Package: WRSS (via r-universe)

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Type Package

Title Water Resources System Simulator

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Description Water resources system simulator is a tool for simulation and analysis of large-scale water resources systems. 'WRSS' proposes functions and methods for construction, simulation and analysis of primary storage and hydropower water resources features (e.g. reservoirs, aquifers, and etc.) based on Standard Operating Policy (SOP).

License GPL-3

Imports ggplot2, GGally, network

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`WRSS-package` *Water Resources System Simulator*

Description

The WRSS is an object-oriented R package, which provides tools for simulation and analysis of large-scale supply and hydropower water resources systems. The package includes functions and methods for building, simulation, and visualization of water resources components.

Details

Package:	WRSS
Type:	Package
Version:	3.0
Date:	2022-05-17
License:	GPL-3

the package includes three major types of functions as follows:

1- functions for construction and manipulatation of water resources features:

a) `createArea` constructor for basin/study area objects

b) `createJunction` constructor for junction objects

c) `createRiver` constructor for reach, river, and channel objects

d) `createReservoir` constructor for reservoir objects

e) `createDiversion` constructor for diversion objects

f) `createAquifer` constructor for aquifer objects

g) `createDemandSite` constructor for demand site objects

h) `set.as` WRSS objects connector

i) `addObjectToArea` adds objects form mentioned above constructors to a basin inherited from class of `createBasin`

2- functions for analysis and operation of water resources objects using Standard Operating Policy (SOP):

a) `riverRouting` river operation using

b) `reservoirRouting` reservoir operation

c) `aquiferRouting` aquifer operation

d) `diversionRouting` diversion operation

e) `sim` simulates an objects inherited from class of `createArea`

f) `rippl` computes no-failure storage volume using the sequent peak algorithm(SPA)

g) `cap_design` computes RRV measures for a range of design parameters

3- functions for performance analysis and visualization.

a) `plot.sim` plots the results of simulations for an object inherited from class of `sim`

b) `plot.createArea` plots an object from class of `createArea`

c) `risk` computes risk-based criateria for an object inherited from class of `sim`

d) `GOF` Goodness of fit function

Author(s)

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References

Loucks, Daniel P., et al. Water resources systems planning and management: an introduction to methods, models and applications. Paris: Unesco, 2005. Arabzadeh, R.; Aberi, P.; Hesarkazzazi, S.; Hajibabaei, M.; Rauch, W.; Nikmehr, S.; Sitzenfrei, R. WRSS: An Object-Oriented R Package for Large-Scale Water Resources Operation. Water 2021, 13, 3037. https://doi.org/10.3390/w13213037

See Also

`addObjectToArea`, `plot.sim`

Examples

```
###---------- loading data
data(zarrineh)

###---------- Constructing main features of Zerrineh river basin
Area<-createArea(name='Zerrineh',location='Kurdistan',
                 simulation=list(start='1900-01-01',
                                 end='1909-12-01',
                                 interval='month'))

   ###---------- Bukan dam
Q<-zarrineh$bukan$timeSeries[,1]
E<-zarrineh$bukan$timeSeries[,2]
R<-zarrineh$bukan$timeSeries[,3]
D<-zarrineh$bukan$timeSeries[,4]
A<-zarrineh$bukan$timeSeries[,5]
RC<-zarrineh$bukan$ratingCurve
min<-zarrineh$bukan$capacity[1]$min
max<-zarrineh$bukan$capacity[2]$max
bukan<-createReservoir(name='bukan',netEvaporation=E,
                       initialStorage=max,
                       geometry=list(deadStorage=min,
                                     capacity=max,
                                     storageAreaTable=RC))
Zerrineh<-createRiver(name='Zerrineh-River',downstream=bukan,discharge=Q)
R<-createDemandSite(name='E1',demandTS=R,suppliers=list(bukan),priority=1)
D<-createDemandSite(name='U1',demandTS=D,suppliers=list(bukan),priority=2)
A<-createDemandSite(name='A1',demandTS=A,suppliers=list(bukan),priority=3)
Area<-addObjectToArea(Area,Zerrineh)
Area<-addObjectToArea(Area,bukan)
Area<-addObjectToArea(Area,R)
Area<-addObjectToArea(Area,D)
Area<-addObjectToArea(Area,A)

   ###---------- a junction located in Bukan dam upstream
J<-createJunction(name='J1', downstream=Zerrineh)
Area<-addObjectToArea(Area,J)

   ###---------- Markhuz dam
Q<-zarrineh$Markhuz$timeSeries[,1]
E<-zarrineh$Markhuz$timeSeries[,2]
```

```
A<-zarrineh$Markhuz$timeSeries[,3]
RC<-zarrineh$Markhuz$ratingCurve
min<-zarrineh$Markhuz$capacity[1]$min
max<-zarrineh$Markhuz$capacity[2]$max
Markhuz<-createReservoir(name='Markhuz',netEvaporation=E,
                         downstream=J,initialStorage=max,
                         geometry=list(deadStorage=min,
                         capacity=max,
                         storageAreaTable=RC))
River<-createRiver(name='Markhuz-River',downstream=Markhuz,discharge=Q)
A<-createDemandSite(name='A3',demandTS=A,returnFlowFraction=0.3,
                    suppliers=list(Markhuz),downstream=J,priority=1)
Area<-addObjectToArea(Area, River)
Area<-addObjectToArea(Area, Markhuz)
Area<-addObjectToArea(Area, A)

   ###---------- Cheragh Veys dam
Q<-zarrineh$cheraghVeys$timeSeries[,1]
E<-zarrineh$cheraghVeys$timeSeries[,2]
R<-zarrineh$cheraghVeys$timeSeries[,3]
D<-zarrineh$cheraghVeys$timeSeries[,4]
A<-zarrineh$cheraghVeys$timeSeries[,5]
RC<-zarrineh$cheraghVeys$ratingCurve
min<-zarrineh$cheraghVeys$capacity[1]$min
max<-zarrineh$cheraghVeys$capacity[2]$max
cheraghVeys<-createReservoir(name='cheraghVeys',netEvaporation=E,
                             downstream=J,initialStorage=max,
                             geometry=list(deadStorage=min,
                                           capacity=max,
                                           storageAreaTable=RC))
River<-createRiver(name='Cheragh Veys-River',downstream=cheraghVeys,discharge=Q)
R<-createDemandSite(name='E2',demandTS=R,returnFlowFraction=1.0,
                    suppliers=list(cheraghVeys),downstream=J,priority=1)
D<-createDemandSite(name='U2',demandTS=D,returnFlowFraction=0.7,
                    suppliers=list(cheraghVeys),downstream=J,priority=2)
                    A<-createDemandSite(name='A2',demandTS=A,returnFlowFraction=0.3,
suppliers=list(cheraghVeys),downstream=J,priority=3)
Area<-addObjectToArea(Area, River)
Area<-addObjectToArea(Area, cheraghVeys)
Area<-addObjectToArea(Area, R)
Area<-addObjectToArea(Area, D)
Area<-addObjectToArea(Area, A)

   ###---------- Sonata dam
Q<-zarrineh$Sonata$timeSeries[,1]
E<-zarrineh$Sonata$timeSeries[,2]
R<-zarrineh$Sonata$timeSeries[,3]
A<-zarrineh$Sonata$timeSeries[,4]
RC<-zarrineh$Sonata$ratingCurve
min<-zarrineh$Sonata$capacity[1]$min
max<-zarrineh$Sonata$capacity[2]$max
Sonata<-createReservoir(name='Sonata',netEvaporation=E,downstream=J,
                        initialStorage=max,
                        geometry=list(deadStorage=min,
                                      capacity=max,
                                      storageAreaTable=RC))
River<-createRiver(name='Sonata-River',downstream=Sonata,discharge=Q)
R<-createDemandSite(name='E3',demandTS=R,returnFlowFraction=1.0,
                    suppliers=list(Sonata),downstream=J,priority=1)
A<-createDemandSite(name='A4',demandTS=A,returnFlowFraction=0.3,
                    suppliers=list(Sonata),downstream=J,priority=2)
Area<-addObjectToArea(Area, River)
Area<-addObjectToArea(Area, Sonata)
Area<-addObjectToArea(Area, R)
Area<-addObjectToArea(Area, A)

   ###---------- Sarogh dam
Q<-zarrineh$Sarogh$timeSeries[,1]
E<-zarrineh$Sarogh$timeSeries[,2]
D<-zarrineh$Sarogh$timeSeries[,3]
A<-zarrineh$Sarogh$timeSeries[,4]
RC<-zarrineh$Sarogh$ratingCurve
min<-zarrineh$Sarogh$capacity[1]$min
max<-zarrineh$Sarogh$capacity[2]$max
Sarogh<-createReservoir(name='Sarogh',netEvaporation=E,downstream=J,
                        initialStorage=max,
                        geometry=list(deadStorage=min,
                                      capacity=max,
                                      storageAreaTable=RC))
River<-createRiver(name='Sarogh-River',downstream=Sarogh,discharge=Q)
D<-createDemandSite(name='U3',demandTS=D,returnFlowFraction=0.7,
                    suppliers=list(Sarogh),downstream=J,priority=1)
                    A<-createDemandSite(name='A5',demandTS=A,returnFlowFraction=0.3,
suppliers=list(Sarogh),downstream=J,priority=2)
Area<-addObjectToArea(Area, River)
Area<-addObjectToArea(Area, Sarogh)
Area<-addObjectToArea(Area, D)
Area<-addObjectToArea(Area, A)
## Not run:
plot(Area)

## End(Not run)
plot(sim(Area))
```

`addObjectToArea` *Adds a feature to area*

Description

This function adds objects from the basin primary features to the object inherited from class of `createArea`.

Usage

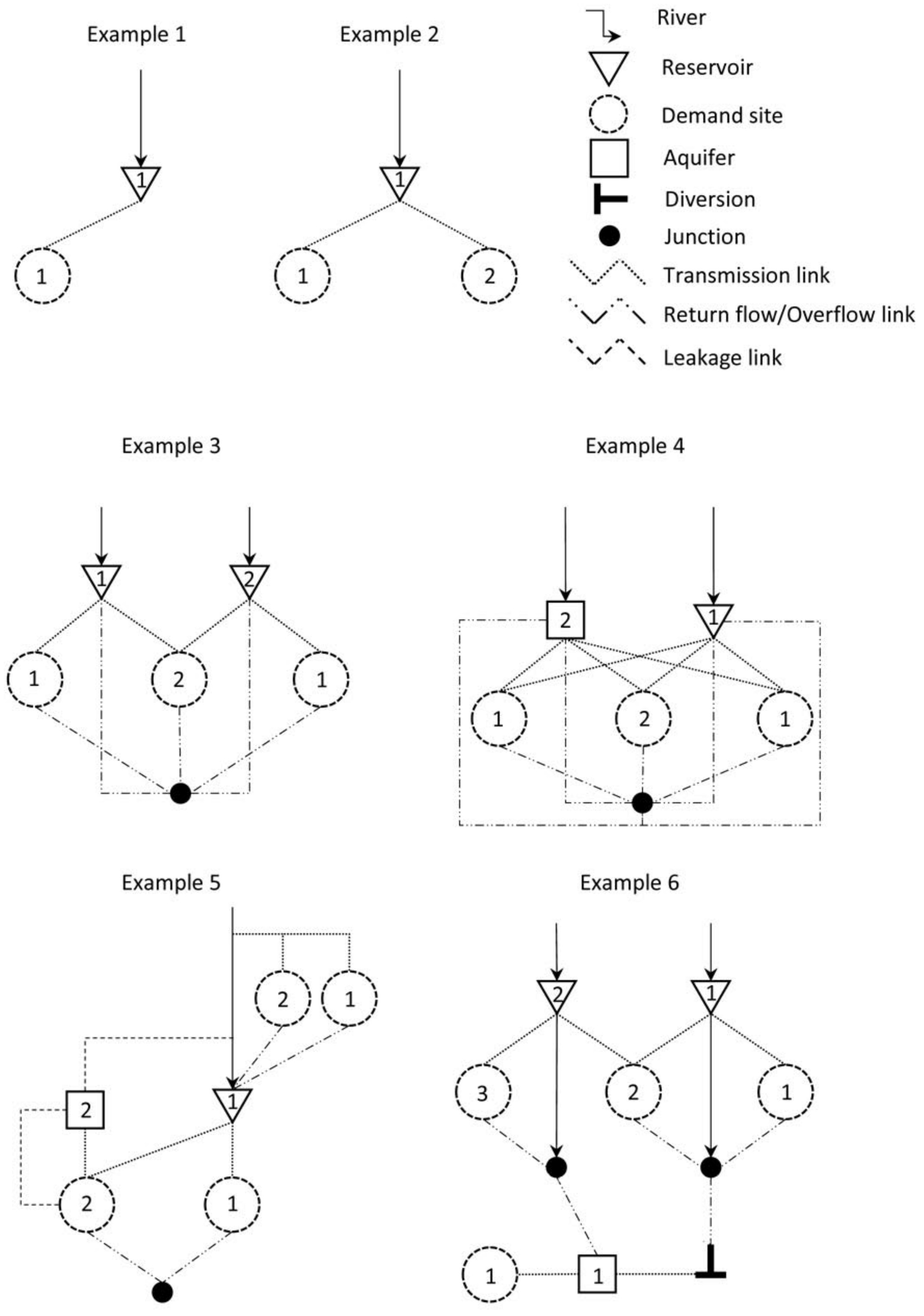
```
addObjectToArea(area, object)
```

Arguments

`area`	An object inherited from `createArea`
`object`	An objects inherited from any of the following constructors: `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, and `createDemandSite`.

Details

The examples included in this documentation show construction and simulation of primary features of a water resources system using `WRSS` package. The Figure below presents schematic layouts attributed to the examples at the rest of the page:


Example 1
Example 2
River
Reservoir
Demand site
Aquifer
Diversion
Junction
Transmission link
Return flow/Overflow link
Leakage link
Example 3
Example 4
Example 5
Example 6

Value

an object from class of `createArea`

Author(s)

Rezgar Arabzadeh

References

Loucks, Daniel P., et al. Water resources systems planning and management: an introduction to methods, models and applications. Paris: Unesco, 2005.

See Also

`sim`

Examples

```
#--------------------1st Example--------------------
R<-createRiver(name="river1",discharge=rnorm(120,5,1.5))
Res<-createReservoir(name="res3",type='storage',
                     priority=1,netEvaporation=rnorm(120,0.5,0.1),
                     geometry=list(deadStorage= 10 ,capacity= 90 ,
                     storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                       100/sum(sin(seq(0,pi,length.out=12))))
D<-createDemandSite(name ="Agri1",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000))
R<-set.as(Res,R,'downstream')
D<-set.as(Res,D,'supplier')

area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                 end  ='2000-04-29',
                                 interval='day'))
area<-addObjectToArea(area,R)
area<-addObjectToArea(area,Res)
area<-addObjectToArea(area,D)
## Not run:
plot(area)
simulated<-sim(area)
plot(simulated)

## End(Not run)


#--------------------2nd Example--------------------
Res<-createReservoir(name="res3",type='storage',
                     priority=1,netEvaporation=rnorm(120,0.5,0.1),
                     geometry=list(deadStorage= 10 ,capacity= 90 ,
                     storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R<-createRiver(name="river1",discharge=rnorm(120,5,1.5))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                       100/sum(sin(seq(0,pi,length.out=12))))
D1<-createDemandSite(name ="Agri1",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,priority=1)
D2<-createDemandSite(name ="Agri2",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,priority=1)

R<-set.as(Res,R,'downstream')
D1<-set.as(Res,D1,'supplier')
D2<-set.as(Res,D2,'supplier')

area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                 end  ='2000-04-29',
                                 interval='day'))
area<-addObjectToArea(area,R)
area<-addObjectToArea(area,Res)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
## Not run:
plot(area)
simulated<-sim(area)
plot(simulated)

## End(Not run)

#--------------------3rd Example--------------------
J1<-createJunction(name="j1")
Res1<-createReservoir(name="res1",type='storage',
                     priority=1,netEvaporation=rnorm(120,0.5,0.1),
                     geometry=list(deadStorage= 10 ,capacity= 90 ,
                     storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
Res2<-createReservoir(name="res2",type='storage',
                     priority=2,netEvaporation=rnorm(120,0.5,0.1),
                     geometry=list(deadStorage= 10 ,capacity= 90 ,
                     storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R1<-createRiver(name="river1",discharge=rnorm(120,5,1.5))
R2<-createRiver(name="river2",discharge=rnorm(120,5,1.5))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                       100/sum(sin(seq(0,pi,length.out=12))))
D1<-createDemandSite(name ="Agri1",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,priority=1)
```

```
D2<-createDemandSite(name ="Agri2",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,priority=2)
D3<-createDemandSite(name ="Agri3",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,priority=1)
area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                 end  ='2000-04-29',
                                 interval='day'))

R1<-set.as(Res1,R1,'downstream')
R2<-set.as(Res2,R2,'downstream')
Res1<-set.as(J1,Res1,'downstream')
Res2<-set.as(J1,Res2,'downstream')
D1<-set.as(J1,D1,'downstream')
D2<-set.as(J1,D2,'downstream')
D3<-set.as(J1,D3,'downstream')
D1<-set.as(Res1,D1,'supplier')
D2<-set.as(Res1,D2,'supplier')
D2<-set.as(Res2,D2,'supplier')
D3<-set.as(Res2,D3,'supplier')

area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,R2)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,Res2)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
area<-addObjectToArea(area,D3)
area<-addObjectToArea(area,J1)
## Not run:
plot(area)
simulated<-sim(area)
plot(simulated)

## End(Not run)

#--------------------4th Example--------------------
J1<-createJunction(name="j1")
Res1<-createReservoir(name="res1",type='storage',
                     priority=1,netEvaporation=rnorm(120,0.5,0.1),downstream =J1 ,
                     geometry=list(deadStorage= 10 ,capacity= 90 ,
                     storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
Auq1<-createAquifer(name="Aquifer1",area=100,volume=5000,
                    rechargeTS=rnorm(120,10,3),Sy=0.1,
                    leakageFraction=0.02,leakageObject=J1,priority=2)
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                       100/sum(sin(seq(0,pi,length.out=12))))
```

```
R1<-createRiver(name="river1",downstream=Res1,discharge=rnorm(120,5,1.5))
R2<-createRiver(name="river2",downstream=Auq1,discharge=rnorm(120,5,1.5))
D1<-createDemandSite(name ="Agri1",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,suppliers=list(Res1,Auq1),
                    downstream=J1,priority=1)
D2<-createDemandSite(name ="Agri2",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,suppliers=list(Res1,Auq1),
                    downstream=J1,priority=2)
D3<-createDemandSite(name ="Agri3",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,suppliers=list(Res1,Auq1),
                    downstream=J1,priority=1)
area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                 end  ='2000-04-29',
                                 interval='day'))
area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,R2)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,Auq1)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
area<-addObjectToArea(area,D3)
area<-addObjectToArea(area,J1)
## Not run:
plot(area)
simulated<-sim(area)
plot(simulated)

## End(Not run)

#--------------------5th Example--------------------
J1<-createJunction(name="junction1")
Res1<-createReservoir(name="res1",type='storage',
                     priority=1,netEvaporation=rnorm(120,0.5,0.1),
                     geometry=list(deadStorage= 10 ,capacity= 90 ,
                     storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
Auq1<-createAquifer(name="Aquifer1",area=100,volume=5000,
                    rechargeTS=rnorm(120,10,3),Sy=0.1,priority=2)
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                       100/sum(sin(seq(0,pi,length.out=12))))
R1<-createRiver(name="River1",
                downstream=Res1,discharge=rnorm(120,20,3),
                seepageFraction=0.1,seepageObject=Auq1)
D1<-createDemandSite(name ="Agri1",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,suppliers=list(Res1),
                    downstream=J1,priority=1)
D2<-createDemandSite(name ="Agri2",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,suppliers=list(Res1,Auq1),
                    downstream=J1,priority=2)
D3<-createDemandSite(name ="Agri3",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,suppliers=list(R1),
                    downstream=Res1,priority=2)
D4<-createDemandSite(name ="Agri4",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,suppliers=list(R1),
                    downstream=Res1,priority=1)
area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                 end  ='2000-04-29',
                                 interval='day'))
area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,Auq1)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
area<-addObjectToArea(area,D3)
area<-addObjectToArea(area,D4)
area<-addObjectToArea(area,J1)
## Not run:
plot(area)
simulated<-sim(area)
plot(simulated)

## End(Not run)


#--------------------6th Example--------------------
Auq1<-createAquifer(name="Aquifer1",area=100,volume=5000,
                    rechargeTS=rnorm(120,10,3),Sy=0.1)
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                       100/sum(sin(seq(0,pi,length.out=12))))
D0<-createDemandSite(name ="Agri0",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),priority=1)
Div1<-createDiversion(name="Div1",capacity=10)
```

```
J2<-createJunction(name="junc2")

Res2<-createReservoir(name="res2",type='storage',
                     priority=1,netEvaporation=rnorm(120,0.5,0.1),
                     geometry=list(deadStorage= 10 ,capacity= 90 ,
                     storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R2<-createRiver(name="river2",discharge=rnorm(120,12,3))
D3<-createDemandSite(name ="Agri3",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,priority=2)
J1<-createJunction(name="junc1")
Res1<-createReservoir(name="res1",type='storage',
                     priority=1,netEvaporation=rnorm(120,0.5,0.1),
                     geometry=list(deadStorage= 10 ,capacity= 90 ,
                     storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R1<-createRiver(name="river1",discharge=rnorm(120,5,1))
D2<-createDemandSite(name ="Agri2",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,priority=2)
D1<-createDemandSite(name ="Agri1",
                    demandParams=list(waterUseRate=1,
                                      waterVariation=waterVariation,
                                      cropArea=1000),
                    returnFlowFraction =0.2,priority=1)
area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                 end  ='2000-04-29',
                                 interval='day'))

R1<-set.as(Res1,R1,'downstream')
R2<-set.as(Res2,R2,'downstream')
Res1<-set.as(J1,Res1,'downstream')
Res2<-set.as(J2,Res2,'downstream')
J1<-set.as(Div1,J1,'downstream')
J2<-set.as(Auq1,J2,'downstream')
Div1<-set.as(Auq1,Div1,'divertObject')
D1<-set.as(J1,D1,'downstream')
D2<-set.as(J1,D2,'downstream')
D3<-set.as(J2,D3,'downstream')
D1<-set.as(Res1,D1,'supplier')
D2<-set.as(Res1,D2,'supplier')
D2<-set.as(Res2,D2,'supplier')
D3<-set.as(Res2,D3,'supplier')
D0<-set.as(Auq1,D0,'supplier')



area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,R2)
```

```
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,Res2)
area<-addObjectToArea(area,D0)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
area<-addObjectToArea(area,D3)
area<-addObjectToArea(area,Div1)
area<-addObjectToArea(area,Auq1)
area<-addObjectToArea(area,J1)
area<-addObjectToArea(area,J2)

simulated<-sim(area)
## Not run:
plot(area)
plot(simulated)

## End(Not run)
```

---

aquiferRouting *base function for aquifer simulation*

Description

Given a sort of demand(s), aquiferRouting function simulates a lumped and simple model of an unconfined aquifer under an optional givn recharge time series, rechargeTS, and specific yield, Sy.

Usage

```
aquiferRouting(demand, priority = NA, area, volume,
               rechargeTS = NA, leakageFraction = NA,
               initialStorage = NA, Sy, simulation)
```

Arguments

demand	(optional) A matrix: is column-wise matrix of demands, at which the rows present demands for each monthly time step and columns are for different individual demand sites (MCM).
priority	(optional) A vector: is a vector of priorities associated to demand
area	The area of aquifer (Km^2)
volume	The aquifer volume (MCM)
rechargeTS	(optional) A vector : a vector of water flowing into the aquifer (MCM)
leakageFraction	(optional) The leakage coeffcient of aquifer storage. The leakage is computed as the product of leakageFraction and aquifer storage. It is in [0, 1] interval
initialStorage	(optional) The initial volume of aquifer at the first step of the simulation (MCM). If missing, the function iterates to carry over the aquifer

`Sy`	Specific yield (default: 0.1)
`simulation`	A list: `simulation` is a list of three vectors: `start`, `end`, and `interval`. the `start` and `end` components must be in `'YYYY-MM-DD'` format. the `interval` component can takes either of `'day'`, `'week'`, or `'month'`.

Value

the `aquiferRouting` function returns a list of objects as bellow:

- `release`: a matrix of release(s) equivalant to each demand (MCM)
- `leakage`: a vector of leakage time series (MCM)
- `storage`: a vector of storage time series (MCM)

Author(s)

Rezgar Arabzadeh

References

Mart nez-Santos, P., and J. M. Andreu. "Lumped and distributed approaches to model natural recharge in semiarid karst aquifers." Journal of hydrology 388.3 (2010): 389-398.

See Also

`reservoirRouting`

Examples

```
area           <-200
leakageFraction<-0.01
Sy             <-0.15
volume         <-20000
priority       <-c(3,1,1,2)
rechargeTS     <-rnorm(120,60,8)
demand         <-matrix(rnorm(480,10,3),120)
simulation     <-list(start='2000-01-01',end='2009-12-29',interval='month')

res<-
  aquiferRouting(demand         =demand         ,
                 priority       =priority       ,
                 area           =area           ,
                 volume         =volume       ,
                 rechargeTS     =rechargeTS     ,
                 leakageFraction=leakageFraction,
                 Sy             =Sy             ,
                 simulation     =simulation)

plot(res$storage$storage,ylab='Storage (MCM)',xlab='time steps(month)',type='o')
```

cap_design *Constructor for class of* cap_design

Description

Calculates the RRV measures for multiple design candidates.

Usage

```
cap_design(area,params,w,plot)
```

Arguments

area	An object from class of 'createArea'
params	A list of list(s), which each sub-list can contains an object from either of classes 'createDemandSite' or 'createReservoir' and a vector of scale factors multiplied to the set design parameters. For reservoirs the scale factor will be multiplied to the capacity for the and for demand site, it will be multiplied to the demand time series
w	(optional) A vector of weights of sustainability indices summing 1 with length of equal with the number of demand site objects built-in 'params' argument or equal with number of demand sites supplied by the reservoirs built-in 'params'. If missing the weights will be assumed equall
plot	(optional) logical: plot the resault or not. The default is TRUE

Value

A matrix of RRV and sustainability index proposed by Hashemitto et al. (1982) and Loucks (1997).

Author(s)

Rezgar Arabzadeh

References

Hashimoto, T., Stedinger, J. R., & Loucks, D. P. (1982). Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation. Water resources research, 18(1), 14-20. Loucks, D. P. (1997). Quantifying trends in system sustainability. Hydrological Sciences Journal, 42(4), 513-530.

See Also

addObjectToArea

Examples

```
Res1<-createReservoir(name="res1",type='storage',
                      priority=1,netEvaporation=rnorm(120,0.5,0.1),
                      geometry=list(deadStorage= 10 ,capacity= 50 ,
                                    storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R1<-createRiver(name="river1",discharge=rnorm(120,25,1.5))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                        100/sum(sin(seq(0,pi,length.out=12))))
D1<-createDemandSite(name ="Agri1",
                     demandParams=list(waterUseRate=1,
                                       waterVariation=waterVariation,
                                       cropArea=500),
                     returnFlowFraction =0.2,priority=2)
area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                 end  ='2000-04-29',
                                 interval='day'))
R1<-set.as(Res1,R1,'downstream')
D1<-set.as(Res1,D1,'supplier')
area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,D1)
params<-list(
  list(Res1,seq(0.5,1.5,0.1))
)
cap_design(area,params)
```

`cap_design.base` *base function for class of* `cap_design`

Description

Calculates the RRV measures for multiple design candidates.

Usage

```
## S3 method for class 'base'
cap_design(area,params,w,plot)
```

Arguments

`area`	An object from class of `'createArea'`
`params`	A list of list(s), which each sub-list can contains an object from either of classes `'createDemandSite'` or `'createReservoir'` and a vector of scale factors multiplied to the set design parameters. For reservoirs the scale factor will be multiplied to the capacity for the and for demand site, it will be multiplied to the demand time series

`w`	(optional) A vector of weights of sustainability indices summing 1 with length of equal with the number of demand site objects built-in `'params'` argument or equal with number of demand sites supplied by the reservoirs built-in `'params'`. If missing the weights will be assumed equall
`plot`	(optional) logical: plot the resault or not. The default is `TRUE`

Value

A matrix of RRV and sustainability index proposed by Hashemitto et al. (1982) and Loucks (1997).

Author(s)

Rezgar Arabzadeh

References

Hashimoto, T., Stedinger, J. R., & Loucks, D. P. (1982). Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation. Water resources research, 18(1), 14-20. Loucks, D. P. (1997). Quantifying trends in system sustainability. Hydrological Sciences Journal, 42(4), 513-530.

See Also

`cap_design`

`cap_design.default` *default function for class of* `cap_design`

Description

Calculates the RRV measures for multiple design candidates.

Usage

```
## Default S3 method:
cap_design(area,params,w=NA,plot=TRUE)
```

Arguments

`area`	An object from class of `'createArea'`
`params`	A list of list(s), which each sub-list can contains an object from either of classes `'createDemandSite'` or `'createReservoir'` and a vector of scale factors multiplied to the set design parameters. For reservoirs the scale factor will be multiplied to the capacity for the and for demand site, it will be multiplied to the demand time series

`w`	(optional) A vector of weights of sustainability indices summing 1 with length of equal with the number of demand site objects built-in `'params'` argument or equal with number of demand sites supplied by the reservoirs built-in `'params'`. If missing the weights will be assumed equall
`plot`	(optional) logical: plot the resault or not. The default is `TRUE`

Value

A matrix of RRV and sustainability index proposed by Hashemitto et al. (1982) and Loucks (1997).

Author(s)

Rezgar Arabzadeh

References

Hashimoto, T., Stedinger, J. R., & Loucks, D. P. (1982). Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation. Water resources research, 18(1), 14-20. Loucks, D. P. (1997). Quantifying trends in system sustainability. Hydrological Sciences Journal, 42(4), 513-530.

See Also

`cap_design`

`createAquifer` *Constructor for class of* `createAquifer`

Description

this function constructs an object from class of `createAquifer` that prescribes a simplified lupmped model of unconfined aquifer.

Usage

```
createAquifer(name, area, volume,
              rechargeTS, Sy, leakageFraction,
              initialStorage, leakageObject, priority)
```

Arguments

`name`	(optional) A string: the name of the aquifer
`area`	The area of aquifer (Km^2)
`volume`	The aquifer volume (MCM)
`rechargeTS`	(optional) A vector : a vector of water flowing into the aquifer (MCM)
`Sy`	Specific yield (default: 0.1)

`leakageFraction`	(optional) The leakage coeffcient of aquifer storage. The leakage is computed as the product of `leakageFraction` and aquifer storage. It is in `[0, 1]` interval
`initialStorage`	(optional) The initial volume of aquifer in the first step of the simulation (MCM). If missing, the function iterates to carry over the aquifer.
`leakageObject`	(optional) an object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which leakage volume pours to it.
`priority`	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to Inf.

Value

An object from class of `createAquifer`

Author(s)

Rezgar Arabzadeh

References

Mart nez-Santos, P., and J. M. Andreu. "Lumped and distributed approaches to model natural recharge in semiarid karst aquifers." Journal of hydrology 388.3 (2010): 389-398.

See Also

`addObjectToArea`

`createAquifer.base` *base function for class of* `createAquifer`

Description

this function constructs an object from class of `createAquifer` that prescribes a simplified lupmped model of unconfined aquifer.

Usage

```
## S3 method for class 'base'
createAquifer(name, area, volume,
                  rechargeTS, Sy,leakageFraction,
                  initialStorage, leakageObject, priority)
```

Arguments

`name`	(optional) A string: the name of the aquifer
`area`	The area of aquifer (Km^2)
`volume`	The aquifer volume (MCM)
`rechargeTS`	(optional) A vector : a vector of water flowing into the aquifer (MCM)
`Sy`	Specific yield (default: 0.1)
`leakageFraction`	(optional) The leakage coeffcient of aquifer storage. The leakage is computed as the product of `leakageFraction` and aquifer storage. It is in `[0, 1]` interval
`initialStorage`	(optional) The initial volume of aquifer in the first step of the simulation (MCM). If missing, the function iterates to carry over the aquifer.
`leakageObject`	(optional) an object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which leakage volume pours to it.
`priority`	(optional) An integer: the supplying priority. Is a value in [1, 99] interval. If missing, the `priority` is set to Inf.

Value

An object from class of `list`

See Also

`createAquifer`

`createAquifer.default` *default function for class of* `createAquifer`

Description

this function constructs an object from class of `createAquifer` that prescribes a simplified lupmped model of unconfined aquifer.

Usage

```
## Default S3 method:
createAquifer(name = "Aquifer1",
                 area                ,
                 volume              ,
                 rechargeTS      = NA ,
                 Sy              = 0.1,
                 leakageFraction = NA ,
                 initialStorage  = NA ,
                 leakageObject   = NA ,
                 priority        = NA)
```

Arguments

`name`	(optional) A string: the name of the aquifer
`area`	The area of aquifer (Km^2)
`volume`	The aquifer volume (MCM)
`rechargeTS`	(optional) A vector : a vector of water flowing into the aquifer (MCM)
`Sy`	Specific yield (default: 0.1)
`leakageFraction`	(optional) The leakage coeffcient of aquifer storage. The leakage is computed as the product of `leakageFraction` and aquifer storage. It is in `[0, 1]` interval
`initialStorage`	(optional) The initial volume of aquifer in the first step of the simulation (MCM). If missing, the function iterates to carry over the aquifer.
`leakageObject`	(optional) an object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which leakage volume pours to it.
`priority`	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to Inf.

Value

An object from class of `createAquifer`

See Also

`createAquifer`

`createArea` *Constructor for class of* `createArea`

Description

this function constructs an object from class of `createArea`, supporting objects inherited from any of the folowing classes: `createAquifer`, `createDemandSite`, `createDiversion`, `createJunction`, `createReservoir`,and `createRiver`.

Usage

```
createArea(name, location, simulation)
```

Arguments

`name`	(optional) A string: the name of the aquifer
`location`	(optional) A string: the physical location of `name`
`simulation`	A list: `simulation` is a list of three vectors: `start`, `end`, and `interval`. the `start` and `end` components must be in `'YYYY-MM-DD'` format. The `interval` component can takes either of `'day'`, `'week'`, or `'month'`

Value

An object from class of `createArea`

Author(s)

Rezgar Arabzadeh

See Also

`addObjectToArea`

`createArea.base` *base function for class of* `createArea`

Description

this function constructs an object from class of `createArea`, supporting objects inherited from any of the folowing classes: `createAquifer`, `createDemandSite`, `createDiversion`, `createJunction`, `createReservoir`,and `createRiver`.

Usage

```
  ## S3 method for class 'base'
createArea(name, location, simulation)
```

Arguments

`name`	(optional) A string: the name of the aquifer
`location`	(optional) A string: the physical location of `name`
`simulation`	A list: `simulation` is a list of three vectors: `start`, `end`, and `interval`. the `start` and `end` components must be in `'YYYY-MM-DD'` format and the `interval` component is a string that can takes either of `'day'`,`'week'`, or `'month'`

Value

An object from class of `list`

See Also

`createArea`

`createArea.default` *default function for class of* `createArea`

Description

this function constructs an object from class of `createArea`, supporting objects inherited from the any of folowing classes: `createAquifer`, `createDemandSite`, `createDiversion`, `createJunction`, `createReservoir`,and `createRiver`.

Usage

```
  ## Default S3 method:
createArea(name = "unknown", location = "unknown",
                          simulation = list(start = NULL, end = NULL, interval=NULL))
```

Arguments

`name`	(optional) A string: the name of the aquifer
`location`	(optional) A string: the physical location of `createArea`
`simulation`	A list: `simulation` is a list of three vectors: `start`, `end`, and `interval`. the `start` and `end` components must be in `'YYYY-MM-DD'` format and the `interval` component can takes either of `'day'`,`'week'`, or `'month'`

Value

An object from class of `createArea`

See Also

`createArea`

`createDemandSite` *Constructor for class of* `createDemandSite`

Description

this function constructs an object from class of `createDemandSite`, which represents a demand site such as domestic, agricultural, and etc, with a specified demand time series.

Usage

```
createDemandSite(name, demandTS, demandParams,
                 returnFlowFraction, suppliers,
                 downstream, priority)
```

Arguments

`name`	(optional) A string: the name of the demand site
`demandTS`	A vector: a vector of demand time series (MCM). If `demandParams` is null, providing the `demandTS` is compulsory.
`demandParams`	A list: If `demandTS` is missing, the `demandParams` must be provided to establish `demandTS`. The `demandParams` includes three parts as follows: • `waterUseRate`: The total water demand per hectare (MCM) per a given water cycle. • `waterVariation`: A vector of the precentages for water demand distribution within a water cycle (the precentages in each `interval`). For instance, if the cycle is annually and the interval is `'month'`ly, the `waterVariation` could be a vector of length of 12, for which its indices signify the monthly portion of water demand, in precentage, by the total water demand required for the whole cycle. • `cropArea`: the area of cropping farms (in hectare).
`returnFlowFraction`	(optional) `returnFlowFraction` is fraction of total supplied water to the demand site. The return flow is computed as the product of `returnFlowFraction` and the amount of water the demand sites receives. `returnFlowFraction` must be in [0, 1] interval.
`suppliers`	(optional) A list of object(s) inherited from the folowing classes: `createAquifer`, `createRiver`, `createReservoir`, codecreateDiversion.
`downstream`	(optional) An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which return flow volume pours to it.
`priority`	(optional) An integer: the priority to be supplied. A value in [1, 99] interval.

Value

An object from class of `createDemandSite`

Author(s)

Rezgar Arabzadeh

See Also

`addObjectToArea`

`createDemandSite.base` *base function for class of* `createDemandSite`

Description

this function constructs an object from class of `createDemandSite`, which represents a demand site such as domestic, agricultural, and etc, with a specified demand time series.

Usage

```
## S3 method for class 'base'
createDemandSite(name, demandTS, demandParams,
                       returnFlowFraction, suppliers,
                       downstream, priority)
```

Arguments

`name`	(optional) A string: the name of the demand site
`demandTS`	A vector: a vector of demand time series (MCM). If `demandParams` is null, providing the `demandTS` is compulsory.
`demandParams`	A list: If `demandTS` is missing, the `demandParams` must be provided to establish `demandTS`. The `demandParams` includes three parts as follows: • `waterUseRate`: The total water demand per hectare (MCM) per a given water cycle • `waterVariation`: A vector of the precentages for water demand distribution within a water cycle (the precentages in each `interval`). For instance, if the cycle is annually and the interval is `'month'`ly, the `waterVariation` could be a vector of length of 12, for which its indices signify the monthly portion of water demand, in precentage, by the total water demand required for the whole cycle • `cropArea`: the area of cropping farms (in hectare)
`returnFlowFraction`	(optional) `returnFlowFraction` is fraction of total supplied water to the demand site. The return flow is computed as the product of `returnFlowFraction` and the amount of water the demand sites receives. `returnFlowFraction` must be in [0, 1] interval.
`suppliers`	(optional) A list of object(s) inherited from the folowing classes: `createAquifer`, `createRiver`, `createReservoir`, codecreateDiversion.
`downstream`	(optional) An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which return flow volume pours to it.
`priority`	(optional) An integer: the priority to be supplied. A value in [1, 99] interval.

Value

An object from class of `list`

See Also

createDemandSite

---

createDemandSite.default

default function for class of createDemandSite

Description

this function constructs an object from class of `createDemandSite`, which represents a demand site such as domestic, agricultural, and etc, with a specified demand time series.

Usage

```
## Default S3 method:
createDemandSite(name  ="Unknown",
         demandTS          =NA                      ,
         demandParams=list(waterUseRate=NULL        ,
                           waterVariation=NULL      ,
                           cropArea=NULL)           ,
         returnFlowFraction =0.0                    ,
         suppliers          = NA                    ,
         downstream         =NA                     ,
         priority           =NA)
```

Arguments

`name`	(optional) A string: the name of the demand site
`demandTS`	A vector: a vector of demand time series (MCM). If `demandParams` is null, providing the `demandTS` is compulsory.
`demandParams`	A list: If `demandTS` is missing, the `demandParams` must be provided to establish `demandTS`. The `demandParams` includes three parts as follows: • `waterUseRate`: The total water demand per hectare (MCM) per a given water cycle. • `waterVariation`: A vector of the precentages for water demand distribution within a water cycle (the precentages in each `interval`). For instance, if the cycle is annually and the interval is `'month'`ly, the `waterVariation` could be a vector of length of 12, for which its indices signify the monthly portion of water demand, in precentage, by the total water demand required for the whole cycle. • `cropArea`: the area of cropping farms (in hectare).
`returnFlowFraction`	(optional) `returnFlowFraction` is fraction of total supplied water to the demand site. The return flow is computed as the product of `returnFlowFraction` and the amount of water the demand sites receives. `returnFlowFraction` must be in [0, 1] interval.

suppliers	(optional) A list of object(s) inherited from the folowing classes: createAquifer, createRiver, createReservoir, codecreateDiversion.
downstream	(optional) An object from either of classes of createAquifer , createRiver, createReservoir, createJunction, createDiversion, or createDemandSite; which return flow volume pours to it.
priority	(optional) An integer: the priority to be supplied. A value in [1, 99] interval.

Value

An object from class of `createDemandSite`

See Also

createDemandSite

---

createDiversion *Constructor for class of* `createDiversion`

Description

this function constructs an object from class of `createDiversion`, acting as a diversion dam which is able to divert water up to a specified capacity.

Usage

```
createDiversion(name, capacity,
                divertObject, downstream, priority)
```

Arguments

name	(optional) A string: the name of the diversion
capacity	The maximum capacity of diversion dam (CMS).
divertObject	(optional) An object from either of classes of createAquifer , createRiver, createReservoir, createJunction, createDiversion, or createDemandSite; which recieves the diverted water volume.
downstream	(optional) An object from either of classes of createAquifer , createRiver, createReservoir, createJunction, createDiversion, or createDemandSite; which overflow volume pours to it.
priority	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to `Inf`.

Value

An object from class of `createDiversion`

Author(s)

Rezgar Arabzadeh

See Also

`addObjectToArea`

`createDiversion.base` *base function for class of* `createDiversion`

Description

this function constructs an object from class of `createDiversion`, acting as a diversion dam which is able to divert water up to a specified capacity.

Usage

```
## S3 method for class 'base'
createDiversion(name, capacity,
                divertObject, downstream, priority)
```

Arguments

`name`	(optional) A string: the name of the diversion
`capacity`	The maximum capacity of diversion dam (CMS).
`divertObject`	(optional) An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which recieves the diverted water volume.
`downstream`	(optional) An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which overflow volume pours to it.
`priority`	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to `Inf`.

Value

An object from class of `list`

See Also

`createDiversion`

createDiversion.default

default function for class of `createDiversion`

Description

this function constructs an object from class of `createDiversion`, acting as a diversion dam which is able to divert water up to a specified capacity.

Usage

```
## Default S3 method:
createDiversion(name = "Div1",
                    capacity         ,
                    divertObject = NA,
                    downstream   = NA,
                    priority     = NA)
```

Arguments

`name`	(optional) A string: the name of the diversion
`capacity`	The maximum capacity of diversion dam (CMS).
`divertObject`	(optional) An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which recieves the diverted water volume.
`downstream`	(optional) An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which overflow volume pours to it.
`priority`	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to `Inf`.

Value

An object from class of `createDiversion`

See Also

`createDiversion`

createJunction *Constructor for class of* `createJunction`

Description

this function constructs an object from class of `createDiversion`, acting as a junction in the basin which is able to aggregate outflow water from upper tributaries and/or objects in the upstream.

Usage

```
createJunction(name, downstream)
```

Arguments

`name`	(optional) A string: the name of the junction
`downstream`	(optional) An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which outflow volume pours to it.

Value

An object from class of `createJunction`

Author(s)

Rezgar Arabzadeh

See Also

`addObjectToArea`

createJunction.base *base function for class of* `createJunction`

Description

this function constructs an object from class of `createDiversion`, acting as a junction in the basin which is able to aggregate outflow water from upper tributaries and/or objects in the upstream.

Usage

```
## S3 method for class 'base'
createJunction(name, downstream)
```

Arguments

`name`	(optional) A string: the name of the junction
`downstream`	(optional) An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which outflow volume pours to it.

Value

An object from class of `list`

See Also

`createJunction`

`createJunction.default` *default function for class of* `createJunction`

Description

this function constructs an object from class of `createDiversion`, acting as a junction in the basin which is able to aggregate outflow water from upper tributaries and/or objects in the upstream.

Usage

```
## Default S3 method:
createJunction(name = "junc1", downstream = NA)
```

Arguments

`name`	(optional) A string: the name of the junction
`downstream`	(optional) An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which outflow volume pours to it.

Value

An object from class of `list`

See Also

`createJunction`

`createReservoir` *Constructor for class of* `createReservoir`

Description

this function constructs an object from class of `createReservoir`, which is able to simulate a storage reservoir under given a sort of demand(s).

Usage

```
createReservoir(type,
                name,
                priority,
                downstream,
                netEvaporation,
                seepageFraction,
                seepageObject,
                geometry,
                plant,
                penstock,
                initialStorage)
```

Arguments

`type`	A string: the type of the reservoir being instantiated: by default 'storage', however, it can be 'hydropower'
`name`	(optional) A string: the name of the reservoir.
`priority`	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to Inf.
`downstream`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which spillage volume pours to it.
`netEvaporation`	A vector: is a vector of net evaporation depth time series at the location of dam site (meter). If omitted, the evaporation is assumed to be zero.
`seepageFraction`	(optional) The seepage coeffcient of reservoir storage. The seepage is computed as the product of `seepageFraction` and reservoir storage. It is in `[0, 1]` interval
`seepageObject`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which seepage volume pours to it.
`geometry`	A list of reservoir geometric specifications: • `storageAreaTable`: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains reservoir area (in Km^2) corresponding to the first column

- `storageElevationTable`: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains elevation (in meter) corresponding to the first column
- `dischargeElevationTable`: is a matrix whose first column includes the capacity of reservoir tailwater discharge rate (in cms) for different elevation levels and the second column contains elevation levels corresponding to the first column, required if the `type = 'hydropower'` and the item `submerged = TRUE`
- `deadStorage`: refers to water in a reservoir that cannot be drained by gravity through the dam outlet works (MCM)
- `capacity`: The maximum capacity of the reservoir

`plant` A list of power plant specifications. It is provided if `type = 'hydropower'`:

- `installedCapacity`: the plant installed capacity (MW)
- `efficiency`: is a matrix whose first column includes discharge rate (in cms) and the second column turbine effeciency, in `[0 1]` interval, corresponding to the first column
- `designHead`: A vector of length of two, containing the minimum and maximum design water head (in meter) of the turbine respecively, that the it is in active state
- `designFlow`: A vector of length of two, containing the minimum and maximum design flow rate (in cms) of the turbine respecively, that the it is in active state
- `turbineAxisElevation`: The elevation of axis of the installed turbine (in meter)
- `submerged`: logical: if the turbine is of type of submeged on, `TRUE`, otherwise, `FALSE`
- `loss`: losses associated with the turbine (in meter)

`penstock` (optional) A list of penstock specifications. It is provided if `type = 'hydropower'`:

- `diameter`: The diameter of the penstock (in meter)
- `length`: The length of the penstock (in meter)
- `roughness`: pipe roughness coefficient used for Hazen-Williams formulation

`initialStorage` (optional) The initial stored water at the reservoir in the first step of the simulation (MCM). If is missing the the function iterate to carry over the reservoir.

Value

An object from class of `createReservoir`

Author(s)

Rezgar Arabzadeh

See Also

`addObjectToArea`

createReservoir.base *base function for class of* createReservoir

Description

this function constructs an object from class of createReservoir, which is able to simulate a storage reservoir under given a sort of demand(s).

Usage

```
  ## S3 method for class 'base'
createReservoir(type,
                                 name,
                                 priority,
                                 downstream,
                                 netEvaporation,
                                 seepageFraction,
                                 seepageObject,
                                 geometry,
                                 plant,
                                 penstock,
                                 initialStorage)
```

Arguments

type	A string: the type of the reservoir being instantiated: by default 'storage', however, it can be 'hydropower'
name	(optional) A string: the name of the reservoir.
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.
downstream	(optional) An object; from either of classes of createAquifer , createRiver, createReservoir, createJunction, createDiversion, or createDemandSite; which spillage volume pours to it.
netEvaporation	A vector: is a vector of net evaporation depth time series at the location of dam site (meter). If omitted, the evaporation is assumed to be zero.
seepageFraction	(optional) The seepage coeffcient of reservoir storage. The seepage is computed as the product of seepageFraction and reservoir storage. It is in [0, 1] interval
seepageObject	(optional) An object; from either of classes of createAquifer , createRiver, createReservoir, createJunction, createDiversion, or createDemandSite; which seepage volume pours to it.
geometry	A list of reservoir geometric specifications: • storageAreaTable: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains reservoir area (in Km^2) corresponding to the first column

- `storageElevationTable`: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains elevation (in meter) corresponding to the first column
- `dischargeElevationTable`: is a matrix whose first column includes the capacity of reservoir tailwater discharge rate (in cms) for different elevation levels and the second column contains elevation levels corresponding to the first column, required if the `type = 'hydropower'` and the item `submerged = TRUE`
- `deadStorage`: refers to water in a reservoir that cannot be drained by gravity through the dam outlet works (MCM)
- `capacity`: The maximum capacity of the reservoir

`plant` A list of power plant specifications. It is provided if `type = 'hydropower'`:

- `installedCapacity`: the plant installed capacity (MW)
- `efficiency`: is a matrix whose first column includes discharge rate (in cms) and the second column turbine effeciency, in `[0 1]` interval, corresponding to the first column
- `designHead`: A vector of length of two, containing the minimum and maximum design water head (in meter) of the turbine respecively, that the it is in active state
- `designFlow`: A vector of length of two, containing the minimum and maximum design flow rate (in cms) of the turbine respecively, that the it is in active state
- `turbineAxisElevation`: The elevation of axis of the installed turbine (in meter)
- `submerged`: logical: if the turbine is of type of submeged on, `TRUE`, otherwise, `FALSE`
- `loss`: losses associated with the turbine (in meter)

`penstock` (optional) A list of penstock specifications. It is provided if `type = 'hydropower'`:

- `diameter`: The diameter of the penstock (in meter)
- `length`: The length of the penstock (in meter)
- `roughness`: pipe roughness coefficient used for Hazen-Williams formulation

`initialStorage` (optional) The initial stored water at the reservoir in the first step of the simulation (MCM). If is missing the the function iterate to carry over the reservoir.

Value

An object from class of `list`

See Also

`createReservoir`

createReservoir.default

default function for class of `createReservoir`

Description

this function constructs an object from class of `createReservoir`, which is able to simulate a storage reservoir under given a sort of demand(s).

Usage

```
  ## Default S3 method:
createReservoir(type='storage',
                          name='unknown',
                          priority=NA,
                          downstream=NA,
                          netEvaporation=NA,
                          seepageFraction=NA,
                          seepageObject=NA,
                          geometry=list(storageAreaTable=NULL,
                                        storageElevationTable=NULL,
                                        dischargeElevationTable=NULL,
                                        deadStorage=NULL,
                                        capacity=NULL),
                          plant=list(installedCapacity=NULL,
                                     efficiency=NULL,
                                     designHead=NULL,
                                     designFlow=NULL,
                                     turbineAxisElevation=NULL,
                                     submerged=FALSE,
                                     loss=0),
                          penstock=list(diameter=NULL,
                                        length=NULL,
                                        roughness=110),
                          initialStorage=NA)
```

Arguments

`type`	A string: the type of the reservoir being instantiated: by default 'storage', however, it can be 'hydropower'
`name`	(optional) A string: the name of the reservoir.
`priority`	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to Inf.
`downstream`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which spillage volume pours to it.

`netEvaporation`	A vector: is a vector of net evaporation depth time series at the location of dam site (meter). If omitted, the evaporation is assumed to be zero.
`seepageFraction`	(optional) The seepage coeffcient of reservoir storage. The seepage is computed as the product of `seepageFraction` and reservoir storage. It is in `[0, 1]` interval
`seepageObject`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which seepage volume pours to it.
`geometry`	A list of reservoir geometric specifications: • `storageAreaTable`: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains reservoir area (in Km^2) corresponding to the first column • `storageElevationTable`: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains elevation (in meter) corresponding to the first column • `dischargeElevationTable`: is a matrix whose first column includes the capacity of reservoir tailwater discharge rate (in cms) for different elevation levels and the second column contains elevation levels corresponding to the first column, required if the `type = 'hydropower'` and the item `submerged = TRUE` • `deadStorage`: refers to water in a reservoir that cannot be drained by gravity through the dam outlet works (MCM) • `capacity`: The maximum capacity of the reservoir
`plant`	A list of power plant specifications. It is provided if `type = 'hydropower'`: • `installedCapacity`: the plant installed capacity (MW) • `efficiency`: is a matrix whose first column includes discharge rate (in cms) and the second column turbine effeciency, in `[0 1]` interval, corresponding to the first column • `designHead`: A vector of length of two, containing the minimum and maximum design water head (in meter) of the turbine respecively, that the it is in active state • `designFlow`: A vector of length of two, containing the minimum and maximum design flow rate (in cms) of the turbine respecively, that the it is in active state • `turbineAxisElevation`: The elevation of axis of the installed turbine (in meter) • `submerged`: logical: if the turbine is of type of submeged on, `TRUE`, otherwise, `FALSE` • `loss`: losses associated with the turbine (in meter)
`penstock`	(optional) A list of penstock specifications. It is provided if `type = 'hydropower'` • `diameter`: The diameter of the penstock (in meter) • `length`: The length of the penstock (in meter) • `roughness`: pipe roughness coefficient used for Hazen-Williams formulation
`initialStorage`	(optional) The initial stored water at the reservoir in the first step of the simulation (MCM). If is missing the the function iterate to carry over the reservoir.

Value

An object from class of `createReservoir`

See Also

`createReservoir`

`createRiver` *Constructor for class of* `createRiver`

Description

this function constructs an object from class of `createRiver`, which is able to act as a chanel or resource to supply a seort of demand(s).

Usage

```
createRiver(name, downstream, seepageFraction,
            seepageObject, discharge, priority)
```

Arguments

`name`	(optional) A string: the name of the river
`downstream`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which outflow volume pours to it.
`seepageFraction`	(optional) The seepage coeffcient of river discharge flow. The seepage is computed as the product of `seepageFraction` and river discharge. It is in `[0, 1]` interval
`seepageObject`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which seepage volume pours to it.
`discharge`	(optional) A vector: is a vector of river discharge time series (MCM).
`priority`	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to `Inf`.

Value

An object from class of `createRiver`

Author(s)

Rezgar Arabzadeh

See Also

`addObjectToArea`

createRiver.base — *base function for class of* createRiver

Description

this function constructs an object from class of `createRiver`, which is able to act as a chanel or resource to supply a seort of demand(s).

Usage

```
## S3 method for class 'base'
createRiver(name, downstream, seepageFraction,
                seepageObject, discharge, priority)
```

Arguments

`name`	(optional) A string: the name of the river
`downstream`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which outflow volume pours to it.
`seepageFraction`	(optional) The seepage coeffcient of river discharge flow. The seepage is computed as the product of `seepageFraction` and river discharge. It is in `[0, 1]` interval
`seepageObject`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which seepage volume pours to it.
`discharge`	(optional) A vector: is a vector of river discharge time series (MCM).
`priority`	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to `Inf`.

Value

An object from class of `list`

See Also

`createRiver`

createRiver.default *default function for class of* createRiver

Description

this function constructs an object from class of `createRiver`, which is able to act as a chanel or resource to supply a seort of demand(s).

Usage

```
## Default S3 method:
createRiver(name = "river1",
                    downstream      = NA,
                    seepageFraction = NA,
                    seepageObject   = NA,
                    discharge       = NA,
                    priority        = NA)
```

Arguments

`name`	(optional) A string: the name of the river
`downstream`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which outflow volume pours to it.
`seepageFraction`	(optional) The seepage coeffcient of river discharge flow. The seepage is computed as the product of `seepageFraction` and river discharge. It is in `[0, 1]` interval
`seepageObject`	(optional) An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which seepage volume pours to it.
`discharge`	(optional) A vector: is a vector of river discharge time series (MCM).
`priority`	(optional) An integer: the supplying priority. `priority` is a value in [1, 99] interval. If missing, the `priority` is set to `Inf`.

Value

An object from class of `createRiver`

See Also

`createRiver`

`diversionRouting` *base function for diversion simulation*

Description

Given a sort of demand(s), `diversionRouting` function enable us to simulate the performance and effect of a diversion dam under a givn recharge time series, `inflow`, on the drainage network.

Usage

```
diversionRouting(demand=NA, priority = NA,
                 capacity, inflow, simulation)
```

Arguments

`demand`	A matrix: is column-wise matrix of demands, at which the rows presents demands for each time step and columns are for different individual demand sites (MCM).
`priority`	A vector: is a vector of priorities associated to `demand`
`capacity`	The maximum capacity of diversion dam (CMS).
`inflow`	A vector : a vector of water flowing into the diversion (MCM)
`simulation`	A list: `simulation` is a list of three vectors: `start`, `end`, and `interval`. the `start` and `end` components must be in `'YYYY-MM-DD'` format. the `interval` component can takes either of `'day'`,`'week'`, or `'month'`.

Value

the `diversionRouting` function returns a list of features given as below:

- `release` : a matrix of release(s) equivalant to each `demand` (MCM)
- `diverted`: a vector of diverted volumes (MCM), release(s) are included
- `overflow`: a vector of overflow passing through the diversion (MCM)

Author(s)

Rezgar Arabzadeh

See Also

`aquiferRouting`

Examples

```
demand          <-matrix(rnorm(480,10,3),120)
priority        <-sample(1:3,4,replace=TRUE)
capacity        <-12
inflow          <-rlnorm(120,log(50),log(4))
simulation      <-list(start='2000-01-01',end='2009-12-29',interval='month')
res<-diversionRouting(demand=demand,
                      priority=priority,
                      capacity=capacity,
                      inflow=inflow,
                      simulation=simulation)
plot(ecdf(res$diverted$diverted),xlab='cms',ylab='exceedance probability')
```

`GOF` *Goodness of fit*

Description

this function calculates the goodness of fit (gof) using chi-squared test.

Usage

```
GOF(basin,object,observed)
```

Arguments

`basin`	An object from class of `sim`.
`object`	An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which is associated with observed time series and exists in the `basin`.
`observed`	A vector of observed time series.

Value

A list with class `"htest"`.

Author(s)

Rezgar Arabzadeh

See Also

`sim`

Examples

```
J1<-createJunction(name="j1")
Res1<-createReservoir(name="res1",type='storage',
                      priority=1,netEvaporation=rnorm(120,0.5,0.1),
                      geometry=list(deadStorage= 10 ,capacity= 90 ,
                                    storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
Res2<-createReservoir(name="res2",type='storage',
                      priority=2,netEvaporation=rnorm(120,0.5,0.1),
                      geometry=list(deadStorage= 10 ,capacity= 90 ,
                                    storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R1<-createRiver(name="river1",discharge=rnorm(120,5,1.5))
R2<-createRiver(name="river2",discharge=rnorm(120,5,1.5))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                        100/sum(sin(seq(0,pi,length.out=12))))
D1<-createDemandSite(name ="Agri1",
                     demandParams=list(waterUseRate=1,
                                       waterVariation=waterVariation,
                                       cropArea=1000),
                     returnFlowFraction =0.2,priority=1)
D2<-createDemandSite(name ="Agri2",
                     demandParams=list(waterUseRate=1,
                                       waterVariation=waterVariation,
                                       cropArea=1000),
                     returnFlowFraction =0.2,priority=2)
D3<-createDemandSite(name ="Agri3",
                     demandParams=list(waterUseRate=1,
                                       waterVariation=waterVariation,
                                       cropArea=1000),
                     returnFlowFraction =0.2,priority=1)
area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                 end  ='2000-04-29',
                                 interval='day'))

R1<-set.as(Res1,R1,'downstream')
R2<-set.as(Res2,R2,'downstream')
Res1<-set.as(J1,Res1,'downstream')
Res2<-set.as(J1,Res2,'downstream')
D1<-set.as(J1,D1,'downstream')
D2<-set.as(J1,D2,'downstream')
D3<-set.as(J1,D3,'downstream')
D1<-set.as(Res1,D1,'supplier')
D2<-set.as(Res1,D2,'supplier')
D2<-set.as(Res2,D2,'supplier')
D3<-set.as(Res2,D3,'supplier')

area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,R2)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,Res2)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
```

```
    area<-addObjectToArea(area,D3)
    area<-addObjectToArea(area,J1)
    ## Not run:
      plot(area)

  ## End(Not run)
    simulated<-sim(area)
    observed<-apply(simulated$operation$operation$junctions[[1]]$operation$outflow,1,sum)
    observed<-observed+rnorm(length(observed),mean(observed)*0.2,sd(observed)*0.1)
    GOF(simulated,J1,observed)
```

`GOF.base` *base function for class of* `GOF`

Description

this function calculates the goodness of fit (gof) using chi-squared test.

Usage

```
## S3 method for class 'base'
GOF(basin,object,observed)
```

Arguments

`basin`	An object from class of `sim`.
`object`	An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which is associated with observed time series and exists in the `basin`.
`observed`	A vector of observed time series.

Value

A list with class `"htest"`.

Author(s)

Rezgar Arabzadeh

See Also

`GOF`

`GOF.default` *default function for class of* `GOF`

Description

this function calculates the goodness of fit (gof) using chi-squared test.

Usage

```
## Default S3 method:
GOF(basin,object,observed)
```

Arguments

`basin`	An object from class of `sim`.
`object`	An object from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`; which is associated with observed time series and exists in the `basin`.
`observed`	A vector of observed time series.

Value

A list with class `"htest"`.

Author(s)

Rezgar Arabzadeh

See Also

`GOF`

`plot.createArea` *plot method for an object from class of* `createArea`

Description

plot method for objects inherited from class of `createArea`

Usage

```
## S3 method for class 'createArea'
plot(x,...)
```

Arguments

`x`	an object from class of `createArea`
`...`	other objects that can be passed to `plot` function

Author(s)

Rezgar Arabzadeh

See Also

`createArea`

`plot.sim` *plot method for an WRSS object*

Description

plot method for objects inherited from class of `sim`

Usage

```
## S3 method for class 'sim'
plot(x,...)
```

Arguments

`x`	an object from class of `sim`
`...`	other objects that can be passed to `plot` function

Author(s)

Rezgar Arabzadeh

See Also

`sim`

`reservoirRouting` *base function for reservoir simulation*

Description

Given a sort of demand(s), `reservoirRouting` function simulates the effect of a dam under givn hydrometeorological time series, e.g. `inflow` and `netEvaporation`, on the drainage network.

Usage

```
reservoirRouting(type='storage',
                 inflow,
                 netEvaporation=NA,
                 demand=NA,
                 priority=NA,
                 seepageFraction=NA,
                 geometry=list(storageAreaTable=NULL,
                               storageElevationTable=NULL,
                               dischargeElevationTable=NULL,
                               deadStorage=0,
                               capacity=NULL),
                 plant=list(installedCapacity=NULL,
                            efficiency=NULL,
                            designHead=NULL,
                            designFlow=NULL,
                            turbineAxisElevation=NULL,
                            submerged=FALSE,
                            loss=0),
                 penstock=list(diameter=NULL,
                               length=0,
                               roughness=110),
                 initialStorage=NA,
                 simulation)
```

Arguments

`type`	A string: the type of the reservoir being instantiated: by default 'storage', however, it can be 'hydropower'
`inflow`	A vector : a vector of water flowing into the diversion (MCM)
`netEvaporation`	A vector: is a vector of net evaporation depth time series at the location of dam site (meter). If omitted, the evaporation is assumed to be zero.
`demand`	A matrix: is column-wise matrix of demands, at which the rows presents demands for each monthly time steps and columns are for different individual demand sites (MCM).
`priority`	(optional) A vector: is a vector of priorities associated to `demand`

`seepageFraction`
: (optional) The seepage coeffcient of reservoir storage. The seepage is computed as the product of `seepageFraction` and reservoir storage.

`geometry`
: A list of reservoir geometric specifications:

- `storageAreaTable`: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains reservoir area (in Km^2) corresponding to the first column
- `storageElevationTable`: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains elevation (in meter) corresponding to the first column
- `dischargeElevationTable`: is a matrix whose first column includes the capacity of reservoir tailwater discharge rate (in cms) for different elevation levels and the second column contains elevation levels corresponding to the first column, required if the `type = 'hydropower'` and the item `submerged = TRUE`
- `deadStorage`: refers to water in a reservoir that cannot be drained by gravity through the dam outlet works (MCM)
- `capacity`: The maximum capacity of the reservoir

`plant`
: A list of power plant specifications. It is provided if `type = 'hydropower'`:

- `efficiency`: is a matrix whose first column includes discharge rate (in cms) and the second column turbine effeciency, in `[0 1]` interval, corresponding to the first column
- `designHead`: A vector of length of two, containing the minimum and maximum design water head (in meter) of the turbine respecively, that the it is in active state
- `designFlow`: A vector of length of two, containing the minimum and maximum design flow rate (in cms) of the turbine respecively, that the it is in active state
- `turbineAxisElevation`: The elevation of axis of the installed turbine (in meter)
- `submerged`: logical: if the turbine is of type of submeged on, `TRUE`, otherwise, `FALSE`
- `loss`: losses associated with the turbine (in meter)

`penstock`
: (optional) A list of penstock specifications. It is provided if `type = 'hydropower'`

- `diameter`: The diameter of the penstock (in meter)
- `length`: The length of the penstock (in meter)
- `roughness`: pipe roughness coefficient used for Hazen-Williams formulation

`initialStorage`
: (optional) The initial stored water at the reservoir in the first step of the simulation (MCM). If is missing the the function iterate to carry over the reservoir.

`simulation`
: A list: `simulation` is a list of three vectors: `start`, `end`, and `interval`. the `start` and `end` components must be in `'YYYY-MM-DD'` format. the `interval` component can takes either of `'day'`, `'week'`, or `'month'`.

Value

the `reservoirRouting` function returns a list of features given as folows:

- `release`: a matrix of release(s) equivalant to each demand (MCM)
- `spill` : a vector of spilage time series (MCM)
- `seepage`: a vector of steepage time series (MCM)
- `storage`: a vector of storage time series (MCM)
- `loss` : a vector of evaporation loss time series (MCM)

Author(s)

Rezgar Arabzadeh

References

Yeh, William WG. "Reservoir management and operations models: A state of the art review." Water resources research 21.12 (1985): 1797-1818.

See Also

`aquiferRouting`

Examples

```
type           <-c('storage','hydropower')
demand         <-matrix(rnorm(480,10,3),120)
priority       <-sample(1:3,4,replace=TRUE)
inflow         <-rlnorm(120,log(50),log(4))
netEvaporation <-rnorm(120,0.4,0.1)
simulation     <-list(start='2000-01-01',end='2009-12-29',interval='month')
seepageFraction<-0.05
geometry       <-list(storageAreaTable=cbind(seq(0,100,10),seq(0,10,1)),
                      storageElevationTable=cbind(seq(0,100,10),seq(0,200,20)),
                      dischargeElevationTable=cbind(seq(0,50,10),seq(0,10,2)),
                      deadStorage=50,
                      capacity=100)
plant          <-list(installedCapacity=50,
                      efficiency=cbind(c(5,25,45),c(0.5,0.9,0.7)),
                      designHead=c(100,200),
                      designFlow=c(10,40),
                      turbineAxisElevation=5,
                      submerged=TRUE,
                      loss=2)
penstock       <-list(diameter=2,
                      length=50,
                      roughness=110)

#-----Storage Reservoir----------
reservoirRouting(type=type[1],
                 inflow=inflow,
                     netEvaporation=netEvaporation,
                     demand=demand,
                     priority=priority,
                     seepageFraction=seepageFraction,
                     geometry=geometry,
                     plant=plant,
                     penstock=penstock,
                     simulation=simulation)
## Not run:
    ##-----Takes Several Minutes----------

    #-----Hydropower Reservoir with demand----------
    reservoirRouting(type=type[2],
                     inflow=inflow,
                     netEvaporation=netEvaporation,
                     demand=demand,
                     priority=priority,
                     seepageFraction=seepageFraction,
                     geometry=geometry,
                     plant=plant,
                     penstock=penstock,
                     simulation=simulation)
    #-----Hydropower Reservoir----------
    reservoirRouting(type=type[2],
                     inflow=inflow,
                     netEvaporation=netEvaporation,
                     priority=priority,
                     seepageFraction=seepageFraction,
                     geometry=geometry,
                     plant=plant,
                     penstock=penstock,
                     simulation=simulation)


## End(Not run)
```

`rippl` *Rippl's method*

Description

Computes the Rippl-no-failure storage for given set of discharges and target.

Usage

```
rippl(discharge,target,plot=TRUE)
```

Arguments

`discharge`	a vector of natural discharge at the reservoir site.
`target`	a vector of demand time series with length equal that of `discharge`. If the time scale doesn't match, the `target` will be cycled or truncated.
`plot`	logical: whether plot the Rippl's method process or merely report the result.

Value

no-failure storage value for the given time series, `discharge` and `target`.

References

Rippl, Wengel. The capacity of storage reservoirs for water supply. Van Nostrand's Engineering Magazine (1879-1886) 29.175 (1883): 67.

See Also

`sim`

Examples

```
## Not run:
rippl(Nile,mean(Nile)*0.95)

## End(Not run)
```

`risk` *risk-based criteria*

Description

this function returns risk-based criteria for demand site(s) built-in the object inherited from class of `sim`.

Usage

```
risk(object , s.const = 0.95)
```

Arguments

`object`	an object from class of `sim`
`s.const`	satisfactory constant: a value in [0, 1] interval, which refers to the level at which if a demand is supplied over the `s.const` is considered fully supplied.

Details

This function computes the riks criteria based on the formulations proposed by Hashimoto et.al (1982).

Value

a matrix of criteria

Author(s)

Rezgar Arabzadeh

References

Hashimoto, Tsuyoshi, Jery R. Stedinger, and Daniel P. Loucks. "Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation." Water resources research 18.1 (1982): 14-20.

See Also

sim

Examples

```
Res<-createReservoir(name="R1",type='storage',
                     netEvaporation=rnorm(120,0.5,0.1),
                     geometry=list(deadStorage= 10,
                                   capacity= 700,
                                   storageAreaTable= cbind(seq(0,900,100),seq(0,9,1))))
R<-createRiver(name="Riv1",downstream=Res,discharge=rnorm(120,500,4))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                       100/sum(sin(seq(0,pi,length.out=12))))
D1<-createDemandSite(name ="D1",
                     demandParams=list(waterUseRate=5,
                                       waterVariation=waterVariation,
                                       cropArea=500),
                     suppliers=list(Res),priority=1)
D2<-createDemandSite(name ="D2",
                     demandParams=list(waterUseRate=5,
                                       waterVariation=waterVariation,
                                       cropArea=500),
                     suppliers=list(Res),priority=2)
D3<-createDemandSite(name ="D3",
                     demandParams=list(waterUseRate=5,
                                       waterVariation=waterVariation,
                                       cropArea=500),
                     suppliers=list(Res),priority=3)
area<-createArea(simulation=list(start='2000-01-01',end='2009-12-29',interval='month'))
area<-addObjectToArea(area,R)
area<-addObjectToArea(area,Res)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
area<-addObjectToArea(area,D3)
risk(sim(area))
```

`riverRouting` *base function for rivers and reachs simulation*

Description

Given a sort of demand(s), `riverRouting` function enable us to simulate rivers and channels under givn a hydrologic time series, `inflow`, and optional `demand`(s).

Usage

```
riverRouting(demand=NA, priority = NA, discharge, seepageFraction=NA, simulation)
```

Arguments

`demand`	(optional) A matrix: is column-wise matrix of demands, at which the rows presents demands for each time step and columns are for different individual demand sites (MCM).
`priority`	(optional) A vector: is a vector of priorities associated to `demand`
`discharge`	(optional) A vector : a vector of water flowing into the diversion (MCM)
`seepageFraction`	(optional) The seepage coeffcient of river discharge flow. The seepage is computed as the product of seepageFraction and river discharge. It is in `[0, 1]` interval
`simulation`	A list: `simulation` is a list of three vectors: `start`, `end`, and `interval`. the `start` and `end` components must be in `'YYYY-MM-DD'` format. the `interval` component can takes either of `'day'`, `'week'`, or `'month'`.

Value

the `riverRouting` returns a matrix of release(s) corresponding to each demand(s).

Author(s)

Rezgar Arabzadeh

See Also

`diversionRouting`

Examples

```
demand          <-matrix(rnorm(480,15,3),120)
priority        <-sample(1:3,4,replace=TRUE)
discharge       <-rlnorm(120,log(50),log(4))
simulation      <-list(start='2000-01-01',end='2000-04-29',interval='day')

riverRouting(demand    = demand   ,
             priority  = priority ,
             discharge = discharge,
             simulation= simulation)
```

set.as   *WRSS objects connector*

Description

this function connects a base object as a either of: `'downstream'`, `'supplier'`, `'leakageObject'`, `'seepageObject'`, or `'divertObject'` to a `target` object, which are both instantiated by WRSS constructors.

Usage

```
set.as(base,target,type='downstream')
```

Arguments

`base`	An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`
`target`	An object; from either of classes of `createAquifer` , `createRiver`, `createReservoir`, `createJunction`, `createDiversion`, or `createDemandSite`
`type`	the type of base object to be set as to the `target` object: `'downstream'`, `'supplier'`, `'leakageObject'`, `'seepageObject'`, or `'divertObject'`

Value

an object from class of `target` object.

Author(s)

Rezgar Arabzadeh

See Also

`addObjectToArea`

`sim` *Constructor for class of* `sim`

Description

`sim` simulates an object inherited from class of `createArea` using Standard Operating Policy (SOP).

Usage

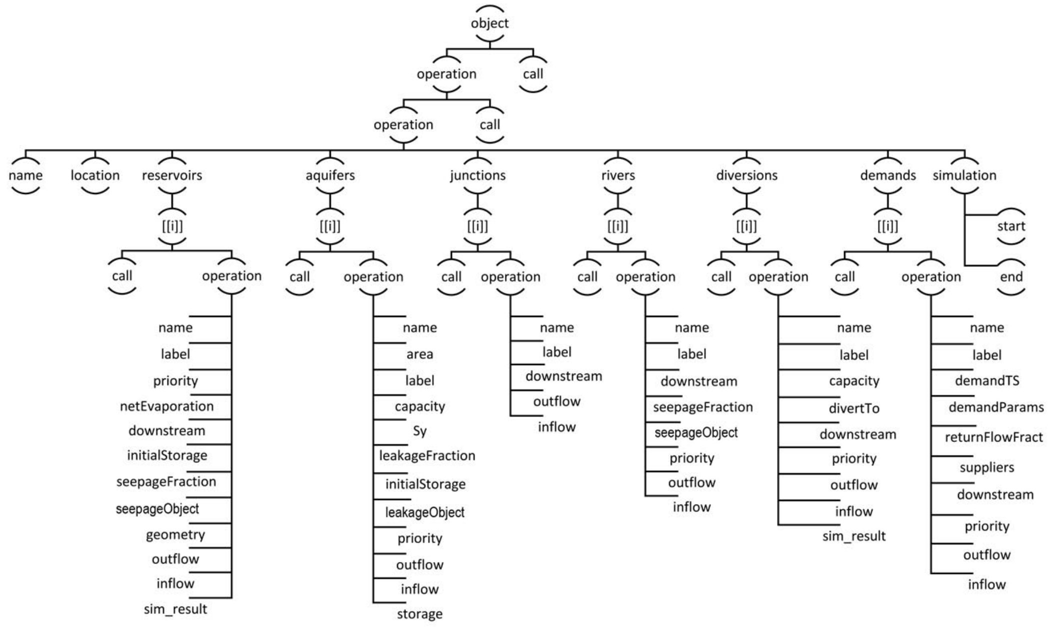
```
sim(object)
```

Arguments

`object`	an object inherited from class of `createArea`.

Value

an object inherited from class of `sim`. Address keys to access components built-in an object inherited from class of `sim` is as figure below:



Author(s)

Rezgar Arabzadeh

References

Loucks, Daniel P., et al. Water resources systems planning and management: an introduction to methods, models and applications. Paris: Unesco, 2005.

See Also

addObjectToArea

`sim.base` *base function for class of* `sim`

Description

`sim` simulates an object inherited from class of `createArea` using Standard Operating Policy (SOP).

Usage

```
## S3 method for class 'base'
sim(object)
```

Arguments

`object`	an object inherited from class of `createArea`.

Value

an object inherited from class of `list` and including features as list(s), which are accessable as follows:

reservoirs: operation$reservoirs rivers: operation$rivers junctions: operation$junctions aquifers: operation$aquifers diversions: operation$diversions demands: operation$demands

See Also

sim

`sim.default` *default function for class of* `sim`

Description

`sim` simulates an object inherited from class of `createArea` using Standard Operating Policy (SOP).

Usage

```
## Default S3 method:
sim(object)
```

Arguments

`object`	an object inherited from class of `createArea`.

Value

an object inherited from class of `sim` and including features as list(s), which are accessable as follows:

reservoirs: $operation$operation$reservoirs rivers: $operation$operation$rivers junctions: $operation$operation$junctions aquifers: $operation$operation$aquifers diversions: $operation$operation$diversions demands: $operation$operation$demands

See Also

`sim`

`zarrineh` *data of Zarrineh-rud river basin*

Description

The `zarrineh` object, is a list of objects including time series and detail a five-reservoir systen in the Zarrineh-rud river basin.

Format

list object

References

Iran Water Resources Management Company, 2016.

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