, normally distributed random variables with mean zero and standard deviation scl, the randomized residuals generated in this manner are an unbiased sample of the true (but unknown) residuals for the censored data. This is an application of the probability integral transform (Mood and others, 1974) to generate random variables from continuous distributions. The plotting position used a censored concentration is `fitted(logC) + resran`. Note that each time a new model fit is performed, a new set of randomized residuals is generated and thus the plotting positions for censored values can change.

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Examples

```
data(swData)
myPlots <- seawaveQPlots(stpars=examplestpars, cmaxt=0.4808743,
tseas=exampletseas, tseaspr=exampletseaspr, tndlin=exampletndlin,
tndlinpr=exampletndlinpr, cdatsub=examplecdatsub, cavdat=examplecavdat,
cavmat=examplecavmat, clog=exampleclog, centmp=examplecentmp,
yrstart=1995, yrend=2003, tyr=exampletyr, tyrpr=exampletyrpr,
pnames=c("04041"), tanm="examplePlots04041", mclass = 2, numknots = 4)
```

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