

# Package ‘geotoolsR’

May 8, 2026

**Type** Package

**Title** Tools to Improve the Use of Geostatistic

**Version** 1.2.1

**Author** Diogo Francisco Rossoni [aut, cre] (ORCID:  
<<https://orcid.org/0000-0001-6337-6628>>),  
Vinicius Basseto Felix [aut],  
Ricardo Puziol de Oliveira [ctb] (ORCID:  
<<https://orcid.org/0000-0001-6134-5975>>)

**Maintainer** Diogo Francisco Rossoni <dfrossoni@uem.br>

## Description

The basic idea of this package is provides some tools to help the researcher to work with geo-statistics. Initially, we present a collection of functions that allow the researchers to deal with spatial data using bootstrap procedure. There are five methods available and two ways to display them: bootstrap confidence interval - provides a two-sided bootstrap confidence interval; bootstrap plot - a graphic with the original variogram and each of the B bootstrap variograms.

**License** GPL (>= 2)

**Encoding** UTF-8

**LazyData** true

**Depends** R (>= 2.10), geoR(>= 1.9), tidyr, dplyr, ggplot2

**RoxygenNote** 7.2.3

**NeedsCompilation** no

**Repository** CRAN

**Date/Publication** 2024-07-21 11:00:04 UTC

## Contents

gboot_block . . . . .	2
gboot_CI . . . . .	4
gboot_cloud . . . . .	5
gboot_cross . . . . .	6
gboot_plot . . . . .	9

gboot_solv . . . . .	9
gboot_variogram . . . . .	11
NVDI . . . . .	13
soilmoisture . . . . .	14

<b>Index</b>	<b>15</b>
--------------	-----------

---

gboot_block	<i>Block bootstrap</i>
-------------	------------------------

---

## Description

Performs a bootstrap based on subdivision of data in blocks

## Usage

```
gboot_block(data, var, model, B, L1, L2)
```

## Arguments

data	object of the class geodata.
var	object of the class variogram.
model	object of the class variomodel.
B	number of the bootstrap that will be performed (default B=1000).
L1	number of cuts in the vertical (L1xL2 blocks).
L2	number of cuts in the horizontal (L1xL2 blocks).

## Details

The algorithm for the block bootstrap is an adaptation of the time series bootstrap. Consider that your data presents the second order stationarity, so, we can subdivide them into small blocks. The steps of the algorithm are:

1. Subdivide the data into L1xL2 blocks;
2. Reallocate each block with probability  $\frac{1}{L1L2}$  ;
3. Calculate the new variogram from the new data;
4. Calculate and save the statistics of interest;
5. Return to step 2 and repeat the process at least 1000 times.

## Value

**variogram\_boot** gives the variogram of each bootstrap.

**variogram\_or** gives the original variogram.

**pars\_boot** gives the estimatives of the nugget, sill, contribution, range and practical range for each bootstrap.

**pars\_or** gives the original estimatives of the nugget, sill, contribution, range and practical range.

Invalid arguments will return an error message.

**Author(s)**

Diogo Francisco Rossoni <dfrossoni@uem.br>

Vinicius Basseto Felix <felix\_prot@hotmail.com>

**References**

DAVISON, A.C.; HINKLEY, D. V. Bootstrap Methods and their Application. [s.l.] Cambridge University Press, 1997. p. 582

**Examples**

```
# Example 1

## transforming the data.frame in an object of class geodata
data<- as.geodata(soilmoisture)

points(data) ## data visualization

var<- variog(data, max.dist = 140) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(2,80),nugget = 2,cov.model = "sph")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure

boot<- gboot_block(data,var,mod,B=10, L1=2, L2=2)
## For better Confidence Interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot

# Example 2

## transforming the data.frame in an object of class geodata
data<- as.geodata(NVDI)

points(data) ## data visualization

var<- variog(data, max.dist = 18) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(0.003,6),nugget = 0.003,cov.model = "gaus")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure
```

```
boot<- boot<- gboot_block(data,var,mod,B=10, L1=2, L2=2)
## For better Confidence interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot
```

---

gboot\_CI

*Bootstrap Confidence Interval*

---

### Description

Provides a two-sided bootstrap confidence interval.

### Usage

```
gboot_CI(x,alpha=0.05,digits=3)
```

### Arguments

x	object generate by functions <a href="#">gboot_block</a> , <a href="#">gboot_cloud</a> , <a href="#">gboot_cross</a> , <a href="#">gboot_solow</a> , <a href="#">gboot_variogram</a>
alpha	significance level (Default=0.05).
digits	number of decimal places.

### Details

Examples of this function can be found in [gboot\\_block](#), [gboot\\_cloud](#), [gboot\\_cross](#), [gboot\\_solow](#), [gboot\\_variogram](#)

### Value

Invalid arguments will return an error message.

### Author(s)

Diogo Francisco Rossoni <dfrossoni@uem.br>

Vinicius Basseto Felix <felix\_prot@hotmail.com>

---

gboot_cloud	<i>Bootstrap of the variogram cloud</i>
-------------	-----------------------------------------

---

**Description**

Performs a bootstrap based on the variogram cloud

**Usage**

```
gboot_cloud(data, var, model, B)
```

**Arguments**

data	object of the class geodata.
var	object of the class variogram.
model	object of the class variomodel.
B	number of the bootstrap that will be performed (default B=1000).

**Details**

The variogram cloud is computed by the function `variog`. It provides all the possible pairs that will generate the classical variogram. The algorithm performs a classical bootstrap in each lag of the variogram. The steps are:

1. Calculate the variogram cloud;
2. Obtain the number of lags (See details in `variog`: defining the bins);
3. Sample with replacement in each lag;
4. Create a new variogram using the average of all pairs in each lag;
5. Calculate and save the statistics of interest;
6. Return to step 3 and repeat the process at least 1000 times.

**Value**

**variogram\_boot** gives the variogram of each bootstrap.

**variogram\_or** gives the original variogram.

**pars\_boot** gives the estimatives of the nugget, sill, contribution, range and practical range for each bootstrap.

**pars\_or** gives the original estimatives of the nugget, sill, contribution, range and practical range.

Invalid arguments will return an error message.

**Author(s)**

Diogo Francisco Rossoni <dfrossoni@uem.br>

Vinicius Basseto Felix <felix\_prot@hotmail.com>

## Examples

```

# Example 1

## transforming the data.frame in an object of class geodata
data<- as.geodata(soilmoisture)

points(data) ## data visualization

var<- variog(data, max.dist = 140) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(2,80),nugget = 2,cov.model = "sph")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure

boot<- gboot_cloud(data,var,mod,B=10)
## For better Confidence interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot

# Example 2

## transforming the data.frame in an object of class geodata
data<- as.geodata(NVDI)

points(data) ## data visualization

var<- variog(data, max.dist = 18) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(0.003,6),nugget = 0.003,cov.model = "gaus")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure

boot<- gboot_cloud(data,var,mod,B=10)
## For better Confidence interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot

```

**Description**

Performs a bootstrap based on error from the cross-validation

**Usage**

```
gboot_cross(data, var, model, B)
```

**Arguments**

data	object of the class geodata.
var	object of the class variogram.
model	object of the class variomodel.
B	number of the bootstrap that will be performed (default B=1000).

**Details**

We can define the error of prediction by  $\epsilon(s_i) = Z(s_i) - \hat{Z}(s_i)$ , where  $\hat{Z}(s_i)$  are obtained from cross-validation. The steps of the algorithm are:

1. Set  $s_i^* = s_i$ ;
2. Obtain  $\hat{Z}(s_i)$  from  $\hat{Z}(s_i) = \sum_{j \neq i}^{n-1} \lambda_j Z(s_j)$ ;
3. Calculate  $\epsilon(s_i) = Z(s_i) - \hat{Z}(s_i)$
4. Sample with replacement  $\epsilon^*(s_i)$  from  $\epsilon(s_i) - \bar{\epsilon}(s_i)$ ;
5. The new data will be  $Z^*(s_i) = \hat{Z}(s_i) + \epsilon^*(s_i)$ ;
6. Calculate the new variogram;
7. Calculate and save the statistics of interest;
8. Return to step 4 and repeat the process at least 1000 times.

**Value**

**variogram\_boot** gives the variogram of each bootstrap.

**variogram\_or** gives the original variogram.

**pars\_boot** gives the estimatives of the nugget, sill, contribution, range and practical range for each bootstrap.

**pars\_or** gives the original estimatives of the nugget, sill, contribution, range and practical range.

Invalid arguments will return an error message.

**Author(s)**

Diogo Francisco Rossoni <dfrossoni@uem.br>

Vinicius Basseto Felix <felix\_prot@hotmail.com>

## Examples

```
# Example 1

## transforming the data.frame in an object of class geodata
data<- as.geodata(soilmoisture)

points(data) ## data visualization

var<- variog(data, max.dist = 140) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(2,80),nugget = 2,cov.model = "sph")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure

boot<- gboot_cross(data,var,mod,B=10)
## For better Confidence interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot

# Example 2

## transforming the data.frame in an object of class geodata
data<- as.geodata(NVDI)

points(data) ## data visualization

var<- variog(data, max.dist = 18) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(0.003,6),nugget = 0.003,cov.model = "gaus")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure

boot<- gboot_cross(data,var,mod,B=10)
## For better Confidence interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot
```

---

gboot_plot	<i>Bootstrap plot</i>
------------	-----------------------

---

**Description**

A graphic with the original variogram and each of the B bootstrap variograms.

**Usage**

```
gboot_plot(x)
```

**Arguments**

x                    object generate by functions [gboot\\_block](#), [gboot\\_cloud](#), [gboot\\_cross](#), [gboot\\_solow](#), [gboot\\_variogram](#)

**Details**

Examples of this function can be found in [gboot\\_block](#), [gboot\\_cloud](#), [gboot\\_cross](#), [gboot\\_solow](#), [gboot\\_variogram](#)

**Value**

Invalid arguments will return an error message.

**Author(s)**

Diogo Francisco Rossoni <dfrossoni@uem.br>  
Vinicius Basseto Felix <felix\_prot@hotmail.com>

---

gboot_solow	<i>Solow bootstrap</i>
-------------	------------------------

---

**Description**

Performs a spatial bootstrap proposed by Solow(1985).

**Usage**

```
gboot_solow(data, var, model, B)
```

**Arguments**

data                object of the class geodata.  
var                 object of the class variogram.  
model               object of the class variomodel.  
B                    number of the bootstrap that will be performed (default B=1000).

## Details

The basic idea involves transforming correlated observation to uncorrelated quantities, forming a bootstrap sample from these quantities, and transforming back to a bootstrap sample from the original observations (SOLOW, 1985). Suppose that  $Z_n$  is an  $n$  vector of observations from a realization of a second-order stationary random process,  $Z(s_i)$ , and the covariance matrix for  $Z_n$  is  $C$ . Suppose further that  $E(Z_n) = 0_n$ , where  $0_n$  is an  $n$  vector of zeroes. In practice  $Z_n$  can be centered by subtracting an estimate of the stationary mean from each observation. So, the steps of the algorithm are:

1. Obtain  $C$ ;
2. Apply the Cholesky decomposition in  $C$ , obtaining  $C = LL^t$ , where  $L$  is lower triangular;
3. Obtain  $U_n = L^{-1}Z_n$ ;
4. Sample with replacement  $U^*_n$  from  $U_n - \bar{U}_n$ ;
5. The new data will be  $Z^*_n = LU^*_n$ ;
6. Calculate the new variogram;
7. Calculate and save the statistics of interest;
8. Return to step 4 and repeat the process at least 1000 times.

## Value

**variogram\_boot** gives the variogram of each bootstrap.

**variogram\_or** gives the original variogram.

**pars\_boot** gives the estimatives of the nugget, sill, contribution, range and practical range for each bootstrap.

**pars\_or** gives the original estimatives of the nugget, sill, contribution, range and practical range.

Invalid arguments will return an error message.

## Author(s)

Diogo Francisco Rossoni <dfrossoni@uem.br>

Vinicius Basseto Felix <felix\_prot@hotmail.com>

## References

Solow, A. R. (1985). Bootstrapping correlated data. *Journal of the International Association for Mathematical Geology*, 17(7), 769-775. <https://doi.org/10.1007/BF01031616>

## Examples

```
# Example 1

## transforming the data.frame in an object of class geodata
data<- as.geodata(soilmoisture)

points(data) ## data visualization
```

```

var<- variog(data, max.dist = 140) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(2,80),nugget = 2,cov.model = "sph")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure

boot<- gboot_solow(data,var,mod,B=10)
## For better Confidence interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot

# Example 2

## transforming the data.frame in an object of class geodata
data<- as.geodata(NVDI)

points(data) ## data visualization

var<- variog(data, max.dist = 18) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(0.003,6),nugget = 0.003,cov.model = "gaus")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure

boot<- gboot_solow(data,var,mod,B=10)
## For better Confidence interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot

```

---

gboot\_variogram

*Variogram bootstrap*


---

### Description

Perform a bootstrap based on error from the fitted model of the variogram.

### Usage

```
gboot_variogram(data,var,model,B)
```

**Arguments**

<code>data</code>	object of the class <code>geodata</code> .
<code>var</code>	object of the class <code>variogram</code> .
<code>model</code>	object of the class <code>variomodel</code> .
<code>B</code>	number of the bootstrap that will be performed (default <code>B=1000</code> ).

**Details**

The algorithm for the bootstrap variogram is the same presented for Davison and Hinkley (1997) for the non linear regression. We can write the variogram as  $\hat{\gamma}(h) = \gamma_{mod}(h) + \epsilon$ , where  $\gamma_{mod}(h)$  is the fitted model. The steps of the algorithm are:

1. Set  $h^* = h$ ;
2. Sample with replacement  $\epsilon^*$  from  $\epsilon - \bar{\epsilon}$ ;
3. The new variogram will be  $\gamma^*(h^*) = \gamma_{mod}(h) + \epsilon^*$ ;
4. Calculate and save the statistics of interest;
5. Return to step 2 and repeat the process at least 1000 times.

**Value**

**`variogram_boot`** gives the variogram of each bootstrap.

**`variogram_or`** gives the original variogram.

**`pars_boot`** gives the estimatives of the nugget, sill, contribution, range and practical range for each bootstrap.

**`pars_or`** gives the original estimatives of the nugget, sill, contribution, range and practical range.

Invalid arguments will return an error message.

**Author(s)**

Diogo Francisco Rossoni <dfrossoni@uem.br>

Vinicius Basseto Felix <felix\_prot@hotmail.com>

**References**

DAVISON, A.C.; HINKLEY, D. V. Bootstrap Methods and their Application. [s.l.] Cambridge University Press, 1997. p. 582

**Examples**

```
# Example 1

## transforming the data.frame in an object of class geodata
data<- as.geodata(soilmoisture)

points(data) ## data visualization
```

```

var<- variog(data, max.dist = 140) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(2,80),nugget = 2,cov.model = "sph")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure

boot<- gboot_variogram(data,var,mod,B=10)
## For better Confidence interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot

# Example 2

## transforming the data.frame in an object of class geodata
data<- as.geodata(NVDI)

points(data) ## data visualization

var<- variog(data, max.dist = 18) ## Obtaining the variogram
plot(var)

## Fitting the model
mod<- variofit(var,ini.cov.pars = c(0.003,6),nugget = 0.003,cov.model = "gaus")
lines(mod, col=2, lwd=2) ##fitted model

## Bootstrap procedure

boot<- gboot_variogram(data,var,mod,B=10)
## For better Confidence interval, try B=1000

gboot_CI(boot,digits = 4) ## Bootstrap Confidence Interval

gboot_plot(boot) ## Bootstrap Variogram plot

```

### Description

Field experiment, realized in CTI (Tecnical Center of Irrigation), in an area of 3 m x 24 m, with 88 observations in a regular grid.

**Usage**

```
data(soilmoisture)
```

**Format**

An object of class data.frame

**Details**

- **x** a vector containing the sample locations(in cm) in the horizontal.
- **y** a vector containing the sample locations(in cm) in the vertical.
- **z** a vector containing the value of normalized difference vegetation index (NDVI).

**References**

HARA. A. T., GONÇALVES, A. C. A. Temporal stability of the spatial pattern of water storage in the soil at different spatial scales. (Doctoral thesis). Retrieved from url <http://www.pga.uem.br/dissertacao-tese/710>

---

soilmoisture

*Soil moisture experiment*

---

**Description**

Field experiment, realized in CTI (Technical Center of Irrigation), in an area of 350 cm x 150 cm, with 355 observations in a regular grid.

**Usage**

```
data(soilmoisture)
```

**Format**

An object of class data.frame

**Details**

- **x** a vector containing the sample locations(in cm) in the horizontal.
- **y** a vector containing the sample locations(in cm) in the vertical.
- **z** a vector containing the value of soil moisture in percents.

**References**

HARA. A. T., GONÇALVES, A. C. A. Temporal stability of the spatial pattern of water storage in the soil at different spatial scales. (Doctoral thesis). Retrieved from url <http://www.pga.uem.br/dissertacao-tese/710>

# Index

- \* **Block**
    - gboot\_block, 2
  - \* **Bootstrap**
    - gboot\_block, 2
    - gboot\_CI, 4
    - gboot\_cloud, 5
    - gboot\_cross, 6
    - gboot\_solow, 9
    - gboot\_variogram, 11
  - \* **CI**
    - gboot\_CI, 4
  - \* **Cloud**
    - gboot\_cloud, 5
  - \* **Cross-validation**
    - gboot\_cross, 6
  - \* **Solow**
    - gboot\_solow, 9
  - \* **Spatial**
    - gboot\_block, 2
    - gboot\_cloud, 5
    - gboot\_cross, 6
    - gboot\_solow, 9
    - gboot\_variogram, 11
  - \* **Variogram**
    - gboot\_cloud, 5
    - gboot\_variogram, 11
  - \* **datasets**
    - NVDI, 13
    - soilmoisture, 14
- gboot\_block, 2, 4, 9  
gboot\_CI, 4  
gboot\_cloud, 4, 5, 9  
gboot\_cross, 4, 6, 9  
gboot\_plot, 9  
gboot\_solow, 4, 9, 9  
gboot\_variogram, 4, 9, 11
- NVDI, 13
- soilmoisture, 14  
variog, 5