# 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.

**Version** 4.2.1

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

**License** GPL (>= 2)

**Encoding** UTF-8

**Depends** R (>= 4.0),

**Imports** airGR, foreach, hydroGOF, raster, terra, geos, rtop, tictoc, lubridate, sf, exactextractr, parallel,

**LazyData** true

**RoxygenNote** 7.3.2

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**RemoteUsername** hllauca

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**GithubUsername** hllauca

**GithubRef** HEAD

**GithubSHA1** 5c71bf9e2da7fd836cbae6e80ac48765e55cf191

**NeedsCompilation** no

## Contents

`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,
  IniGrids = "01/1981",
  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 dates of the output dataset. |
| `DateIni` | Initial date of the output database in 'mm/yyyy' format. |
| `DateEnd` | Ending date of the output database in 'mm/yyyy' format. |
| `IniGrids` | Initial date of the gridded data (P and PE) in 'mm/yyy' 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',
                              IniGrids='01/1981')
View(data)
```

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

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## 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)
```

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

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## 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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