Package 'GR2MSemiDistr'

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Type Package

Title A package for hydrological modeling with a semi-distribute GR2M model adaptation in large-sample studies.

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Description This package run a semi-distributed GR2M model adaptation using the Weighted Flow Accumulation algorithm in TauDEM_537 (required)

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hydroGOF,
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`Create_Forcing_Inputs` *Extract and prepare model's inputs data in the airGR format (DatesR, P and E) from gridded P and E monthly data.*

Description

Extract and prepare model's inputs data in the airGR format (DatesR, P and E) from gridded P and E monthly data.

Usage

```
Create_Forcing_Inputs(Subbasins, Precip, PotEvap, Qobs = NULL, DateIni,
  DateEnd, Save = FALSE, Update = FALSE, Resolution = 0.01,
  Buffer = 1.1, Members = NULL)
```

Arguments

`Subbasins`	Subbasins' shapefile. Must contain the following attributes: 'Area' (in km2), 'Region' (in letters), and 'COMID' (identifier number).
`Precip`	Raster brick of the precipitation data in [mm/month].
`PotEvap`	Raster brick of the evapotranspiration data in [mm/month].
`Qobs`	Observed streamflow data in [m3/s] at the basin outlet. Must have the same length as P and E data (including NA values). NULL as default.
`DateIni`	Initial date of the database in 'mm/yyyy' format.
`DateEnd`	Ending date of the database in 'mm/yyyy' format.
`Save`	Boolean to save results as a text file in the 'Outputs' location. FALSE as default.
`Update`	Boolean for the updating mode where only the last month's values will be returned. FALSE as default.
`Resolution`	Resampling resolution for improving subbasins' data extraction. 0.01degrees as default.
`Buffer`	Factor for increase subbasins' limits extents. 1.1 as default.
`Members`	Número de miembros del conjunto modelo. Only for streamflow forecasting purposes. NULL por defecto.

Value

Return a dataframe of model's inputs data in the airGR format (DatesR, P, E, Q).

References

Cesar Aybar, Carlos Fernández, Adrian Huerta, Waldo Lavado, Fiorella Vega & Oscar Felipe-Obando (2020) Construction of a high-resolution gridded rainfall dataset for Peru from 1981 to the present day, Hydrological Sciences Journal, 65:5, 770-785, DOI: 10.1080/02626667.2019.1649411

Llauca H, Lavado-Casimiro W, Montesinos C, Santini W, Rau P. PISCO_HyM_GR2M: A Model of Monthly Water Balance in Peru (1981–2020). Water. 2021; 13(8):1048. https://doi.org/10.3390/w13081048

Examples

```
# Load data
require(GR2MSemiDistr)
data(pisco_pr)
data(pisco_pe)
data(qobs)
data(roi)

# Create a database with model's inputs data
data <- Create_Forcing_Inputs(Subbasins=roi,
                              Precip=pisco_pr,
                              PotEvap=pisco_pe,
                              Qobs=qobs,
                              DateIni='01/1981',
                              DateEnd='12/2016')
View(data)
```

`Optim_GR2MSemiDistr` *Model parameter optimization with the SCE-UA algorithm.*

Description

Model parameter optimization with the SCE-UA algorithm.

Usage

```
Optim_GR2MSemiDistr(Data, Subbasins, RunIni, RunEnd, WarmUp = NULL,
  Parameters, Parameters.Min, Parameters.Max, Max.Functions = 5000,
  Optimization = "NSE", No.Optim = NULL)
```

Arguments

`Data`	Dataframe with model input's data in airGR format from `Create_Forcing_Inputs`. (DatesR, P_1, P_2,..,P_n, E_1, E_2, ...E_n, Q). If Q is not available please provide only DatesR, P, and E.
`Subbasins`	Subbasins' shapefile. Must contain the following attributes: 'Area' (in km2), 'Region' (in letters), and 'COMID' (identifier number).
`RunIni`	Initial date of the model simulation in 'mm/yyyy' format.
`RunEnd`	Ending date of the model simulation in 'mm/yyyy' format.
`WarmUp`	Number of months for the warm-up period. NULL as default.
`Parameters`	Vector of initial model parameters (X1 and X2) and correction factors of P (fp) and E (fpe) in the following order: c(X1, X2, fp, fpe). In the case of existing more than one 'Region' (e.g. regions A and B) please provide model parameters in the following order: c(X1_A, X1_B, X2_A, X2_B, Fp_a, Fp_B, Fpe_A, Fpe_B).
`Parameters.Min`	Vector of minimum values of GR2M model parameters and correction factors in the following order: c(X1_min, X2_min, fp_min, fpe_min).
`Parameters.Max`	Vector of maximum values of GR2M model parameters and correction factors in the following order: c(X1_max, X2_max, fp_max, fpe_max).

Max.Functions	Maximum number of function evaluation for optimization. 5000 as default.
Optimization	Objective function for optimization (NSE, KGE, or RMSE).
No.Optim	Regions not to be optimized. NULL as default.

Value

List of optimal GR2M model parameters for each 'Region'.

Param: Best set of GR2M model parameters (sorted by 'Region').

Value: Final value of the objective function.

References

Llauca H, Lavado-Casimiro W, Montesinos C, Santini W, Rau P. PISCO_HyM_GR2M: A Model of Monthly Water Balance in Peru (1981–2020). Water. 2021; 13(8):1048. https://doi.org/10.3390/w13081048

Examples

```
# Optimize GR2M model parameters for a single 'Region' using the KGE metric
optim <- Optim_GR2MSemiDistr(Data=data,
                             Subbasins=roi,
                             RunIni='01/1981',
                             RunEnd='12/2002',
                             WarmUp=36,
                             Parameters=c(1000, 1, 1, 1),
                             Parameters.Min=c(1, 0.01, 0.8, 0.8),
                             Parameters.Max=c(2000, 2, 1.2, 1.2),
                             Max.Functions=1000,
                             Optimization='KGE')
 best_param <- optim$Param
```

Routing_GR2MSemiDistr *Routing discharges for each subbasin.*

Description

Routing discharges for each subbasin.

Usage

```
Routing_GR2MSemiDistr(Model, Subbasins, Dem, AcumIni = NULL,
  AcumEnd = NULL, Save = FALSE, Update = FALSE)
```

Arguments

Model	List of model results from Run_GR2MSemiDistr.
Subbasins	Subbasins' shapefile. Must contain the following attributes: 'Area' (in km2), 'Region' (in letters), and 'COMID' (identifier number).
Dem	Digital elevation model raster for the extent of the basin.
AcumIni	Initial date of the model routing in 'mm/yyyy' format. NULL as default
AcumEnd	Ending date of the model routing in 'mm/yyyy' format. NULL as default
Save	Boolean to save results as a text file in the 'Outputs' location. FALSE as default.
Update	Boolean for the updating mode where only the last month's values will be returned. FALSE as default.

Value

List of model routing outputs.

QR: Routed discharge timeseries for all subbasins in [m3/s].

Dates: Vector of dates of the simulation period.

COMID: Vector of identifier numbers for each subbasin.

Author(s)

Llauca H, Lavado-Casimiro W, Montesinos C, Santini W, Rau P. PISCO_HyM_GR2M: A Model of Monthly Water Balance in Peru (1981–2020). Water. 2021; 13(8):1048. https://doi.org/10.3390/w13081048

Examples

```
# Load data
require(GR2MSemiDistr)
data(dem)

# Routing discharges in the streamflow network
rou <- Routing_GR2MSemiDistr(Model=model,
                             Subbasins=roi,
                             Dem=dem,
                             AcumIni='01/1981',
                             AcumEnd='12/2016')
View(rou$QR)
```

Run_GR2MSemiDistr *Run the GR2M model for 'n' subbasins.*

Description

Run the GR2M model for 'n' subbasins.

Usage

```
Run_GR2MSemiDistr(Data, Subbasins, RunIni, RunEnd, WarmUp = NULL,
  Parameters, IniState = NULL, Save = FALSE, Update = FALSE)
```

Arguments

Data	Dataframe with model input's data in airGR format from Create_Forcing_Inputs. (DatesR, P_1, P_2,..,P_n, E_1, E_2, ...E_n, Q). If Q is not available please provide only DatesR, P, and E.
Subbasins	Subbasins' shapefile. Must contain the following attributes: 'Area' (in km2), 'Region' (in letters), and 'COMID' (identifier number).
RunIni	Initial date of the model simulation in 'mm/yyyy' format.
RunEnd	Ending date of the model simulation in 'mm/yyyy' format.
WarmUp	Number of months for warm-up. NULL as default.

Parameters	Vector of model parameters (X1 and X2) and correction factors of P (fp) and E (fpe) in the following order: c(X1, X2, fp, fpe). In the case of existing more than one 'Region' (e.g. regions A and B) please provide model parameters in the following order: c(X1_A, X1_B, X2_A, X2_B, Fp_a, Fp_B, Fpe_A, Fpe_B).
IniState	Initial states variables. NULL as default.
Save	Boolean to save results as a text file in the 'Outputs' location. FALSE as default.
Update	Boolean for the updating mode where only the last month's values will be returned. FALSE as default.

Value

List of GR2M model outputs.

PR: Precipitation timeseries for all subbasins in [mm/month].

AE: Actual evapotranspiration timeseries for all subbasins in [mm/month].

SM: Soil Moisture timeseries for all subbasins in [mm/month].

RU: Runoff timeseries for all subbasins in [mm/month].

QS: Discharge timeseries for all subbasins in [m3/s] (not routed).

Dates: Vector of dates of the simulation period.

COMID: Vector of identifier numbers for each subbasin.

EndState: List of end model states of each subbasin.

SINK: Basin outlet which contains qsim and qobs data time series in [m3/s].

References

Llauca H, Lavado-Casimiro W, Montesinos C, Santini W, Rau P. PISCO_HyM_GR2M: A Model of Monthly Water Balance in Peru (1981–2020). Water. 2021; 13(8):1048. https://doi.org/10.3390/w13081048

Examples

```
# Run the GR2M model for each subbasin
model <- Run_GR2MSemiDistr(Data=data,
                           Subbasins=roi,
                           RunIni='01/1981',
                           RunEnd='12/2016',
                           Parameters=c(10.976, 0.665, 1.186, 1.169))

# Extract model results
View(model$PR) # precipitation [mm/month]
View(model$AE) # actual evapotranspiration [mm/month]
View(model$SM) # soil moisture [mm/month]
View(model$RU) # runoff in [mm/month]
print(model$SINK$obs) # observed discharge in [m3/s] at basin outlet
print(model$SINK$sim) # simulated discharge in [m3/s] at basin outlet
```

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