Package 'foreSIGHT'

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LinkingTo Rcpp

Imports doParallel, ggplot2 (>= 3.3.0), directlabels, cowplot, stats, graphics, grDevices, utils, moments, Rcpp, jsonlite, progress, rcorpora, scales, viridisLite, fields, RColorBrewer, rlang, lattice, mvtnorm

Suggests knitr (>= 1.8), rmarkdown (>= 1.18),testthat, evd

Title Systems Insights from Generation of Hydroclimatic Timeseries

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BugReports https://github.com/ClimateAnalytics/foreSIGHT/issues

Description A tool to create hydroclimate scenarios, stress test systems and visualize system performance in scenario-neutral climate change impact assessments. Scenario-neutral approaches 'stress-test' the performance of a modelled system by applying a wide range of plausible hydroclimate conditions (see Brown & Wilby (2012) <doi:10.1029/2012EO410001> and Prudhomme et al. (2010) <doi:10.1016/j.jhydrol.2010.06.043>). These approaches allow the identification of hydroclimatic variables that affect the vulnerability of a system to hydroclimate variation and change. This tool enables the generation of perturbed time series using a range of approaches including simple scaling of observed time series (e.g. Culley et al. (2016) <doi:10.1002/2015WR018253>) and stochastic simulation of perturbed time series via an inverse approach (see Guo et al. (2018) <doi:10.1016/j.jhydrol.2016.03.025>). It incorporates 'Richardson-type' weather generator model configurations documented in Richardson (1981) <doi:10.1029/WR017i001p00182>, Richardson and Wright (1984), as well as latent variable type model configurations documented in Bennett et al. (2018) <doi:10.1016/j.jhydrol.2016.12.043>, Ras-

mussen (2013) <doi:10.1002/wrcr.20164>, Bennett et al. (2019) <doi:10.5194/hess-23-4783-2019> to generate hydroclimate variables on a daily basis (e.g. precipitation, temperature, potential evapotranspiration) and allows a variety of different hydroclimate variable properties, herein called attributes, to be perturbed. Options are included for the easy integration of existing system models both internally in R and externally for seamless 'stress-testing'. A suite of visualization options for the results of a scenario-neutral analysis (e.g. plotting performance spaces and overlaying climate projection information) are also included. Version 1.0 of this package is described in Bennett et al. (2021) <doi:10.1016/j.envsoft.2021.104999>. As further developments in scenario-neutral approaches occur the tool will be updated to incorporate these advances.

License GPL-3

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`barossa_obs` *Multi-site rainfall observations in the Barossa Valley used in examples and vignette*

Description

Dataset of observed rainfall for multiple sites in the Barossa Valley based on SILO point data

Format

A list of observed rainfall data with elements *Year Month Day P*. *P* is a matrix with rows corresponding to dates, and columns corresponding to 13 sites in the Barossa Valley

Source

SILO point rainfall data obtained from https://www.longpaddock.qld.gov.au. Data obtained for stations *23300, 23302, 23305, 23309, 23312, 23313, 23317, 23318, 23321, 23363, 23373, 23752, 23756* for the period 1 Jan 1972 to 31 December 1999.

`calculateAttributes` *Calculates the attributes of the hydroclimate time series*

Description

`calculateAttributes` calculates the specified attributes of the input daily hydroclimate time series.

Usage

```
calculateAttributes(climateData, attSel, startYr = NULL, endYr = NULL)
```

Arguments

`climateData`	data.frame or list; daily climate data, the attributes of which are to be calculated. If `climateData` is a data.frame, it must have columns named *year*, *month*, *day*, **variable_name1**, **variable_name2**. Note that the first three columns of the data.frame contain the year, month, and day of the data. The columns have to be named as specified. Data.frame format is applicable for single site data only. If `climateData` is a list, it must have elements named *year*, *month*, *day*, **variable_name1**, **variable_name2**. List format is suitable for both single and multi-site data. For multi-site data, climate variables are specified as matrices, with columns for each site. Use `viewModels()` to view the valid variable names. Please refer to data provided with the package that may be loaded using `data(tankDat)` and `data(barossaDat)` for examples of the expected format of single site and multi-site `climateData`.
`attSel`	a vector; specifying the names of the attributes to be calculated.
`startYr`	a number (default `NULL`); to specify the starting year to subset `climateData` if required. If `NULL`, `startYr` is starting year in the input `climateData`.
`endYr`	a number (default `NULL`); to specify the ending year to subset `climateData` if required. If `NULL`, `endYr` is last year in the input `climateData`.

Value

The function returns a vector of attributes with names of the attributes (`attSel`). For multi-site data, names are combinations of attribute and site names.

Examples

```
#----------------------------------------------------------------------
# Example 1: Single-site data.frame input
# load 'tank' example climate data available in the package
data("tankDat")
# specify rainfall and temperature attributes to calculate
attSel <- c("P_ann_tot_m", "P_ann_nWet_m", "P_ann_R10_m", "Temp_ann_rng_m", "Temp_ann_avg_m")
tank_obs_atts <- calculateAttributes(tank_obs, attSel = attSel)
#----------------------------------------------------------------------
# Example 2: Multi-site list input
# load 'Barossa' example climate data available in the package
data("barossaDat")
# specify rainfall attributes to calculate
attSel <- c("P_ann_tot_m", "P_ann_nWet_m", "P_ann_P99")
barossa_obs_atts <- calculateAttributes(tank_obs, attSel = attSel)
```

---

calc_meanClimDaily_dayOfYearWindow

Calculates the seasonal pattern (i.e. climatological mean)

Description

Calculates the seasonal pattern (i.e. climatological mean)

Usage

```
calc_meanClimDaily_dayOfYearWindow(obs, doy, inc)
```

Arguments

obs	is a vector, representing a time series
doy	is the day of year for each value in the time series
inc	is the half-window size used in moving average

---

climdata

Example climate projection data

Description

A dataframe of climate projection data for superposition on performance spaces via plotLayers

Format

climdata is a dataframe with 12 rows and 3 columns

climdata A dataframe of climate attributes and performance in the form *P_ann_tot_m Temp_ann_avg_m performance*.

createExpSpace *Creates exposure space of hydroclimatic targets for generation of scenarios using 'generateScenarios'*

Description

createExpSpace returns a list containing the targets (targetMat) and the metadata (input arguments) used to create the exposure space.

Usage

```
createExpSpace(
  attPerturb,
  attPerturbSamp,
  attPerturbMin,
  attPerturbMax,
  attPerturbType = "regGrid",
  attPerturbBy = NULL,
  attHold = NULL,
  attTargetsFile = NULL
)
```

Arguments

attPerturb	A char vector; the names of the attributes to be perturbed. This vector can contain attributes of different hydroclimatic variables.
attPerturbSamp	An integer vector; the number of samples for each attribute attPerturb. The length of this vector should be equal to the length of attPerturb.
attPerturbMin	A numeric vector; the minimum bounds for sampling of attPerturb. The length of this vector should be equal to the length of attPerturb. For variables like precipitation, evapotranspiration, radiation, etc. attPerturbMin should specified as a fraction of the original (eg: 0.9 = 90% of the original attribute). For temperature, attPerturbMin should be specified in K (eg: 0.9 = 0.9 K).
attPerturbMax	A numeric vector; the maximum bounds for sampling of attPerturb. The length of this vector should be equal to the length of attPerturb. For variables like precipitation, evapotranspiration, radiation, etc. attPerturbMax should specified as a fraction of the original (eg: 0.9 = 90% of the original attribute). For temperature, attPerturbMax should be specified in K (eg: 0.9 = 0.9 K). Note that to create a single sample of the attribute, attPerturbSamp could be specified as 1 with attPerturbMin and attPerturbMax specified as equal.
attPerturbType	A string to specify the type of sampling, defaults to regular spacing. Valid sampling types are: • "regGrid" a regular grid sampling all the attributes specified in attPerturb simultaneously • "OAT" one-at-a-time sampling of the attributes specified in attPerturb

attPerturbBy	A numeric vector; increment of values to create samples between attPerturbMin and attPerturbMax. If attPerturbBy is specified, attPerturbSamp should be set as NULL.
attHold	A char vector; the names of the attributes to be held at historical levels. This vector can contain attributes of different hydroclimatic variables.
attTargetsFile	String specifying the full path to a CSV file containing the target exposure space. The column names in the file should correspond to the attributes specified in attPerturb and attHold. attTargetsFile is alternate way to specify exposure space targets that do not form a regular grid. If attTargetsFile is specified, the inputs arguments attPerturbSamp, attPerturbMin, attPerturbMax, and attPerturbType should be set to NULL and will not be used by the function.

Details

See "Detailed Tutorial: Climate 'Stress-Testing' using *fore*SIGHT" vignette for specifying attribute names for attPerturb and attHold. The definition of the attribute can be viewed using the function viewAttributeDef.

Value

The exposure space as a list containing the following fields:

- targetMat a dataframe or matrix; each column is a perturb/hold attribute, each row is a point in the exposure space.
- attRot a char vector containing the one-at-a-time ("OAT") attributes associated with targetMat, attRot is NULL for other types of sampling.
- attPerturb, attHold, attPerturbSamp, attPerturbMin, attPerturbMax, attPerturbType in the function input arguments, if not NULL.

See Also

generateScenarios, viewAttributeDef

Examples

```
# To view the definition of any valid attribute
viewAttributeDef("P_ann_tot_m")

# To create an exposure space of points on a regular grid
attPerturb <- c("P_ann_tot_m", "P_ann_nWet_m", "P_ann_R10_m")
attPerturbType <- "regGrid"
attPerturbSamp <- c(3, 1, 1)
attPerturbMin <- c(0.9, 1, 1)
attPerturbMax <- c(1.1, 1, 1)
attHold <- c("P_Feb_tot_m", "P_SON_dyWet_m", "P_JJA_avgWSD_m",
"P_MAM_tot_m", "P_DJF_avgDSD_m", "Temp_ann_rng_m", "Temp_ann_avg_m")
expSpace <- createExpSpace(attPerturb = attPerturb, attPerturbSamp = attPerturbSamp,
attPerturbMin = attPerturbMin, attPerturbMax = attPerturbMax,
attPerturbType = attPerturbType, attHold = attHold, attTargetsFile = NULL)
```

```
# Using attPerturbBy to specify the increment of perturbation (attPerturbSamp set to NULL)

attPerturb <- c("P_ann_tot_m", "P_ann_nWet_m", "P_ann_R10_m")
attPerturbType <- "regGrid"
attPerturbMin <- c(0.9, 1, 1)
attPerturbMax <- c(1.1, 1, 1)
attPerturbBy <- c(0.1, 0, 0)
attHold <- c("P_Feb_tot_m", "P_SON_dyWet_m", "P_JJA_avgWSD_m", "P_MAM_tot_m",
"P_DJF_avgDSD_m", "Temp_ann_rng_m", "Temp_ann_avg_m")
expSpace <- createExpSpace(attPerturb = attPerturb, attPerturbSamp = NULL,
attPerturbMin = attPerturbMin, attPerturbMax = attPerturbMax, attPerturbType = attPerturbType,
attPerturbBy = attPerturbBy, attHold = attHold, attTargetsFile = NULL)

# To create an exposure space of observed attributes without perturbation
# Note that attPerturbMin and attPerturbMax values are set to 1 for variables like precipitation,
# and 0 for temperature
attPerturb <- c("P_ann_tot_m", "P_ann_nWet_m", "P_ann_R10_m", "Temp_DJF_avg_m")
attPerturbType <- "regGrid"
attPerturbSamp <- c(1, 1, 1, 1)
attPerturbMin <- c(1, 1, 1, 0)
attPerturbMax <- c(1, 1, 1, 0)
expSpace <- createExpSpace(attPerturb = attPerturb, attPerturbSamp = attPerturbSamp,
attPerturbMin = attPerturbMin, attPerturbMax = attPerturbMax, attPerturbType = attPerturbType,
attHold = NULL, attTargetsFile = NULL)
```

`egClimData` *Climate attributes from projections.*

Description

A example dataset containing the climate attribute values in fraction/additive change

Usage

```
egClimData
```

Format

A data frame with 6 rows and 6 variables:

P_ann_tot_m change in mean annual total P, fraction

P_ann_seasRatio change in seasonal ratio of P, fraction

P_ann_nWet_m change in the number of wet days, fraction

Temp_ann_avg_m change in average annual Temp, additive

Name name of the climate model

Avg. Deficit performance metric values

egMultiSiteSim *Output from call to generateScenarios() using multi-site model (see example 5 in generateScenarios).*

Description

Output from call to generateScenarios() using multi-site model (see example 5 in generateScenarios).

Usage

```
egMultiSiteSim
```

Format

A list with 4 elements

Rep1 List containing majority of simulation output, including output for different calibration stages

simDates the dates of the simulation

expSpace the exposure space of the simulation

controlFile the setting in the control file

egScalPerformance *Performance metrics of the tank model using simple scaled scenarios.*

Description

Performance metrics of the tank model using simple scaled scenarios.

Usage

```
egScalPerformance
```

Format

A list with 2 elements

Avg. Deficit average daily deficit of water, litres

Reliability reliability of the tank, fraction

egScalSummary *Summary of a simple scaled scenario.*

Description

Summary generated using the function `getSimSummary`.

Usage

```
egScalSummary
```

Format

A list containing 3 elements

simDates the dates of the simulation

expSpace the exposure space of the simulation

controlFile "scaling"

egSimOATPerformance *Performance metrics of the tank model using OAT scenarios.*

Description

Performance metrics of the tank model using OAT scenarios.

Usage

```
egSimOATPerformance
```

Format

A list with 2 elements

Avg. Deficit average daily deficit of water, litres

Reliability reliability of the tank, fraction

egSimOATSummary *Summary of a OAT scenario.*

Description

Summary generated using the function `getSimSummary` for a scenarios generated using stochastic models for an OAT exposure space

Usage

```
egSimOATSummary
```

Format

A list containing 13 elements

egSimPerformance *Performance metrics of the tank model using regGrid scenarios.*

Description

Performance metrics of the tank model using regGrid scenarios.

Usage

```
egSimPerformance
```

Format

A list with 2 elements

Avg. Deficit average daily deficit of water, litres

Reliability reliability of the tank, fraction

`egSimPerformance_systemB` *Performance metrics of an alternate tank model using regGrid scenarios.*

Description

Performance metrics of an alternate tank model using regGrid scenarios.

Usage

```
egSimPerformance_systemB
```

Format

A list with 2 elements

Avg. Deficit average daily deficit of water, litres

Reliability reliability of the tank, fraction

`egSimSummary` *Summary of a regGrid scenario.*

Description

Summary generated using the function `getSimSummary` for a scenarios generated using stochastic models for a regGrid exposure space

Usage

```
egSimSummary
```

Format

A list containing 13 elements

`foreSIGHT` *foreSIGHT: A package for XXX*

Description

The foreSIGHT package provides XXX.

foreSIGHT functions

The foreSIGHT functions ...

func_avg *Calculates average of time series*

Description

Calculates average of time series

Usage

```
func_avg(data)
```

Arguments

data	is a vector, representing a time series

func_avgDSD *Calculates average dry spell duration (below threshold)*

Description

Calculates average dry spell duration (below threshold)

Usage

```
func_avgDSD(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$threshold denoting the threshold

func_avgWSD *Calculates average wet spell duration (below threshold)*

Description

Calculates average wet spell duration (below threshold)

Usage

```
func_avgWSD(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$threshold denoting the threshold

func_CSL *Calculates the cold season length*

Description

Calculates the cold season length

Usage

```
func_CSL(data)
```

Arguments

data	is a vector, representing a time series

func_dyWet *Calculates average rainfall on wet days (above threshold)*

Description

Calculates average rainfall on wet days (above threshold)

Usage

```
func_dyWet(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$threshold denoting the threshold

func_F0 *Calculates the number of frost days*

Description

Calculates the number of frost days

Usage

```
func_F0(data)
```

Arguments

data	is a vector, representing a time series

func_GSL *Calculates the growing season length*

Description

Calculates the growing season length

Usage

```
func_GSL(data)
```

Arguments

data	is a vector, representing a time series

func_maxDSD *Calculates maximum dry spell duration (below threshold)*

Description

Calculates maximum dry spell duration (below threshold)

Usage

```
func_maxDSD(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$threshold denoting the threshold

func_maxWSD *Calculates maximum wet spell duration (above threshold)*

Description

Calculates maximum wet spell duration (above threshold)

Usage

```
func_maxWSD(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$threshold denoting the threshold

func_nWet *Calculates number of wet days (above threshold)*

Description

Calculates number of wet days (above threshold)

Usage

```
func_nWet(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$threshold denoting the threshold

func_P *Calculates a quantile value*

Description

Calculates a quantile value

Usage

```
func_P(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$quant denoting the probability of the quantile

func_R *Calculates the number of days above a threshold (often used for temperature)*

Description

Calculates the number of days above a threshold (often used for temperature)

Usage

```
func_R(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$threshold denoting the threshold

func_rng *Calculates the inter-quantile range*

Description

Calculates the inter-quantile range

Usage

```
func_rng(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$lim denoting the probability limit width

func_seasRatio *Calculates seasonality ratio*

Description

Calculates seasonality ratio

Usage

```
func_seasRatio(data, attArgs)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$indexWet corresponding to wet season and attArgs$indexDry dry season

func_tot *Calculates total of time series*

Description

Calculates total of time series

Usage

```
func_tot(data)
```

Arguments

data	is a vector, representing a time series

func_wettest6monPeakDay *Calculates the day of year corresponding to the wettest 6 months*

Description

Calculates the day of year corresponding to the wettest 6 months

Usage

```
func_wettest6monPeakDay(data, attArgs = NULL)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$doy denoting the day of year for each value in the time series

func_wettest6monSeasRatio *Calculates the ratio of wet season to dry season rainfall, based on wettest6monPeakDay*

Description

Calculates the ratio of wet season to dry season rainfall, based on wettest6monPeakDay

Usage

```
func_wettest6monSeasRatio(data, attArgs = NULL)
```

Arguments

data	is a vector, representing a time series
attArgs	is a list, with attArgs$doy denoting the day of year for each value in the time series

generateScenario *Produces time series of hydroclimatic variables for an exposure target.*

Description

generateScenario is the base function used by generateScenarios. The function produces time series of hydroclimatic variables using requested climate attributes that correspond to a single target in the exposure space. The function argument definitions are detailed in the documentation of generateScenarios; please refer to that documentation using ?generateScenarios.

Usage

```
generateScenario(
  reference,
  expTarg,
  simLengthNyrs = NULL,
  seedID = NULL,
  controlFile = NULL
)
```

Arguments

reference	data.frame or list; contains reference daily climate data. For single site data, reference is a data.frame with columns named *year*, *month*, *day*, **variable_name1**, **variable_name2**. Note that the first three columns of the data.frame contain the year, month, and day of the data. The columns have to be named as specified. For multi-site data, reference is a list, with elements named *year*, *month*, *day*, **variable_name1**, **variable_name2**. List format is suitable for both single and multi-site data. Climate variables are specified as matrices, with columns for each site. Use viewModels() to view the valid variable names. Please refer to data provided with the package that may be loaded using data(tankDat) and data(barossaDat) for examples of the expected format of single site and multi-site reference.
expTarg	a named vector; the attributes at the target location in the exposure space generateScenario is intended to be used to adapt the functionality of generateScenarios for use in a parallel computing environment.
simLengthNyrs	a number; a scalar that specifies the length in years of each generated scenario. This argument is used only with stochastic generation. If NULL (the default), the generated simulation will be as long as reference.
seedID	a number; a scalar that specifies the seed to be used for the first replicate. Subsequent replicates will use seeds incremented by one. If seedID is NULL (which is the default), the function will use a random seed for stochastic time series generation. The seed used will be specified in the output. This argument is intended for use in cases that aim to reproduce an existing simulation.
controlFile	a string; to specify the model/optimisation options used for simulating time series data. The valid values are:

- NULL : the simulation uses the foreSIGHT default stochastic model settings.
- "scaling" : the simulation uses scaling (simple/seasonal) instead of a stochastic model. If all attributes in *expSpace* are annual totals/averages, then simple scaling is used. If seasonality ratio attributes are also included in *expSpace*, then seasonal scaling is used.
- path to a JSON file : the JSON file contains advanced options specify the stochastic model and optimisation inputs. These options can be used to change stochastic model types, overwrite default model parameter bounds, change default optimisation arguments, and set penalty attributes to be used in optimisation. Please refer to the function writeControlFile in order to create an controlFile JSON file.

See Also

generateScenarios

---

generateScenarios *Produces time series of hydroclimatic variables for an exposure space.*

Description

generateScenarios produces time series of hydroclimatic variables using requested climate attributes that correspond to a target exposure space using a reference daily time series as an input.

Usage

```
generateScenarios(
  reference,
  expSpace,
  simLengthNyrs = NULL,
  numReplicates = 1,
  seedID = NULL,
  controlFile = NULL
)
```

Arguments

reference	data.frame or list; contains reference daily climate data. For single site data, reference is a data.frame with columns named *year*, *month*, *day*, **variable_name1**, **variable_name2**. Note that the first three columns of the data.frame contain the year, month, and day of the data. The columns have to be named as specified. For multi-site data, reference is a list, with elements named *year*, *month*, *day*, **variable_name1**, **variable_name2**. List format is suitable for both single and multi-site data. Climate variables are specified as matrices, with columns for each site. Use viewModels() to view the valid variable names. Please refer to data provided with the package that may be loaded using data(tankDat) and data(barossaDat) for examples of the expected format of single site and multi-site reference.

`expSpace` a list; created using the function `createExpSpace`

`simLengthNyrs` a number; a scalar that specifies the length in years of each generated scenario. This argument is used only with stochastic generation. If `NULL` (the default), the generated simulation will be as long as `reference`.

`numReplicates` a number; a scalar that specific the number of stochastic replicates to be generated. The default is 1.

`seedID` a number; a scalar that specifies the seed to be used for the first replicate. Subsequent replicates will use seeds incremented by one. If `seedID` is `NULL` (which is the default), the function will use a random seed for stochastic time series generation. The seed used will be specified in the output. This argument is intended for use in cases that aim to reproduce an existing simulation.

`controlFile` a string; to specify the model/optimisation options used for simulating time series data. The valid values are:

- `NULL` : the simulation uses the foreSIGHT default stochastic model settings.
- `"scaling"` : the simulation uses scaling (simple/seasonal) instead of a stochastic model. If all attributes in *expSpace* are annual totals/averages, then simple scaling is used. If seasonality ratio attributes are also included in *expSpace*, then seasonal scaling is used.
- `path to a JSON file` : the JSON file contains advanced options specify the stochastic model and optimisation inputs. These options can be used to change stochastic model types, overwrite default model parameter bounds, change default optimisation arguments, and set penalty attributes to be used in optimisation. Please refer to the function `writeControlFile` in order to create an `controlFile` JSON file.

Value

The function returns a list containing the time series data generated. The list can contain multiple replicates (named as `Rep1`, `Rep2` etc.) equal to the `numReplicates` function argument. Each replicate can contain multiple targets (named as `Target1`, `Target2` etc.) based on the specified exposure space (`expSpace`). The `expSpace` and `controlFile` are also returned as part of this output list.

See Also

`createExpSpace`, `writeControlFile`, `viewModels`

Examples

```
# Example 1: Simple scaling
#-------------------------------------------------------------------------
attPerturb<-c("P_ann_tot_m","Temp_ann_avg_m")
attPerturbType = "regGrid"
attPerturbSamp = c(2, 2)
attPerturbMin = c(0.8, -1)
attPerturbMax = c(1.1, 1)
expSpace <- createExpSpace(attPerturb = attPerturb,
                           attPerturbSamp = attPerturbSamp,
                           attPerturbMin = attPerturbMin,
```

```
                            attPerturbMax = attPerturbMax,
                            attPerturbType = attPerturbType)
data(tankDat)
simScaling <- generateScenarios(reference = tank_obs,
                                expSpace = expSpace,
                                controlFile = "scaling")

# Example 2: Seasonal scaling
#-----------------------------------------------------------------------
attPerturb<-c("P_ann_tot_m","P_ann_seasRatio")
attPerturbType = "regGrid"
attPerturbSamp = c(2, 2)
attPerturbMin = c(0.8, 0.9)
attPerturbMax = c(1.1, 1.2)
expSpace <- createExpSpace(attPerturb = attPerturb,
                            attPerturbSamp = attPerturbSamp,
                            attPerturbMin = attPerturbMin,
                            attPerturbMax = attPerturbMax,
                            attPerturbType = attPerturbType)
data(tankDat)
seasScaling <- generateScenarios(reference = tank_obs,
                                expSpace = expSpace,
                                controlFile = "scaling")

# Example 3: Stochastic simulation using foreSIGHT default settings
#-----------------------------------------------------------------------
## Not run:
# create an exposure space
attPerturb <- c("P_ann_tot_m", "P_ann_nWet_m", "P_ann_R10_m")
attHold <- c("P_Feb_tot_m", "P_SON_dyWet_m", "P_JJA_avgWSD_m", "P_MAM_tot_m",
"P_DJF_avgDSD_m", "Temp_ann_rng_m", "Temp_ann_avg_m")
attPerturbType = "regGrid"
attPerturbSamp = c(2, 1, 1)
attPerturbMin = c(0.8, 1, 1)
attPerturbMax = c(1.1, 1, 1)
expSpace <- createExpSpace(attPerturb = attPerturb,
                            attPerturbSamp = attPerturbSamp,
                            attPerturbMin = attPerturbMin,
                            attPerturbMax = attPerturbMax,
                            attPerturbType = attPerturbType,
                            attHold = attHold,
                            attTargetsFile = NULL)
# load example data available in foreSIGHT
data(tankDat)
# perform stochastic simulation
simStochastic <- generateScenarios(reference = tank_obs,
                                   expSpace = expSpace,
                                   simLengthNyrs = 30)

## End(Not run)
# Example 4: Simple Scaling with multi-site data
#-----------------------------------------------------------------------
attPerturb <- c("P_ann_tot_m","P_ann_seasRatio")
```

```
attPerturbType = "regGrid"
attPerturbSamp = c(3, 3)
attPerturbMin = c(0.8, 1.2)
attPerturbMax = c(0.8, 1.2)
expSpace <- createExpSpace(attPerturb = attPerturb,
                           attPerturbSamp = attPerturbSamp,
                           attPerturbMin = attPerturbMin,
                           attPerturbMax = attPerturbMax,
                           attPerturbType = attPerturbType)
# load multi-site rainfall data
data(barossaDat)
# perform simple scaling
simScaling <- generateScenarios(reference = barossa_obs,
                                expSpace = expSpace,
                                controlFile = "scaling")

# Example 5: Multi-site stochastic simulation
#-----------------------------------------------------------------------
## Not run:
attPerturb <- c("P_ann_tot_m")
attHold <- c("P_ann_wettest6monSeasRatio","P_ann_wettest6monPeakDay",
"P_ann_P99","P_ann_avgWSD_m", "P_ann_nWetT0.999_m")
attPerturbType = "regGrid"
# consider unperturbed climates in this example
attPerturbSamp = attPerturbMin = attPerturbMax = c(1)
expSpace <- createExpSpace(attPerturb = attPerturb,
                           attPerturbSamp = attPerturbSamp,
                           attPerturbMin = attPerturbMin,
                           attPerturbMax = attPerturbMax,
                           attPerturbType = attPerturbType,
                           attHold = attHold)
# load multi-site rainfall data
data(barossaDat)
# specify the penalty settings in a list
controlFileList <- list()
controlFileList[["penaltyAttributes"]] <- c("P_ann_tot_m",
"P_ann_wettest6monSeasRatio","P_ann_wettest6monPeakDay")
controlFileList[["penaltyWeights"]] <- c(0.5,0.5,0.5)
# specify the alternate model selections
controlFileList[["modelType"]] <- list()
controlFileList[["modelType"]][["P"]] <- "latent"
# specify model parameter selection
controlFileList[["modelParameterVariation"]] <- list()
controlFileList[["modelParameterVariation"]][["P"]] <- "harmonic"
# specify settings for multi-site model
controlFileList[["spatialOptions"]] <- list()
# specify spatial correlation perturbation factor
controlFileList[["spatialOptions"]][["spatCorFac"]] = 0.9
# write control file sttings to file
controlFileJSON <- jsonlite::toJSON(controlFileList, pretty = TRUE, auto_unbox = TRUE)
write(controlFileJSON, file = paste0(tempdir(), "controlFile.json"))
# run multi-site stochastic simulation - this will take a long time (e.g. hours)
sim <- generateScenarios(reference = barossa_obs, expSpace = expSpace,
```

```
                          controlFile = paste0(tempdir(), "controlFile.json"),seed=1)
## End(Not run)
```

`getSimSummary` *Produces a summary object containing the metadata of a full simulation*

Description

`getSimSummary` uses a full simulation generated using the function `generateScenarios` as input and outputs a summary object containing the metadata of the full simulation. The output summary object may be used as an input to the plotting functions in this package. The output summary object will be much smaller in size than the full simulation for ease of storage and use with the plotting functions.

Usage

```
getSimSummary(sim)
```

Arguments

`sim`	list; a simulation containing the scenarios generated using the function `generateScenarios`.

See Also

`generateScenarios`, `plotPerformanceSpace`, `plotPerformanceOAT`

`modCalibrator` *modCalibrator*

Description

Calibrates weather generator models specified using modelTag.

Usage

```
modCalibrator(obs = NULL, modelTag = NULL, window = NULL)
```

Arguments

`obs`	A dataframe of observed climate data in the form *Year Month Day P Temp*.
`modelTag`	A character vector of which stochastic models to use to create each climate variable. Supported tags are shown in under details below.
`window`	moving average window to calibrate daily gamma parameters for the modelTag `"P-har-WGEN"`.

Details

modelTag provides the main function with requested models. modelTag is vector of any of the following supported models:

- "Simple-ann"a simple annual scaling
- "P-ann-wgen"a four parameter annual rainfall model
- "P-seas-wgen"a 16 parameter seasonal rainfall model
- "P-har6-wgen"a harmonic rainfall model with 6 periods
- "P-har12-wgen"a harmonic rainfall model
- "P-har12-wgen-FS"a harmonic rainfall model where seasonality is fixed (phase angles must be specified via modelInfoMod=list("P-har12-wgen-FS"=fixedPars=c(x,x,x,x))
- "P-har26-wgen"a harmonic rainfall model
- "P-2har26-wgen"a double harmonic rainfall model
- "Temp-har26-wgen"a harmonic temperature model not conditional on rainfall
- "Temp-har26-wgen-wd"a harmonic temperature model dependent on wet or dry day
- "Temp-har26-wgen-wdsd"a harmonic temperature model where standard deviation parameters are dependent on wet or dry day
- "PET-har12-wgen"a harmonic potential evapotranspiration model
- "PET-har26-wgen"a harmonic potential evapotranspiration model
- "PET-har26-wgen-wd"a harmonic potential evapotranspiration model dependent on wet or dry day
- "Radn-har26-wgen"a harmonic solar radiation model (MJ/m2)

Examples

```
data(tankDat)                               #Load tank data (tank_obs)
modelTag=c("P-ann-wgen","Temp-har26-wgen") #Select a rainfall and a temperature generator
out<- modCalibrator(obs = tank_obs,         #Calibrate models
                    modelTag = modelTag)
```

---

modSimulator *modSimulator*

Description

Simulates using weather generator models specified using modelTag.

Usage

```
modSimulator(
  datStart = NULL,
  datFinish = NULL,
  modelTag = NULL,
  parS = NULL,
  seed = NULL,
  file = NULL,
  IOmode = "suppress"
)
```

Arguments

datStart	A date string in an accepted date format e.g. *"01-10-1990"*.
datFinish	A date string in an accepted date format e.g. *"01-10-1990"*. Must occur after datStart.
modelTag	A character vector of which stochastic models to use to create each climate variable. Supported tags are shown in details below.
parS	A list (names must match supplied modelTags) containing numeric vectors of model parameters.
seed	Numeric. Seed value supplied to weather generator.
file	Character. Specifies filename for simulation output.
IOmode	A string that specifies the input-output mode for the time series = "verbose", "dev" or "suppress".

Details

modelTag provides the main function with requested models. modelTag is vector of any of the following supported models:

- "Simple-ann"a simple annual scaling
- "P-ann-wgen"a four parameter annual rainfall model
- "P-seas-wgen"a 16 parameter seasonal rainfall model
- "P-har6-wgen"a harmonic rainfall model with 6 periods
- "P-har12-wgen"a harmonic rainfall model
- "P-har12-wgen-FS"a harmonic rainfall model where seasonality is fixed (phase angles must be specified via modelInfoMod=list("P-har12-wgen-FS"=fixedPars=c(x,x,x,x))
- "P-har26-wgen"a harmonic rainfall model
- "P-2har26-wgen"a double harmonic rainfall model
- "Temp-har26-wgen"a harmonic temperature model not conditional on rainfall
- "Temp-har26-wgen-wd"a harmonic temperature model dependent on wet or dry day
- "Temp-har26-wgen-wdsd"a harmonic temperature model where standard deviation parameters are dependent on wet or dry day

- "PET-har12-wgen"a harmonic potential evapotranspiration model
- "PET-har26-wgen"a harmonic potential evapotranspiration model
- "PET-har26-wgen-wd"a harmonic potential evapotranspiration model dependent on wet or dry day
- "Radn-har26-wgen"a harmonic solar radiation model (MJ/m2)

Examples

```
## Not run:
data(tankDat); obs=tank_obs                      #Get observed data
modelTag=c("P-har12-wgen","Temp-har26-wgen")     #Select models
pars=modCalibrator(obs=obs,modelTag=modelTag)    #Calibrate models
sim=modSimulator(datStart="1970-01-01",          #Simulate!
                 datFinish="1999-12-31",
                 modelTag=modelTag,
                 parS=pars,
                 seed=123,
                 file=paste0("tester.csv"),
                 IOmode="verbose")
plot(sim$P[1:365])                              #Plot first year of rainfall

## End(Not run)
```

---

plotExpSpace *Plots the location of points in a two-dimensional exposure space*

Description

The function uses an exposure space created using the function createExpSpace as input and creates a plot of the two dimensional (2D) exposure space. plotExpSpace plots only 2D spaces consisting of samples of 2 attributes.

Usage

```
plotExpSpace(
  expSpace,
  y = expSpace[["attPerturb"]][1],
  x = expSpace[["attPerturb"]][2]
)
```

Arguments

expSpace	list; an exposure space created using the function createExpSpace
y	a string; tag of a perturbed attribute to plot on the y-axis. Defaults to expSpace[["attPerturb"]][1].
x	a string; tag of a perturbed attribute to plot on the x-axis. Defaults to expSpace[["attPerturb"]][2].

Details

The number of dimensions of an exposure space is equal to the number of perturbed attributes in that space. If the exposure space has more than 2 dimensions (perturbed attributes), this function can be used to plot 2D slices of the space. Note that the default arguments of this function is defined to plot a slice showing the first two dimensions of the space, arguments `x` and `y` may be specified to plot alternate dimensions.

See Also

`createExpSpace`

Examples

```
# create an exposure space that has more than 2 dimensions
attPerturb <- c("P_ann_tot_m", "P_ann_nWet_m", "P_Feb_tot_m")
attHold <- c("P_SON_dyWet_m", "P_JJA_avgWSD_m", "P_MAM_tot_m", "P_DJF_avgDSD_m",
"Temp_ann_rng_m", "Temp_ann_avg_m")
attPerturbType = "regGrid"
attPerturbSamp = c(5, 5, 5)
attPerturbMin = c(0.8, 0.9, 0.85)
attPerturbMax = c(1, 1.1, 1.05)
expSpace <- createExpSpace(attPerturb = attPerturb,
                           attPerturbSamp = attPerturbSamp,
                           attPerturbMin = attPerturbMin,
                           attPerturbMax = attPerturbMax,
                           attPerturbType = attPerturbType,
                           attHold = attHold,
                           attTargetsFile = NULL)
# plot the first two dimensions
plotExpSpace(expSpace)
# plot another slice
plotExpSpace(expSpace, y = "P_ann_tot_m", x = "P_Feb_tot_m")
```

---

plotMultiSiteScenarios

Creates summary plots of the biases in the multi-site scenarios

---

Description

`plotMultiSiteScenarios` uses a multi-site simulation performed using the function `generateScenarios` as input, and creates heatmaps that show biases in simulated attributes and spatial correlation. The function creates heatmaps (for each replicate and target) that show:

- magnitude of biases in single site attributes
- magnitude of biases in catchment total attributes
- biases in spatial correlation

Usage

```
plotMultiSiteScenarios(
  reference,
  sim,
  attSel = NULL,
  targets = 1,
  reps = 1,
  stages = c("Stage1", "Stage2", "Stage3")
)
```

Arguments

reference	list; contains reference daily climate data, with elements named *year*, *month*, *day*, **variable_name1**, **variable_name2**. List format is suitable for both single and multi-site data. Climate variables are specified as matrices, with columns for each site. Please refer to data provided with the package that may be loaded using `data(barossaDat)` for examples of the expected format of multi-site `reference`.
sim	a list; contains a multi-site stochastic simulation created using the function `generateScenarios`
attSel	a vector; contains names of selected attributes to be evaluated
targets	a vector; contains set of targets in exposure space to be evaluated
reps	a vector; contains replicates of stochastic simulation to be evaluated
stages	a vector; contains names of approaches used to generate multi-site stochastic simulations ('Stage3' is recommended approach, while 'Stage1' and 'Stage2' show intermediate results)

Value

The function returns three R plots for each target and replicate showing the biases in single site attributes, catchment average attributes, and spatial correlations.

See Also

`generateScenarios`

Examples

```
# load data from multi-site simulation
data(egMultiSiteSim)
# plot performance of simulated time series in terms of single site
# and catchment attributes, and correlation between sites
## Not run:
plotMultiSiteScenarios(reference=barossa_obs,sim=egMultiSiteSim)

## End(Not run)
```

plotOptions *Plots the differences in performance metrics from two system options*

Description

plotOptions uses the system model performances calculated using the function runSystemModel for two alternate system model options, and the summary of the simulation generated using the functions generateScenarios & getSimSummary as input. The function plots the differences in the performance metrics between the two options, and the changes in performance thresholds in the space. The user may specify the attributes to be used as the axes of the plot. The function contains arguments to control the finer details of the plot.

Usage

```
plotOptions(
  performanceOpt1,
  performanceOpt2,
  sim,
  metric = NULL,
  attX = NULL,
  attY = NULL,
  topReps = NULL,
  opt1Label = "Option 1",
  opt2Label = "Option 2",
  titleText = paste0(opt2Label, " - ", opt1Label),
  perfThresh = NULL,
  perfThreshLabel = "Threshold",
  attSlices = NULL,
  climData = NULL,
  colMap = NULL,
  colLim = NULL
)
```

Arguments

performanceOpt1	a named list; contains the system model performance calculated using runSystemModel for system model option 1. If the list contains more than one performance metric, the argument metric can be used to specify the metric to be used.
performanceOpt2	a named list; contains the system model performance calculated using runSystemModel for system model option 2. If the list contains more than one performance metric, the argument metric can be used to specify the metric to be used.
sim	a list; summary of the simulation containing the scenarios generated using the function generateScenarios that is used to run the system model using runSystemModel. The summary of the simulation may be obtained by using the function getSimSummary

on the full simulation. The summary object is much smaller in size for ease of storage and use with the performance plotting functions like `plotPerformanceSpace`.

`metric` a string; the name of the performance metric to be plotted. The argument can be used to select the metric from `performanceOpt1` and `performanceOpt2` lists for plotting. If `NULL` (the default), the first metric in the lists will be used.

`attX` a string; the tag of the perturbed attribute to plot on the xaxis. The attribute must be one of the perturbed attributes of `sim`. Type `sim$expSpace$attPerturb` to view all perturbed attributes of `sim`. If `NULL` (default), the first perturbed attribute of `sim` will be used.

`attY` a string; the tag of the perturbed attribute to plot on the yaxis. The attribute must be another perturbed attribute of `sim`. If `NULL`, the second perturbed attribute of `sim` will be used.

`topReps` an integer (default is `NULL`); the number of "top" replicates in terms of simulation fitness to be used. If `topReps` is specified, `topReps` number of replicates will be identified for each target and the average performance across these replicates will be plotted. If `NULL`, the average performance across all the replicates will be plotted.

`opt1Label` a string; the text to label `performanceOpt1`.

`opt2Label` a string; the text to label `performanceOpt2`.

`titleText` a string; text for the title of the plot. The default is `paste0(opt2Label, " - ", opt1Label)`.

`perfThresh` a number; the minimum or maximum threshold value of the performance metric. A line will be drawn to mark this threshold value in the performance space.

`perfThreshLabel`
a string; the text to label `perfThresh`.

`attSlices` a list; used to subset perturbed attributes in `sim` for the plot. This argument would typically be used in cases where there are more than two perturbed attributes. The elements of the list correspond to the perturbed attributes to be subsetted and must be named using the attribute tag. Each element may contain a single value or a two-element vector specifying the minimum-maximum values. If the element is a single value, the exposure space is sliced on this single value of the attribute. If minimum-maximum values are specified, the exposure space will be sliced to subset this range. If `attSlices` includes `attX` or `attY`, these attributes will be sliced and the resulting plot will be a "zoomed-in" space.

`climData` data.frame; the values of attX and attY from other sources like climate models. This data will be plotted as points in the performance space. The data frame may contain columns with values of the performance metric to be plotted and the "Name" of the dataset. If the performance metric is available in the data.frame, the points will be coloured based on the performance `colMap` scale. If the `Name` of the data is available in the data.frame, the points will be identified using the `Name`. Please refer data provided with the package that may be loaded using `data("egClimData")` for an example of the expected format of `climData`.

`colMap` a vector of colours; to specify the colourmap to be used. If `NULL`, the default foreSIGHT colourmap is used.

`colLim` a vector of 2 values; the minimum and maximum limits of the colour scale.

Value

The plot of the differences in the performance metrics (option 2 - option 1) in a ggplot object.

See Also

runSystemModel, plotPerformanceSpace, generateScenarios, getSimSummary

Examples

```
# load example datasets
data("egSimSummary")
data("egSimPerformance")       # performance of option1
data("egSimPerformance_systemB")  # performance of option2
data("egClimData")
plotOptions(egSimPerformance[1], egSimPerformance_systemB [1], egSimSummary,
attX = "P_ann_seasRatio", attY = "P_ann_tot_m", topReps = 7, perfThreshLabel = "Threshold (28L)",
perfThresh = 28,  opt1Label = "System A", opt2Label = "System B", climData = egClimData)
```

---

plotPerformanceOAT *Plots performance for one-at-a-time (OAT) perturbations in attributes*

Description

plotPerformanceOAT uses the system model performance calculated using the function runSystemModel and the summary of the simulation generated using the function generateScenarios & getSimSummary as input. The function creates line plots, each panel shows the variations in performance with perturbations in a single attribute. The function is intended for use with simulations with attributes perturbed on a one-at-a-time (OAT) grid.

Usage

```
plotPerformanceOAT(
  performance,
  sim,
  metric = NULL,
  topReps = NULL,
  col = NULL,
  ylim = NULL
)
```

Arguments

performance	a named list; contains the system model performance calculated using runSystemModel. If the list contains more than one performance metric, the first metric will be plotted.
sim	a list; a summary of a simulation containing the scenarios generated using the function generateScenarios that is used to run the system model using runSystemModel. The summary may be obtained using the function getSimSummary

metric	a string; the name of the performance metric to be plotted. The argument can be used to select a metric from performance for plotting.
topReps	an integer (default = NULL); the number of "top" replicates to be used. The "top" replicates will be identified for each target based on the simulation fitness. The average performance across topReps replicates will be plotted.
col	a colour; the colour of the lines. If NULL, the a default colour is used.
ylim	a vector of 2 values; the minimum and maximum limits of the y-axis (performance) scale.

Details

The plots show the mean value of performance across replicates. The ranges between the minimum and maximum values of performance across replicates are shaded. The function is intended for use with simulations containing attributes perturbed on an "OAT" grid. If the perturbations are on a "regGrid", this function will subset OAT perturbations, if available, to create the plots. The function creates separate plots for perturbations in attributes of temperature and other variables. The function may be called with performance argument specifying the metric to be plotted to plot other metrics.

Value

The plot of the performance space and the ggplot object.

See Also

runSystemModel, generateScenarios, plotPerformanceSpace, getSimSummary

Examples

```
# load example datasets
data("egSimSummary")
data("egSimPerformance")
plotPerformanceOAT(egSimPerformance[2], egSimSummary)
plotPerformanceOAT(egSimPerformance[1], egSimSummary)
# using the metric argument
plotPerformanceOAT(egSimPerformance, egSimSummary, metric = "Reliability (-)")
```

---

plotPerformanceSpace *Plots a performance space using the system performance and scenarios as input*

Description

plotPerformanceSpace uses the system model performance calculated using the function runSystemModel and the summary of the simulation generated using the functions generateScenarios & getSimSummary as input to plot the performance space of the system. The user may specify the attributes to be used as the axes of the performance space.

Usage

```
plotPerformanceSpace(
  performance,
  sim,
  metric = NULL,
  attX = NULL,
  attY = NULL,
  topReps = NULL,
  perfThresh = NULL,
  perfThreshLabel = "Threshold",
  attSlices = NULL,
  climData = NULL,
  colMap = NULL,
  colLim = NULL,
  contourBreaks = NULL,
  axesPercentLabel = FALSE,
  type = "heat.plot"
)
```

Arguments

performance	a named list; contains the system model performance calculated using runSystemModel. If the list contains more than one performance metric, the argument metric can be used to specify the metric to be used.
sim	a list; summary of the simulation containing the scenarios generated using the function generateScenarios that is used to run the system model using runSystemModel. The summary of the simulation may be obtained by using the function getSimSummary on the full simulation. The summary object is much smaller in size for ease of storage and use with the performance plotting functions like plotPerformanceSpace.
metric	a string; the name of the performance metric to be plotted. The argument can be used to select a metric from performance for plotting. If NULL (the default), the first metric in the list will be used.
attX	a string; the tag of the perturbed attribute to plot on the xaxis. The attribute must be one of the perturbed attributes of sim. Type sim$expSpace$attPerturb to view all perturbed attributes of sim. If NULL (default), the first perturbed attribute of sim will be used.
attY	a string; the tag of the perturbed attribute to plot on the yaxis. The attribute must be another perturbed attribute of sim. If NULL, the second perturbed attribute of sim will be used.
topReps	an integer (default is NULL); the number of "top" replicates in terms of simulation fitness to be used. If topReps is specified, topReps number of replicates will be identified for each target and the average performance across these replicates will be plotted. If NULL, the average performance across all the replicates will be plotted.
perfThresh	a number; the minimum or maximum threshold value of the performance metric. A line will be drawn to mark this threshold value in the performance space.

perfThreshLabel
: a string; the text to label perfThresh.

attSlices
: a list; used to subset perturbed attributes in sim for the plot. This argument would typically be used in cases where there are more than two perturbed attributes. The elements of the list correspond to the perturbed attributes to be subsetted and must be named using the attribute tag. Each element may contain a single value or a two-element vector specifying the minimum-maximum values. If the element is a single value, the exposure space is sliced on this single value of the attribute. If minimum-maximum values are specified, the exposure space will be sliced to subset this range. If attSlices includes attX or attY, these attributes will be sliced and the resulting plot will be a "zoomed-in" space.

climData
: data.frame; the values of attX and attY from other sources like climate models. This data will be plotted as points in the performance space. The data frame may contain columns with values of the performance metric to be plotted and the "Name" of the dataset. If the performance metric is available in the data.frame, the points will be coloured based on the performance colMap scale. If the Name of the data is available in the data.frame, the points will be identified using the Name. Please refer data provided with the package that may be loaded using data("egClimData") for an example of the expected format of climData.

colMap
: a vector of colours; to specify the colourmap to be used. If NULL, the default foreSIGHT colourmap is used.

colLim
: a vector of 2 values; the minimum and maximum limits of the colour scale.

contourBreaks
: a vector; specifies breaks in the performance metric

axesPercentLabel
: a logical flag; if TRUE x and y axes to be displayed in terms of percentage change instead of fraction

type
: a string; indicates type of plot as "heat.plot" (default) or "filled.contour"

Details

If the space contains more than two perturbed attributes, the performance values are averaged across the perturbations in the attributes other than attX and attY. The user may specify argument attSlices to slice the performance space at specific values of the other perturbed attributes. If attSlices are used to specify minimum-maximum values to subset other perturbed attributes, the performance values are averaged across the subsetted perturbations in these attributes. If the input performance list contains multiple performance metrics, the function plots the first metric. The function may be called with performance argument specifying the metric to be plotted plotPerformanceSpace(performance[2], sim) to plot other metrics.

Value

The plot of the performance space and the ggplot object.

See Also

runSystemModel, generateScenarios, getSimSummary, plotPerformanceOAT

Examples

```
# load example datasets
data("egSimSummary")       # summary of stochastic simulation
data("egSimPerformance")   # system performance calculated using the stochastic simulation
data("egClimData")         # alternate climate data and system performance

plotPerformanceSpace(performance=egSimPerformance[2], sim=egSimSummary)

## Not run:
# change plot style to "filled.contour" and specify contours - show contours from
# 0.76 to 0.9 in increments of 0.02
plotPerformanceSpace(type="filled.contour",performance=egSimPerformance[2],
                     sim=egSimSummary,contourBreaks=seq(0.76,0.9,0.02))


# adding climate data, using top 10 replicates
plotPerformanceSpace(performance=egSimPerformance[1], sim=egSimSummary,
                     topReps = 10, climData = egClimData)

# adding a threshold
plotPerformanceSpace(performance=egSimPerformance, sim=egSimSummary, metric = "Avg. Deficit (L)",
              climData = egClimData, perfThresh = 27.5, perfThreshLabel = "Max Avg. Deficit")

# user specified colMap
plotPerformanceSpace(performance=egSimPerformance[1], sim=egSimSummary,
                     climData = egClimData, perfThresh = 27.5,
                     perfThreshLabel = "Max Avg. Deficit",
                     colMap = viridisLite::inferno(100))

#modify theme to change axes positioning to stacked vertically and left aligned
plotPerformanceSpace(performance=egSimPerformance[1], sim=egSimSummary,
                     climData = egClimData, perfThresh = 27.5,
                     perfThreshLabel = "Max Avg. Deficit",
                     colMap = viridisLite::inferno(100))+
ggplot2::theme(legend.box="vertical",
               legend.position="bottom",
               legend.box.just = "left",
               legend.margin = ggplot2::margin(t=0.01, r=0.1, b=0.01, l=0.1, "cm"),
               legend.justification=c(0.01,0.01))

# display fractional changes axes as percentage change
plotPerformanceSpace(performance=egSimPerformance, sim=egSimSummary,
                     metric = "Avg. Deficit (L)",
                     climData = egClimData, perfThresh = 27.5,
                     perfThreshLabel = "Max Avg. Deficit",
                     axesPercentLabel=TRUE)

# change displayed contours on performance space - show contours from 18 to 34 in increments of 2 L
plotPerformanceSpace(performance=egSimPerformance, sim=egSimSummary,
                     metric = "Avg. Deficit (L)",
                     climData = egClimData, perfThresh = 27.5,
                     perfThreshLabel = "Max Avg. Deficit",axesPercentLabel=TRUE,
```

```
                    contourBreaks=seq(18,34,2))

# change plot type to filled.contour style
plotPerformanceSpace(type="filled.contour",performance=egSimPerformance,
                     sim=egSimSummary, metric = "Avg. Deficit (L)",
                     climData = egClimData, perfThresh = 27.5,
                     perfThreshLabel = "Max Avg. Deficit",axesPercentLabel=TRUE,
                     contourBreaks=seq(18,34,2))

#example overlay points manually from a dataset in a similar style to egClimData
ptStyle= c(21,22, 24)  #select set of pt styles (e.g. hollow circle, square, triangle)
plotPerformanceSpace(performance=egSimPerformance[1], sim=egSimSummary,axesPercentLabel=TRUE)+
ggplot2::geom_point(data = egClimData,
                    mapping = ggplot2::aes(x = .data[["P_ann_tot_m"]],
                    y = .data[["P_ann_seasRatio"]],
                    shape = .data[["Name"]]),
                   show.legend = TRUE, size = 5, colour = "black", fill = "lightgray") +
ggplot2::scale_shape_manual(name = NULL, values = ptStyle,
                            guide = ggplot2::guide_legend(order = 2, nrow = 1))+
                   #one row of legend for specified ptStyle types
ggplot2::theme(legend.box="vertical", # vertical arrangement of items in legends
               legend.position="bottom", # position legends base of figure
               legend.justification=c(0,0)) # justification according to the plot area

# example of performance generated using simple scaled simulation
data("egScalPerformance")
data("egScalSummary")
data("egClimData")
plotPerformanceSpace(performance=egScalPerformance[1], sim=egScalSummary, climData = egClimData,
                     perfThresh = 28.25, perfThreshLabel = "Max Avg. Deficit")

## End(Not run)
```

`plotPerformanceSpaceMulti` *Plots contours of the number of performance thresholds exceeded in the perturbation space*

Description

`plotPerformanceSpaceMulti` uses multiple system model performances calculated using the function `runSystemModel` and the summary of the simulation generated using the functions `generateScenarios` & `getSimSummary` as input to plot filled contours showing the number of performance thresholds exceeded in the perturbation space. The user may specify the attributes to be used as the axes of the perturbation space.

Usage

```
plotPerformanceSpaceMulti(
```

```
  performance,
  sim,
  perfThreshMin,
  perfThreshMax,
  attX = NULL,
  attY = NULL,
  attSlices = NULL,
  topReps = NULL,
  climData = NULL,
  col = NULL,
  axesPercentLabel = FALSE
)
```

Arguments

performance	a list; each element of the list should be a performance metric. May be calculated using the function runSystemModel
sim	a list; summary of the simulation containing the scenarios generated using the function generateScenarios that is used to run the system model using runSystemModel. The summary of the simulation may be obtained by using the function getSimSummary on the full simulation. The summary object is much smaller in size for ease of storage and use with the performance plotting functions like plotPerformanceSpace.
perfThreshMin	a vector; the minimum threshold value of each performance metric. The length of the vector should be equal to length(performance). If the metric does not have a minimum threshold, specify the corresponding element in perfThreshMin as NA.
perfThreshMax	a vector; the maximum threshold value of each performance metric. The length of the vector should be equal to length(performance). If the metric does not have a maximum threshold, specify the corresponding element in perfThreshMax as NA.
attX	a string; the tag of the perturbed attribute to plot on the xaxis. The attribute must be one of the perturbed attributes of sim. Type sim$expSpace$attPerturb to view all perturbed attributes of sim. If NULL (default), the first perturbed attribute of sim will be used.
attY	a string; the tag of the perturbed attribute to plot on the yaxis. The attribute must be another perturbed attribute of sim. If NULL, the second perturbed attribute of sim will be used.
attSlices	a list; used to subset perturbed attributes in sim for the plot. This argument would typically be used in cases where there are more than two perturbed attributes. The elements of the list correspond to the perturbed attributes to be subsetted and must be named using the attribute tag. Each element may contain a single value or a two-element vector specifying the minimum-maximum values. If the element is a single value, the exposure space is sliced on this single value of the attribute. If minimum-maximum values are specified, the exposure space will be sliced to subset this range. If attSlices includes attX or attY, these attributes will be sliced and the resulting plot will be a "zoomed-in" space.

topReps — an integer (default is NULL); the number of "top" replicates in terms of simulation fitness to be used. If topReps is specified, topReps number of replicates will be identified for each target and the average performance across these replicates will be plotted. If NULL, the average performance across all the replicates will be plotted.

climData — data.frame; the values of attX and attY from other sources like climate models. This data will be plotted as points in the perturbation space. If the Name of the data is available in the data.frame, the points will be identified using the Name. Please refer data provided with the package that may be loaded using data("egClimData") for an example of the expected format of climData.

col — a vector of colours; The length of the vector should atleast be sufficient to assign unique colours to all the different values in the generated plot. If NULL, the default foreSIGHT colours is used.

axesPercentLabel — a logical flag; if TRUE x and y axes to be displayed in terms of percentage change instead of fraction

Details

If the space contains more than two perturbed attributes, the performance values are averaged across the perturbations in the attributes other than attX and attY. The user may specify argument attSlices to slice the performance space at specific values of the other perturbed attributes. If attSlices are used to specify minimum-maximum values to subset other perturbed attributes, the performance values are averaged across the subsetted perturbations in these attributes. This function cannot be used with sim perturbed on an "OAT" grid since contours of the number of performance thresholds exceeded cannot be calculated for an irregular perturbation space.

Value

The plot showing the number of thresholds exceeded and the ggplot object.

See Also

runSystemModel, generateScenarios, getSimSummary, plotPerformanceSpace

Examples

```
# load example datasets
data("egSimPerformance")
data("egSimSummary")
data("egClimData")

plotPerformanceSpaceMulti(performance=egSimPerformance, sim=egSimSummary,
perfThreshMin = c(NA, 0.80), perfThreshMax = c(30, NA))

#replot with axes as percentage changes
plotPerformanceSpaceMulti(performance=egSimPerformance, sim=egSimSummary,
perfThreshMin = c(NA, 0.80), perfThreshMax = c(30, NA),axesPercentLabel=TRUE)

# add alternate climate data and specify different colours for the plot
```

```
plotPerformanceSpaceMulti(performance=egSimPerformance, sim=egSimSummary,
                          perfThreshMin = c(NA, 0.80),perfThreshMax = c(30, NA),
                          climData = egClimData, col = viridisLite::magma(3))

# example using simple scaled simulations
data("egScalPerformance")
data("egScalSummary")
data("egClimData")
plotPerformanceSpaceMulti(performance=egScalPerformance, sim=egScalSummary,
                          perfThreshMin = c(NA, 0.80),perfThreshMax = c(30, NA),
                          climData = egClimData)

# replot with axes as percentage changes (Note: modifies fractional change attributes only)
plotPerformanceSpaceMulti(performance=egScalPerformance, sim=egScalSummary,
                          perfThreshMin = c(NA, 0.80),perfThreshMax = c(30, NA),
                          climData = egClimData,axesPercentLabel=TRUE)
```

`plotScenarios` *Creates summary plots of the biases in the scenarios*

Description

`plotScenarios` uses a simulation performed using the function `generateScenarios` as input and creates heatmaps that show the biases in the simulated attributes with respect to the specified target values of the attributes. The plots show the magnitude (absolute value) of the mean biases, and the standard deviation of biases across replicates. The heatmaps can be used to evaluate how well the simulated attributes match the specified targets. The biases are in units of percentage for attributes of variables like precipitation, and in units of degrees K for attributes of temperature. The function creates two heatmaps that show:

- magnitude of the mean biases across all the replicates
- standard deviation of biases across all the replicates

Usage

```
plotScenarios(
  sim,
  simName = NULL,
  writeToFile = FALSE,
  fileName = "plotScenarios.pdf",
  colMapRange = "default"
)
```

Arguments

`sim`	a list; contains a stochastic simulation or the summary of a stochastic simulation created using the function `generateScenarios`

simName	a string; defaults to NULL). User-specified name of the simulation that will used as the heading in the saved pdf file to identify the simulation later. If simName is NULL, a random name will be assigned for the simulation.
writeToFile	logical; defaults to FALSE. Specifies whether the plots should be saved to a pdf file. If set to true, the heatmaps will be saved to a pdf file that would also contain summary pages that show the attributes, models, and optimisation settings used to create sim.
fileName	a string; defaults to "plotScenarios.pdf". Specifies the name of the pdf file to be written, if the file exists it will be overwritten.
colMapRange	a string; may be set to "default" or "full". The argument specifies whether the colormap of the heatmap should span the full range of the data. If set to "default", the colourmap limits of attributes that are in units of percentage is set to 0% to 10%, and the colourmap limits of the attributes of temperature is set to 0 degrees K to 1 degrees K. If set to "full", the colourmap limits are set to the minimum and maximum values in the data.

Details

The argument sim may be a full stochastic simulation generated using the function generateScenarrios or the summary of the stochastic simulation generated using getSimSummary

Value

The function returns two R plots showing the biases in the targets of the scenarios generated using the function generateScenarios. The figures may be saved to a pdf file by setting the writeToFile argument to TRUE.

See Also

createExpSpace, generateScenarions, getSimSummary

Examples

```
## Not run:
# the examples are nnot run since the run times are too long for CRAN
# create an exposure space
attPerturb <- c("P_ann_tot_m", "P_ann_nWet_m", "P_ann_R10_m")
attHold <- c("P_Feb_tot_m", "P_SON_dyWet_m", "P_JJA_avgWSD_m", "P_MAM_tot_m",
"P_DJF_avgDSD_m", "Temp_ann_rng_m", "Temp_ann_avg_m")
attPerturbType = "regGrid"
attPerturbSamp = c(2, 1, 1)
attPerturbMin = c(0.9, 1, 1)
attPerturbMax = c(1.1, 1, 1)
expSpace <- createExpSpace(attPerturb = attPerturb,
                           attPerturbSamp = attPerturbSamp,
                           attPerturbMin = attPerturbMin,
                           attPerturbMax = attPerturbMax,
                           attPerturbType = attPerturbType,
                           attHold = attHold,
                           attTargetsFile = NULL)
```

```
# load example data available in foreSIGHT
data(tankDat)
# perform stochastic simulation
sim <- generateScenarios(reference = tank_obs,
                         expSpace = expSpace,
                         simLengthNyrs = 30,
                         numReplicates = 2)
# plots heatmaps showing biases in simulated targets
plotScenarios(sim)
# to save the figures to a pdf file set writeToFile = TRUE
# using an example stochastic simulation summary provided with the package
data("egSimSummary")
plotScenarios(egSimSummary)

## End(Not run)
```

`runSystemModel` *Runs a system model and outputs the system performance*

Description

`runSystemModel` uses time series of hydroclimatic variables generated using the function `generateScenarios` as input to a systemModel and collates the system performance for all the targets and replicates in the scenarios.

Usage

```
runSystemModel(sim, systemModel, systemArgs, metrics)
```

Arguments

`sim`	list; a simulation containing the scenarios generated using the function `generateScenarios`.
`systemModel`	a function; The function runs the system model using climate data in a data.frame as input. The function is expected to be created by the user for specific system models. `tankWrapper` is an example system model function available in this package. `runSystemModel` calls the function `systemModel` with two arguments: • `data` : data.frame; the climate data in a data frame with columns named *year month day *variable_name1* *variable_name2**. • `systemArgs` : list; containing the other arguments required by the system model.`systemModel` unpack the arguments from the list and uses them as required. • `metrics` : string vector; containing the names of the performance metrics that the system model returns. It is recommended that the names also contain the units of the metric. See `viewTankMetrics()` for examples.
`systemArgs`	a list; containing the input arguments to `systemModel`.
`metrics`	a string vector; the names of the performance metrics the `systemModel` function returns.

Details

The runSystemModel function code is structured to be simple and may be used as an example to create scripts that use scenarios generated using generateScenarios to run system models in other programming languages. Type runSystemModel to view the function code. The function tankWrapper in this package may be used as an example to create user defined functions for the systemModel argument. Refer to tankWrapper to understand how the systemModel is expected to use systemArgs and return the calculated performance metrics. The systemModel function is expected to return a named list of performance metrics. The elements of the vector should correspond to metrics.

Value

The function returns a list containing the performance metrics calculated by the systemModel. Each element of the list corresponds to a performance metric and is named using the metrics argument. Each element contains performance values calculated at all the target points in the exposure space in a matrix with nrow corresponding to the targets and ncol corresponding to the replicates.

See Also

tankWrapper, generateScenarios

Examples

```
# Example using tankWrapper as the systemModel
#=====================================================
## Not run:
# create an exposure space
attPerturb <- c("P_ann_tot_m", "P_ann_nWet_m")
attHold <- c("P_Feb_tot_m", "P_SON_dyWet_m", "P_JJA_avgWSD_m", "P_MAM_tot_m",
"P_DJF_avgDSD_m", "Temp_ann_rng_m", "Temp_ann_avg_m")
attPerturbType = "regGrid"
attPerturbSamp = c(2, 2)
attPerturbMin = c(0.9, 0.9)
attPerturbMax = c(1.1, 1.1)
expSpace <- createExpSpace(attPerturb = attPerturb,
                           attPerturbSamp = attPerturbSamp,
                           attPerturbMin = attPerturbMin,
                           attPerturbMax = attPerturbMax,
                           attPerturbType = attPerturbType,
                           attHold = attHold,
                           attTargetsFile = NULL)
# load example observed data available in foreSIGHT
data(tankDat)
# perform stochastic simulation
sim <- generateScenarios(reference = tank_obs,
                                 expSpace = expSpace,
                                 simLengthNyrs = 30)
# use the simulation to run a system model
systemArgs <- list(roofArea = 205, nPeople = 1, tankVol = 2400,
firstFlush = 2.0, write.file = FALSE)
tankMetrics <- viewTankMetrics()
```

```
systemPerf = runSystemModel(sim = sim,
                            systemModel = tankWrapper,
                            systemArgs = systemArgs,
                            metrics = tankMetrics[1:2])

## End(Not run)
```

`tankPerformance` *A function to calculate difference performance from simulated tank behaviour*

Description

A function to calculate difference performance from simulated tank behaviour

Usage

```
tankPerformance(data=NULL,
                      roofArea=50,
                      nPeople=1,
                      tankVol=3000,
      firstFlush=1,
                      write.file=TRUE,
                      fnam="tankperformance.csv")
```

Arguments

`data`	A dataframe of observed climate data in the form *Year Month Day P Temp*.
`roofArea`	roof area in m2
`nPeople`	number of people using water
`tankVol`	tank volume in L
`firstFlush`	first flush depth over roof in mm
`write.file`	logical. write output tank timeseries to file T/F?
`fnam`	string indicating name of file

tankWrapper *Wrapper function for a rain water tank system model*

Description

tankWrapper is a wrapper function for a rainwater tank system model in foreSIGHT. This function is used in examples in function help files and vignettes. This function may also be used as an example to create wrapper functions for other system models with scenarios generated using foreSIGHT in R or other programming languages.

Usage

```
tankWrapper(data, systemArgs, metrics)
```

Arguments

data	data.frame; contains observed daily precipitation and temperature to be used to run the rain water tank system model in a data.frame with columns named *year month day P Temp*. Note that the first three columns of the data.frame contain the year, month, and day of observation. The columns have to be named as specified. Please refer data provided with the package that may be loaded using data(tankDat) for an example of the expected format of data.
systemArgs	a list; contains the input arguments to the rain water tank system model. The valid fields in the list are: • roofArea : numeric; the roof area in sq.m • nPeople : integer; number of people using water • tankVol : numeric; volume of the tank in L • firstFlush : numeric; first flush depth over roof in mm • write.file : logical; indicates whether output is to be written to file • fnam : string; name of the output file
metrics	string vector; the metrics of performance of the system model to be reported. The valid strings may be viewed using the function viewTankMetrics()

Value

The function returns a list containing the calculated values of the performance metrics specified in metrics after running the system model.

See Also

runSystemModel, viewTankMetrics

Examples

```
# view available performance metrics
viewTankMetrics()
# load example climate data to run the system model
data(tankDat)
systemArgs <- list(roofArea = 205, nPeople = 1, tankVol = 2400,
firstFlush = 2.0, write.file = FALSE)
tankWrapper(tank_obs, systemArgs,
metrics = c("average daily deficit (L)", "reliability (fraction)"))
```

---

tank_obs *Observations for demo tank model examples and vignette*

Description

Dataset of observations for tank model examples

Format

A dataframe of observed climate data in the form *Year Month Day P Temp*.

---

viewAttributeDef *Prints the definition of an attribute*

Description

`viewAttributeDef` prints the short definition of a valid attribute

Usage

```
viewAttributeDef(attribute)
```

Arguments

`attribute`	A string; the name of the attribute.

See Also

`createExpSpace`

Examples

```
# To view the definition of any valid attribute
viewAttributeDef("P_ann_tot_m")
```

viewAttributeFuncs *Prints the list of built-in attribute functions*

Description

viewAttributeFuncs prints the list of built-in attribute functions

Usage

```
viewAttributeFuncs()
```

See Also

viewAttributeDef, createExpSpace

Examples

```
# To view the list of built-in functions used to calculate attributes
viewAttributeFuncs()
```

viewDefaultOptimArgs *Prints the default optimisation arguments*

Description

viewDefautOptimArgs() prints the default values of optimisation arguments (optimisationArguments) used by generateScenarios

Usage

```
viewDefaultOptimArgs()
```

Details

The function does not take any input arguments. This a helper function that prints the default values of the optimisation arguments. The user may specify alternate values of these arguments in fields named according to the corresponding argument name nested under optimisationArguments in a JSON file to use as the controlFile input to the generateScenarios function.

See Also

writeControlFile

Examples

```
# To view the default optimisation arguments
viewDefaultOptimArgs()
```

viewModelParameters *Prints the names and bounds of the parameters of the stochastic models*

Description

viewModelParameters prints the names of the parameters of the stochastic model and its default minimum and maximum bounds. The stochastic model is specified using the function arguments.

Usage

```
viewModelParameters(variable, modelType, modelParameterVariation)
```

Arguments

variable	A string; the name of the variable. Type viewModels() to view valid variable names
modelType	A string; the model type. Use viewModels to view the valid values.
modelParameterVariation	A string; the parameter variation. Use viewModels to view the valid values.

Details

The available stochastic models can be viewed using the function viewModels(). This function prints the default ranges of the parameters of the stochastic model specified the stochastic model of interest.

See Also

viewModels, writeControlFile

Examples

```
viewModelParameters("P", "wgen", "annual")
viewModelParameters("P", "wgen", "harmonic")
```

viewModels *Prints the available stochastic model options*

Description

viewModels prints the stochastic model options available for the different hydroclimatic variables in foreSIGHT. These options may be used to create an controlFile for input to function generateScenarios.

Usage

```
viewModels(variable = NULL)
```

Arguments

variable	String; the variable name. Type `viewModels()` without arguments to view the valid variable names.

See Also

`writeControlFile`, `generateScenarios`

Examples

```
# To view the valid variable names use the function without arguments
viewModels()

# Examples to view the model options available for different variables
viewModels("P")
viewModels("Temp")
viewModels("Radn")
viewModels("PET")
```

---

viewTankMetrics *Prints the names of the performance metrics of the rain water tank system model*

Description

`viewTankMetrics` prints the names of the performance metrics available in the example rain water tank system model. T

Usage

```
viewTankMetrics()
```

Details

This is a helper function that does not take any input arguments. The user may specify one or more of the metric names as the `metric` argument of `tankWrapper` to select the performance metrics from the tank system model. to select the performance metrics.

See Also

`tankWrapper`

Examples

```
viewTankMetrics()
```

viewVariables *Prints the names of and units of valid variables*

Description

viewVariables() prints the names of valid variables and their units in the package. The user should input these variable in the same units.

Usage

```
viewVariables()
```

Details

The function does not take any input arguments.

See Also

generateScenarios

Examples

```
# To view the valid variables
viewVariables()
```

writeControlFile *Writes a sample* controlFile.json *file*

Description

writeControlFile() writes a sample controlFile.json file. The controlFile.json file is used to specify alternate model and optimisation options and used as an input to the function generateScenarios. The user may use the sample file created by this function as a guide to create an "controlFile.json" file for their application.

Usage

```
writeControlFile(
  jsonfile = "sample_controlFile.json",
  basic = TRUE,
  nml = NULL
)
```

Arguments

jsonfile	string; to specify the name of the json file to be written. The default name of the sample file is "sample_controlFile.json". The file will be written to the working directory of the user.
basic	logical (TRUE/FALSE); used to specify whether a "basic" or "advanced" sample file is to be written. The default is TRUE. A "basic" controlFile does not contain modelParameterBounds, and is sufficient for most applications.
nml	list; the namelist to be written to the json file, as an R list. This argument may be used to create a JSON file using an controlFile from an existing simulation. If this argument is set to NULL, the function writes the default model/optimisation options defined in the package to the json file.

Details

The function may be used without any input arguments to write a "basic" sample controlFile.

Value

A json file. The file may be used as an example to create an "controlFile.json" file for input to generateScenarios. An "controlFile.json" file may contain any subset of the fields listed below. The user may delete the unused fields from the file. The exception cases where it is mandatory to specify two fields together in controlFile are detailed as part of the list below.

- modelType : a list by variable. Each element of the list is a string specifying the type of stochastic model. if modelType is specified for a variable in controlFile, modelParameterVariation should also be specified. This is because these two fields together define the stochastic model. Use viewModels() to view the valid options for modelType by variable.
- modelParameterVariation : a list by variable. Each element of the list is a string specifying the type of the parameter variation (annual, seasonal, harmonic etc.) of the stochastic model. if modelParameterVariation is specified for a variable in controlFile, modelType should also be specified. This is because these two fields together define the stochastic model. Use viewModels() to view valid options for modelParameterVariation by variable.
- modelParameterBounds a nested list by variable. Each element is a list containing the bounds of the parameters of the chosen stochastic model. This field exists to provide an option to overwrite the default bounds of the parameters of the stochastic model. Careful consideration is recommended prior to setting modelParameterBounds in the controlFile to overwrite the defaults provided in the package.
- optimisationArguments : a list. Contains the optimisation options used by function ga from the ga package. Brief definitions are given below.
  - pcrossover a value of probability of crossover. Defaults to 0.8.
  - pmutation a value of probability of mutation. Defaults to 0.1.
  - maxiter a value of the maximum number of generations. Defaults to 50.
  - maxFitness a value of the stopping criteria. Defaults to -0.001.
  - popSize a value of the population size. Defaults to 500.
  - run a value of an alternative stopping criteria, consecutive runs without improvement in fitness. Defaults to 20.

  - seed a value of the random seed. Defaults to NULL.
  - parallel specifies if parallel computing should be used. Defaults to False. Can be set to the number of desired cores, or TRUE, where it will detect the number of available cores and run.
  - keepBest specifies if the optimisation should keep the best solution in each generation. Defaults to TRUE.
  - suggestions suggestions for starting values of parameters for optimisation.

- penaltyAttributes : a character vector of climate attributes to place specific focus on during targeting via the use of a penalty function during the optimisation process. The penaltyAttributes should belong to attPerturb or attHold that are specified in the exposure space used as input to generateScenarios. If penaltyAttributes are specified in the controlFile, penaltyWeights should also be specified.
- penaltyWeights : a numeric vector; the length of the vector should be equal to the length of penaltyAttributes. penaltyWeights are the multipliers of the corresponding penaltyAttributes used during the optimisation.

See Also

generateScenarios, viewModels, viewDefaultOptimArgs

Examples

```
## Not run:
# To write a sample controlFile
writeControlFile()

# To write an advanced sample controlFile
writeControlFile(jsonfile = "sample_controlFile_advanced.json", basic = FALSE)

## End(Not run)
```

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