

# Package ‘GSA.UN’

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**Type** Package

**Title** Global Sensitivity Analysis Tool

**Version** 1.0.0

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**Description** A tool to sensitivity analysis using SOBOL (Sobol, 1993) and AMA (Dell'Oca et al. 2017 <[doi:10.5194/hess-21-6219-2017](https://doi.org/10.5194/hess-21-6219-2017)>) indices.

It allows to identify the most sensitive parameter or parameters of a model.

**Depends** R (>= 3.4)

**Imports** stats, e1071, utils

**Suggests** knitr, rmarkdown

**License** GPL-2

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.1.0

**VignetteBuilder** knitr

**NeedsCompilation** no

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**Repository** CRAN

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AMA

*AMA indices*

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## Description

This function calculates the AMA indices: AMAE, AMAV, AMAR and AMAK.

## Usage

```
AMA(data_Bstat, CM, pp_names, steps = 100)
```

## Arguments

data_Bstat	a data frame of dimensions t x 6, here t is the number of temporary steps and each column corresponds to a statistical measure: mean, variance, skewness, kurtosis and excess kurtosis.
CM	A list of arrays, each array corresponds to the conditional moments calculated with the mean, variance, skewness, kurtosis. Each array has dimensions of steps, t, p.
pp_names	vector that contains the names of the parameters (pp)
steps	number of divisions of the parametric range

## Value

A list of four matrices, which corresponds to AMAE, AMAV, AMAR and AMAK indices. Each matrix has dimensions of t x pp.

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## References

Dell’Oca, A., Riva, M., & Guadagnini, A. (2017). Moment-based metrics for global sensitivity analysis of hydrological systems. *Hydrology and Earth System Sciences*, 21(12), 6219–6234. <https://doi.org/10.5194/hess-21-6219-2017>

## Examples

```
data("data_Bstat", "CM", "pp_names")
AMA_indices <- AMA(data_Bstat, CM, pp_names, steps= 15)
```

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Bstat

*Basic statistical measures of a mathematical model results*

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## Description

This function calculates the mean, variance, skewness, kurtosis and excess kurtosis of a model output, this output can be given for different temporal periods (days, months or years).

## Usage

```
Bstat(out_set)
```

## Arguments

`out_set` matrix of dimensions  $n \times t$ , where  $n$  equals the number of runs and  $t$  is equal to the number of temporary steps.

## Value

a data frame of dimensions  $t \times 6$ , here  $t$  is the number of temporary steps and each column corresponds to a statistical measure: mean, variance, skewness, kurtosis and excess kurtosis.

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## Examples

```
data("out_set")
data_Bstat <- Bstat(out_set)
```

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CM	<i>@title First four conditional moments of example data</i>
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**Description**

@description Data generated by Cond\_Moments example

**Usage**

CM

**Format**

A list

**CM** A list of arrays, each array has dimensions of steps, t, pp

**Author(s)**

Camila Garcia-Echeverri

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Cond_Moments	<i>Conditional statistical moments of a model output</i>
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**Description**

This function evaluates the first four statistical moments after grouping the model output by different parametric ranges.

**Usage**

```
Cond_Moments(parameters_set, out_set, pp_names, steps = 100)
```

**Arguments**

parameters_set	matrix of dimensions n x pp, where n is the number of runs and pp is the number of parameters.
out_set	matrix of dimensions n x t, where n is the number of runs and t is the number of temporary steps.
pp_names	vector that contains the names of the parameters.
steps	number of divisions of the parametric range.

**Value**

A list of arrays, each array has dimensions of steps, t, pp.

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**Examples**

```
data("parameters_set", "out_set", "pp_names")  
  
CM <- Cond_Moments(parameters_set, out_set, pp_names, steps=15)
```

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data_Bstat	<i>@title First four conditional moments of example data</i>
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**Description**

@description Data generated with the example of the function Cond\_Moments

**Usage**

```
data_Bstat
```

**Format**

A data.frame

**data\_Bstat** a data frame of dimensions t x 6

**Author(s)**

Camila Garcia-Echeverri

**Source**

Function Bstat

**Description**

This function performs the global sensitivity analysis starting from the gross results of the model.

**Usage**

```
GSAtool(  
  parameters_set,  
  out_set,  
  pp_names,  
  steps = 100,  
  save = FALSE,  
  dir = NULL  
)
```

**Arguments**

<code>parameters_set</code>	matrix of dimensions $n \times pp$ , where $n$ is the number of runs and $pp$ is the number of parameters.
<code>out_set</code>	matrix of dimensions $n \times t$ , where $n$ is the number of runs and $t$ is the number of temporary steps.
<code>pp_names</code>	a strings vector with the names of the parameters of the model
<code>steps</code>	number of divisions of the parametric range.
<code>save</code>	T to save the results in .csv files, by default <code>save=F</code> .
<code>dir</code>	a directory to save the results

**Value**

a list containing two outputs: SOBOL and AMA indices.

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## References

Dell’Oca, A., Riva, M., & Guadagnini, A. (2017). Moment-based metrics for global sensitivity analysis of hydrological systems. *Hydrology and Earth System Sciences*, 21(12), 6219–6234. <https://doi.org/10.5194/hess-21-6219-2017>

Sobol, I. M. (2001). Global sensitivity indices for nonlinear mathematical models and their Monte Carlo estimates. *Mathematics and Computers in Simulation*, 55(1–3), 271–280. [https://doi.org/10.1016/S0378-4754\(00\)00270-6](https://doi.org/10.1016/S0378-4754(00)00270-6)

## Examples

```
data("parameters_set", "out_set", "pp_names")
```

```
GSA_results <- GSAtool(parameters_set, out_set, pp_names, steps = 15, save=FALSE)
```

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out_set	<i>@title Results of a sample model</i>
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## Description

@description Output generated with an example mathematical model.

## Usage

```
out_set
```

## Format

A matrix

**out\_set** a matrix of dimensions 500 x 365 (pp x t), runs of the model x temporary steps (365 days)

## References

Arenas-Bautista, M. C. (2020). Integration of Hydrological and Economical Aspects for Water Management in Tropical Regions. Case Study: Middle Magdalena Valley, Colombia. National University of Colombia.

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parameters\_set                    *@title Set of parameters randomly generated*

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### Description

@description It contains 10 parameters

### Usage

parameters\_set

### Format

A matrix

**parameters\_set** a matrix of dimensions 500 x 10 (n x pp), runs of the model x number of parameters

### References

Arenas-Bautista, M. C. (2020). Integration of Hydrological and Economical Aspects for Water Management in Tropical Regions. Case Study: Middle Magdalena Valley, Colombia. National University of Colombia.

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pp\_names                            *@title Example - parameters names*

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### Description

@description 10 parameters names.

### Usage

pp\_names

### Format

A value

**pp\_names** a vector of characters

### Author(s)

CGE

### References

Arenas-Bautista, M. C. (2020). Integration of Hydrological and Economical Aspects for Water Management in Tropical Regions. Case Study: Middle Magdalena Valley, Colombia. National University of Colombia.

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save_results	<i>Save GSA results</i>
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### Description

This function helps to save the results in .csv format

### Usage

```
save_results(  
  SOBOL = NULL,  
  SOBOL_total = NULL,  
  amae = NULL,  
  amav = NULL,  
  amar = NULL,  
  amak = NULL,  
  dir  
)
```

### Arguments

SOBOL	SOBOL index
SOBOL_total	SOBOL_total
amae	AMAE index
amav	AMAV index
amar	AMAR index
amak	AMAK index
dir	a directory to save the results

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SOBOL

*SOBOL indices***Description**

This function calculates the first order and total SOBOL indices.

**Usage**

```
SOBOL(data_var, CM_mean, CM_var, pp_names)
```

**Arguments**

data_var	a vector containing the variance of the model output for each modelling time step.
CM_mean	An array containing the conditional mean of each parameter of the model. This array has dimensions of steps x t x pp, where steps is the number of divisions of the parametric range, t is the number of temporary steps and pp the number of parameters of the model.
CM_var	An array containing the conditional variance of each parameter of the model. This array has dimensions of steps x t x pp, where steps is the number of divisions of the parametric range, t is the number of temporary steps and pp the number of parameters of the model.
pp_names	a strings vector with the names of the parameters of the model.

**Value**

a list containing two matrices. The first contains the first order sobol, the second sobol\_total.

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**References**

Sobol, I. M. (2001). Global sensitivity indices for nonlinear mathematical models and their Monte Carlo estimates. *Mathematics and Computers in Simulation*, 55(1–3), 271–280. [https://doi.org/10.1016/S0378-4754\(00\)00270-6](https://doi.org/10.1016/S0378-4754(00)00270-6)

**Examples**

```
data("data_Bstat", "CM", "pp_names")
SOBOL_indices <- SOBOL(data_Bstat[,3], CM$CM_mean, CM$CM_var , pp_names)
```

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