

# Package ‘gcKrig’

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**Type** Package

**Title** Analysis of Geostatistical Count Data using Gaussian Copulas

**Version** 1.1.8

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**Description** Provides a variety of functions to analyze and model geostatistical count data with Gaussian copulas, including

- 1) data simulation and visualization;
- 2) correlation structure assessment (here also known as the Normal To Anything);
- 3) calculate multivariate normal rectangle probabilities;
- 4) likelihood inference and parallel prediction at predictive locations.

Description of the method is available from: Han and DeOliveira (2018) <[doi:10.18637/jss.v087.i13](https://doi.org/10.18637/jss.v087.i13)>.

**License** GPL (>= 2)

**LazyData** TRUE

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**Imports** Rcpp (>= 0.12.0)

**LinkingTo** Rcpp, RcppArmadillo

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AtlanticFish

*Dataset of Mid-Atlantic Highlands Fish*

---

### Description

This dataset was studied by Johnson and Hoeting (2011) for analyzing pollution tolerance in Mid-Atlantic Highlands Fish. Pollution intolerant fish were sampled, and several stream characteristics were measured to assess water quality at 119 sites in the Mid-Atlantic region of the United States. All covariates of the data had been standardized to have mean 0 and variance 1.

### Usage

`data(AtlanticFish)`

**Format**

A data frame with 119 observations and 12 variables.

LON Longitude of the location.

LAT Latitude of the location.

ABUND Fish abundance at given locations, the discrete response.

ORDER Strahler stream order, a natural covariate measuring stream size.

DISTOT Watershed classified as disturbed by human activity, a variable reflecting stream quality.

HAB An index of fish habitat quality at the stream site, a variable reflecting stream quality.

WSA Watershed area, a natural covariate.

ELEV Elevation.

RD Road density in the watershed, a variable reflecting stream quality.

DO Concentration of dissolved oxygen in the stream at the sampling site, a stream quality variable.

XFC Percent of areal fish cover at the sampling site, a stream quality variable.

PCT Percent of sand in streambed substrate, a stream quality variable.

**References**

Johnson, D. and Hoeting, J. (2011) Bayesian Multimodel Inference for Geostatistical Regression Models, *PLOS ONE*, 6:e25677. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0025677>.

**Examples**

```
data(AtlanticFish)
str(AtlanticFish)
```

---

beta.gc

*The Beta Marginal of Class* [marginal.gc](#)

---

**Description**

The Beta marginal used for simulation and computing correlation in the trans-Gaussian random field in function `simgc` and `corrTG` of the package `gcKrig`. It cannot be used in function `mlegc` nor `predgc` to make model inferences.

**Usage**

```
beta.gc(shape1 = 1, shape2 = 1)
```

**Arguments**

shape1 non-negative scalar, the shape parameter of the Beta distribution.  
shape2 non-negative scalar, another shape parameter of the Beta distribution.

**Details**

The Beta distribution with parameters shape1 = a and shape2 = b has density

$$\frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)}x^{a-1}(1-x)^{b-1}$$

for  $a > 0, b > 0$  and  $0 \leq x \leq 1$  where the boundary values at  $x = 0$  or  $x = 1$  are defined as by continuity (as limits).

**Value**

An object of class `marginal.gc` representing the marginal component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[marginal.gc](#), [binomial.gc](#), [gm.gc](#), [gaussian.gc](#), [negbin.gc](#), [poisson.gc](#), [weibull.gc](#), [zip.gc](#)

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binomial.gc

*The Binomial Marginal of Class `marginal.gc`*

---

**Description**

The binomial marginal parameterized in terms of its size and probability.

By default, this function is used for likelihood inference and spatial prediction in function `mlegc` and `predgc` of the package `gcKrig`. When all marginal parameters are given, the function is used for simulation and computing correlation in a trans-Gaussian random field in function `simgc` and `corrTG`.

**Usage**

```
binomial.gc(link = "logit", size = NULL, prob = NULL)
```

**Arguments**

<code>link</code>	the model link function.
<code>size</code>	number of trials (zero or more).
<code>prob</code>	probability of success on each trial.

**Value**

An object of class `marginal.gc` representing the marginal component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[marginal.gc](#), [beta.gc](#), [gm.gc](#), [gaussian.gc](#), [negbin.gc](#), [poisson.gc](#), [weibull.gc](#), [zip.gc](#)

---

corr.gc

*Spatial Correlation Functions for Simulation, Likelihood Inference and Spatial Prediction in Gaussian Copula Models with Geostatistical Count Data*

---

**Description**

Class of isotropic correlation functions available in the gcKrig library.

**Details**

By default, range parameter is not provided, so this function is used for likelihood inference and spatial prediction with function `mlegc` and `predgc`. Users need to specify if the correlation model includes a nugget effect `nugget = TRUE` or not `nugget = FALSE`. For Matern and powered exponential correlation functions, the shape parameter `kappa` is also required from users.

When both range and nugget parameters are given, the function is used to specify the correlation structure in simulation with function `simgc` in package `gcKrig`.

**Value**

At the moment, the following three correlation functins are implemented:

<a href="#">matern.gc</a>	the Matern correlation function.
<a href="#">powerexp.gc</a>	the powered exponential correlation function.
<a href="#">spherical.gc</a>	the spherical correlation function.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

De Oliveira, V. (2013) Hierarchical Poisson models for spatial count data. *Journal of Multivariate Analysis*, 122:393-408.

Han, Z. and De Oliveira, V. (2018) gcKrig: An R Package for the Analysis of Geostatistical Count Data Using Gaussian Copulas. *Journal of Statistical Software*, 87(13), 1–32. doi: [10.18637/jss.v087.i13](https://doi.org/10.18637/jss.v087.i13).

**See Also**

[matern.gc](#), [powerexp.gc](#), [spherical.gc](#)

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 corrTG

---

*Compute the Correlation in Transformed Gaussian Random Fields*


---

**Description**

This function implements two general methods for computing the correlation function in a transformed Gaussian random field.

**Usage**

```
corrTG(marg1, marg2, corrGauss = 0.5, method = "integral", nrep = 1000,
       kmax = 10, earlystop = FALSE, epscut = 1e-3)
```

**Arguments**

marg1	an object of class <a href="#">marginal.gc</a> specifying the first marginal distribution.
marg2	an object of class <a href="#">marginal.gc</a> specifying the second marginal distribution.
corrGauss	the correlation in the Gaussian random field. Should be a scalar between 0 and 1.
method	the computation method of calculating correlation in the transformed Gaussian random field. Can be either "integral" or "mc". If use "integral" then a series expansion based on the Hermite Polynomials will be used to approximate the correlation, see De Oliveira (2013) or Han and De Oliveira (2016). If use "mc" then the Monte Carlo method will be used.
nrep	the Monte Carlo size in computing the correlation. Only need to be specified if method = "mc".
kmax	the maximum number of terms used in the series summation (with Hermite polynomial expansion). Only need to be specified if method = "integral".
earlystop	whether or not to allow the series summation to stop early. If earlystop = FALSE then a total number of kmax terms will be kept. If earlystop = TRUE then the series will be automatically truncated if the absolute values of the three consecutive terms are smaller than epscut.
epscut	a small positive value used to truncate the series.

**Value**

If method = "mc" the output is a scalar between 0 and 1, denoting the correlation of the transformed Gaussian random field. If method = "integral" the output is a scalar of the correlation in the transformed Gaussian random field, and a list of the values in the series expansion based on the integral with Hermite polynomials.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

De Oliveira, V. (2013) Hierarchical Poisson models for spatial count data. *Journal of Multivariate Analysis*, 122:393-408.

Han, Z. and De Oliveira, V. (2016) On the correlation structure of Gaussian copula models for geostatistical count data. *Australian and New Zealand Journal of Statistics*, 58:47-69.

Han, Z. and De Oliveira, V. (2018) gcKrig: An R Package for the Analysis of Geostatistical Count Data Using Gaussian Copulas. *Journal of Statistical Software*, 87(13), 1–32. doi: [10.18637/jss.v087.i13](https://doi.org/10.18637/jss.v087.i13).

**Examples**

```
## Not run:
corrTG(marg1 = poisson.gc(lambda = 10), marg2 = binomial.gc(size = 1, prob = 0.1),
       corrGauss = 0.5, method = "integral", kmax = 10, earlystop = TRUE, epscut = 1e-5)
set.seed(12345)
corrTG(marg1 = poisson.gc(lambda = 10), marg2 = binomial.gc(size = 1, prob = 0.1),
       corrGauss = 0.5, nrep = 100000, method = "mc")

## End(Not run)
```

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FHUBdiscrete

*Compute the Frechet Hoeffding Upper Bound for Given Discrete Marginal Distributions*

---

**Description**

This function implemented the method of computing the Frechet Hoeffding upper bound for discrete marginals described in Nelsen (1987), which can only be applied to discrete marginals. Four commonly used marginal distributions were implemented. The distribution "nb" (negative binomial) and "zip" (zero-inflated Poisson) are parameterized in terms of the mean and overdispersion, see Han and De Oliveira (2016).

**Usage**

```
FHUBdiscrete(marg1, marg2, mu1, mu2, od1 = 0, od2 = 0, binomial.size1 = 1,
             binomial.size2 = 1)
```

**Arguments**

**marg1** name of the first discrete marginal distribution. Should be one of the "poisson", "zip", "nb" or "binomial".

**marg2** name of the second discrete marginal distribution. Should be one of the "poisson", "zip", "nb" or "binomial".

mu1	mean of the first marginal distribution. If binomial then it is $n_1p_1$ .
mu2	mean of the second marginal distribution. If binomial then it is $n_2p_2$ .
od1	the overdispersion parameter of the first marginal. Only used when marginal distribution is either "zip" or "nb".
od2	the overdispersion parameter of the second marginal. Only used when marginal distribution is either "zip" or "nb".
binomial.size1	the size parameter (number of trials) when marg1 = "binomial".
binomial.size2	the size parameter (number of trials) when marg2 = "binomial".

### Value

A scalar denoting the Frechet Hoeffding upper bound of the two specified marginal.

### Author(s)

Zifei Han <hanzifei1@gmail.com>

### References

- Nelsen, R. (1987) Discrete bivariate distributions with given marginals and correlation. *Communications in Statistics Simulation and Computation*, 16:199-208.
- Han, Z. and De Oliveira, V. (2016) On the correlation structure of Gaussian copula models for geostatistical count data. *Australian and New Zealand Journal of Statistics*, 58:47-69.
- Han, Z. and De Oliveira, V. (2018) gcKrig: An R Package for the Analysis of Geostatistical Count Data Using Gaussian Copulas. *Journal of Statistical Software*, **87**(13), 1–32. doi: [10.18637/jss.v087.i13](https://doi.org/10.18637/jss.v087.i13).

### Examples

```
## Not run:

FHUBdiscrete(marg1 = 'nb', marg2 = 'zip', mu1 = 10, mu2 = 2, od1 = 2, od2 = 0.2)
FHUBdiscrete(marg1 = 'binomial', marg2 = 'zip', mu1 = 10, mu2 = 4, binomial.size1 = 25, od2 = 2)
FHUBdiscrete(marg1 = 'binomial', marg2 = 'poisson', mu1 = 0.3, mu2 = 20, binomial.size1 = 1)

NBmu = seq(0.01, 30, by = 0.02)
fhub <- c()
for(i in 1:length(NBmu)){
  fhub[i] = FHUBdiscrete(marg1 = 'nb', marg2 = 'nb', mu1 = 10, mu2 = NBmu[i], od1 = 0.2, od2 = 0.2)
}
plot(NBmu, fhub, type='l')

## End(Not run)
```



---

`gaussian.gc`*The Gaussian Marginal of Class `marginal.gc`*

---

**Description**

The Gaussian marginal used for simulation and computing correlation in the trans-Gaussian random field in function `simgc` and `corrTG` of the package `gcKrig`. It cannot be used in function `mlegc` nor `predgc` to make model inferences.

**Usage**

```
gaussian.gc(mean = 0, sd = 1)
```

**Arguments**

<code>mean</code>	the mean of the Gaussian distribution, a scalar.
<code>sd</code>	a positive scalar, the standard deviation of the Gaussian distribution.

**Value**

An object of class `marginal.gc` representing the marginal component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[marginal.gc](#), [beta.gc](#), [binomial.gc](#), [gm.gc](#), [negbin.gc](#), [poisson.gc](#), [weibull.gc](#), [zip.gc](#)

---

`gm.gc`*The Gamma Marginal of Class `marginal.gc`*

---

**Description**

The Gamma marginal used for simulation and computing correlation in the trans-Gaussian random field in functions `simgc` and `corrTG` of the package `gcKrig`. It cannot be used in functions `mlegc` nor `predgc` to make model inferences.

**Usage**

```
gm.gc(shape = 1, rate = 1)
```

**Arguments**

<code>shape</code>	a non-negative scalar, shape parameter of the Gamma distribution.
<code>rate</code>	a non-negative scalar, rate parameter of the Gamma distribution.

**Details**

The Gamma distribution with parameters shape = a and rate = r has density

$$\frac{r^a}{\Gamma(a)} x^{a-1} \exp(-rx)$$

for  $x \geq 0$ ,  $a > 0$  and  $s > 0$ .

**Value**

An object of class `marginal.gc` representing the marginal component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[marginal.gc](#), [beta.gc](#), [binomial.gc](#), [gaussian.gc](#), [negbin.gc](#), [poisson.gc](#), [weibull.gc](#), [zip.gc](#)

---

LansingTrees

*Locations and Botanical Classification of Trees in Lansing Woods*

---

**Description**

The data is aggregated from the dataset `lansing` in library `spatstat`, which came from an investigation of a 924 ft x 924 ft (19.6 acres) plot in Lansing Woods, Clinton County, Michigan USA by D.J. Gerrard. The original point process data described the locations of 2,251 trees and their botanical classification (into maples, hickories, black oaks, red oaks, white oaks and miscellaneous trees). The original plot size has been rescaled to the unit square and the number of different types of trees has been counted within squares of length 1/16.

**Usage**

```
data(LansingTrees)
```

**Format**

A data frame with 256 observations and 8 variables.

`Easting` Cartesian x-coordinate of the locations.

`Northing` Cartesian y-coordinate of the locations.

`maple` Number of maples in the area.

`hickory` Number of hickories in the area.

`blackoak` Number of black oaks in the area.

`redoak` Number of red oaks in the area.

`whiteoak` Number of white oaks in the area.

`misc` Number of miscellaneous trees in the area.

## References

Kazianka, H. (2013) Approximate copula-based estimation and prediction of discrete spatial data. *Stoch Environ Res Risk Assess*, 27:2015-2026

## Examples

```
data(LansingTrees)
str(LansingTrees)
```

---

marginal.gc

*Marginals for Data Simulation, Correlation Assessment, Likelihood Inference and Spatial Prediction in Gaussian Copula Models for Geostatistical Data*

---

## Description

Class of marginals available in gcKrig library for geostatistical data simulation, correlation structure assessment (both continuous and discrete marginals) and model inferences (discrete marginals only). In former cases parameters of the marginals are given by users, otherwise parameters are estimated from the data (except when doing prediction with function predgc, users can choose to either input known estimates or estimate the parameters with input data).

## Details

The package gcKrig does not include inference and prediction functionalities for continuous marginals. For inference with continuous marginals, see Masarotto and Varin (2012).

By default, when the marginals are discrete, they are used for estimation with function mlegc and prediction with function predgc. They can be used in function simgc and corrTG as well for the purpose of data simulation and correlation computation in a transformed Gaussian random field (Han and De Oliveira, 2016), if parameter values are specified.

For continuous marginals, they are used for simulation with function simgc and correlation computation with corrTG only, so parameters should always be specified.

## Value

At the moment, the following marginals are implemented:

<a href="#">beta.gc</a>	beta marginals.
<a href="#">binomial.gc</a>	binomial marginals.
<a href="#">gm.gc</a>	gamma marginals.
<a href="#">gaussian.gc</a>	Gaussian marginals.
<a href="#">negbin.gc</a>	negative binomial marginals.
<a href="#">poisson.gc</a>	Poisson marginals.
<a href="#">weibull.gc</a>	Weibull marginals.
<a href="#">zip.gc</a>	zero-inflated Poisson marginals.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

- Cribari-Neto, F. and Zeileis, A. (2010) Beta regression in R. *Journal of Statistical Software*, **34**(2), 1–24. doi: [10.18637/jss.v034.i02](https://doi.org/10.18637/jss.v034.i02).
- Ferrari, S.L.P. and Cribari-Neto, F. (2004) Beta regression for modeling rates and proportions. *Journal of Applied Statistics*, **31**:799-815.
- Han, Z. and De Oliveira, V. (2016) On the correlation structure of Gaussian copula models for geostatistical count data. *Australian and New Zealand Journal of Statistics*, **58**:47-69.
- Masarotto, G. and Varin, C. (2012) Gaussian copula marginal regression. *Electronic Journal of Statistics*, **6**:1517-1549.
- Masarotto, G. and Varin C. (2017) Gaussian Copula Regression in R. *Journal of Statistical Software*, **77**(8), 1–26. doi: [10.18637/jss.v077.i08](https://doi.org/10.18637/jss.v077.i08).
- Han, Z. and De Oliveira, V. (2018) gcKrig: An R Package for the Analysis of Geostatistical Count Data Using Gaussian Copulas. *Journal of Statistical Software*, **87**(13), 1–32. doi: [10.18637/jss.v087.i13](https://doi.org/10.18637/jss.v087.i13).

**See Also**

[beta.gc](#), [binomial.gc](#), [gm.gc](#), [gaussian.gc](#), [negbin.gc](#), [poisson.gc](#), [weibull.gc](#), [zip.gc](#)

---

matern.gc

*The Matern Correlation Function of Class* [corr.gc](#)

---

**Description**

The Matern correlation function in spatial statistics.

By default, range parameter is not available, so this function is used for likelihood inference and spatial prediction in function `mlegc` and `predgc`. Users need to specify the shape parameter `kappa` and if the correlation model includes a nugget effect `nugget = TRUE` or not `nugget = FALSE`.

When both range and nugget parameters are given, the function is used for simulation with function `simgc` in package `gcKrig`.

**Usage**

```
matern.gc(range = NULL, kappa = 0.5, nugget = TRUE)
```

**Arguments**

range	a non-negative scalar of the range parameter in Matern correlation function.
kappa	a non-negative scalar of the shape parameter in the Matern correlation function. The default <code>kappa = 0.5</code> corresponds to an exponential correlation model.
nugget	the nugget effect of the correlation function. If specified, it must be a scalar between 0 and 1.

**Details**

The Matern correlation function with a nugget  $\tau^2$  is of the form:

$$\rho(h) = \frac{1 - \tau^2}{2^{\kappa-1}\Gamma(\kappa)} \left(\frac{h}{\phi}\right)^{\kappa} K_{\kappa}\left(\frac{h}{\phi}\right)$$

when  $h > 0$  and  $\rho(h) = 1$  when  $h = 0$ . Here  $\phi$  is range parameter,  $\kappa$  is the shape parameter and  $\tau^2$  is the nugget parameter.  $K_{\kappa}(\cdot)$  denotes the modified Bessel function of the third kind of order  $\kappa$ .

**Value**

An object of class `corr.gc` representing the correlation component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

Diggle, P. and Ribeiro, P.J. (2007) Model-based Geostatistics. *Springer*.

**See Also**

[powerexp.gc](#), [spherical.gc](#)

---

mlegc

*Maximum Likelihood Estimation in Gaussian Copula Models for Geostatistical Count Data*

---

**Description**

Computes the maximum likelihood estimates. Two methods are implemented. If `method = 'GHK'` then the maximum simulated likelihood estimates are computed, if `method = 'GQT'` then the maximum surrogate likelihood estimates are computed.

**Usage**

```
mlegc(y, x = NULL, locs, marginal, corr, effort = 1, longlat = FALSE,
      distscale = 1, method = "GHK", corrpars = NULL, ghkoptions = list(nrep
      = c(100, 1000), reorder = FALSE, seed = 12345))
```

**Arguments**

<code>y</code>	a non-negative integer vector of response with its length equals to the number of sampling locations.
<code>x</code>	a numeric matrix or data frame of covariates, with its number of rows equals to the number of sampling locations. If no covariates then <code>x = NULL</code> .
<code>locs</code>	a numeric matrix or data frame of $n$ - $D$ points with row denoting points. The first column is <code>x</code> or longitude, the second column is <code>y</code> or latitude. The number of locations is equal to the number of rows.
<code>marginal</code>	an object of class <code>marginal.gc</code> specifying the marginal distribution.
<code>corr</code>	an object of class <code>corr.gc</code> specifying the correlation function.
<code>effort</code>	the sampling effort. For binomial marginal it is the size parameter (number of trials). See details.
<code>longlat</code>	if <code>FALSE</code> , use Euclidean distance, if <code>TRUE</code> use great circle distance. The default is <code>FALSE</code> .
<code>distscale</code>	a numeric scaling factor for computing distance. If original distance is in kilometers, then <code>distscale = 1000</code> will convert it to meters.
<code>method</code>	two methods are implemented. If <code>method = 'GHK'</code> then the maximum simulated likelihood estimates are computed, if <code>method = 'GQT'</code> then the maximum surrogate likelihood estimates are computed.
<code>corrpar0</code>	the starting value of correlation parameter in the optimization procedure. If <code>corrpar0 = NULL</code> then initial range is set to be half of the median distance in distance matrix and initial nugget (if <code>nugget = TRUE</code> ) is 0.2.
<code>ghkoptions</code>	a list of three elements that only need to be specified if <code>method = 'GHK'</code> . <code>nrep</code> is the Monte Carlo size of the importance sampling algorithm for likelihood approximation. It can be a vector with increasing positive integers so that the model is fitted with a sequence of different Monte Carlo sizes, and the starting values for optimization are taken from the previous fitting. The default value is 100 for the first optimization and 1000 for the second and definitive optimization. <code>reorder</code> indicates whether the integral will be reordered every iteration in computation according to the algorithm in Gibson, etal (1994), default is <code>FALSE</code> . <code>seed</code> is the seed of the pseudorandom generator used in Monte Carlo simulation.

**Details**

This program implemented one simulated likelihood method via sequential importance sampling (see Masarotto and Varin 2012), which is same as the method implemented in package `gcmr` (Masarotto and Varin 2016) except an antithetic variable is used. It also implemented one surrogate likelihood method via distributional transform (see Kazianka and Pilz 2010), which is generally faster.

The argument `effort` is the sampling effort (known). It can be used to consider the heterogeneity of the measurement time or area at different locations. The default is 1 for all locations. See Han and De Oliveira (2016) for more details.

**Value**

A list of class "mlegc" with the following elements:

MLE	the maximum likelihood estimate.
x	the design matrix.
nug	1 if nugget = TRUE, 0 if nugget = FALSE.
nreg	number of regression parameters.
log.lik	the value of the maximum log-likelihood.
AIC	the Akaike information criterion.
AICc	the AICc information criterion; essentially AIC with a greater penalty for extra parameters.
BIC	the Bayesian information criterion.
kmarg	number of marginal parameters.
par.df	number of parameters.
N	number of observations.
D	the distance matrix.
optlb	lower bound in optimization.
optub	upper bound in optimization.
hessian	the hessian matrix evaluated at the final estimates.
args	arguments passed in function evaluation.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

- Han, Z. and De Oliveira, V. (2016) On the correlation structure of Gaussian copula models for geostatistical count data. *Australian and New Zealand Journal of Statistics*, 58:47-69.
- Kazianka, H. and Pilz, J. (2010) Copula-based geostatistical modeling of continuous and discrete data including covariates. *Stoch Environ Res Risk Assess* 24:661-673.
- Masarotto, G. and Varin, C. (2012) Gaussian copula marginal regression. *Electronic Journal of Statistics* 6:1517-1549. <https://projecteuclid.org/euclid.ejs/1346421603>.
- Masarotto, G. and Varin C. (2017). Gaussian Copula Regression in R. *Journal of Statistical Software*, 77(8), 1–26. doi: [10.18637/jss.v077.i08](https://doi.org/10.18637/jss.v077.i08).
- Han, Z. and De Oliveira, V. (2018) gcKrig: An R Package for the Analysis of Geostatistical Count Data Using Gaussian Copulas. *Journal of Statistical Software*, 87(13), 1–32. doi: [10.18637/jss.v087.i13](https://doi.org/10.18637/jss.v087.i13).

**See Also**

[gcmr](#)

**Examples**

```

## Not run:
## Fit a Simulated Dataset with 100 locations
grid <- seq(0.05, 0.95, by = 0.1)
xloc <- expand.grid(x = grid, y = grid)[,1]
yloc <- expand.grid(x = grid, y = grid)[,2]

set.seed(123)
simData1 <- simgc(locs = cbind(xloc,yloc), sim.n = 1,
                 marginal = negbin.gc(mu = exp(1+xloc), od = 1),
                 corr = matern.gc(range = 0.4, kappa = 0.5, nugget = 0))

simFit1 <- mlegc(y = simData1$data, x = xloc, locs = cbind(xloc,yloc),
               marginal = negbin.gc(link = 'log'),
               corr = matern.gc(kappa = 0.5, nugget = FALSE), method = 'GHK')

simFit2 <- mlegc(y = simData1$data, x = xloc, locs = cbind(xloc,yloc),
               marginal = negbin.gc(link = 'log'),
               corr = matern.gc(kappa = 0.5, nugget = FALSE), method = 'GQT')
#summary(simFit1);summary(simFit2)
#plot(simFit1);plot(simFit2)

## Time consuming examples
## Fit a real dataset with 70 sampling locations.
data(Weed95)
weedobs <- Weed95[Weed95$dummy==1, ]
weedpred <- Weed95[Weed95$dummy==0, ]
Weedfit1 <- mlegc(y = weedobs$weedcount, x = weedobs[,4:5], locs = weedobs[,1:2],
                marginal = poisson.gc(link='log'),
                corr = matern.gc(kappa = 0.5, nugget = TRUE),
                method = 'GHK')

summary(Weedfit1)
plot(Weedfit1)

## Fit a real dataset with 256 locations
data(LansingTrees)
Treefit1 <- mlegc(y = LansingTrees[,3], x = LansingTrees[,4], locs = LansingTrees[,1:2],
                 marginal = negbin.gc(link = 'log'),
                 corr = matern.gc(kappa = 0.5, nugget = FALSE), method = 'GHK')

summary(Treefit1)
plot(Treefit1)

# Try to use GQT method
Treefit2<- mlegc(y = LansingTrees[,3], x = LansingTrees[,4],
                locs = LansingTrees[,1:2], marginal = poisson.gc(link='log'),
                corr = matern.gc(kappa = 0.5, nugget = TRUE), method = 'GQT')

summary(Treefit2)
plot(Treefit2)

```



```

## Fit a real dataset with randomized locations
data(AtlanticFish)
Fitfish <- mlegc(y = AtlanticFish[,3], x = AtlanticFish[,4:6], locs = AtlanticFish[,1:2],
               longlat = TRUE, marginal = negbin.gc(link='log'),
               corr = matern.gc(kappa = 0.5, nugget = TRUE), method = 'GHK')
summary(Fitfish)

## Fit a real dataset with binomial counts; see Masarotto and Varin (2016).
library(gcmr)
data(malaria)
malariax <- data.frame(netuse = malaria$netuse,
                      green = malaria$green/100,
                      phc = malaria$phc)
Fitmalaria <- mlegc(y = malaria$cases, x = malariax, locs = malaria[,1:2],
                  marginal = binomial.gc(link='logit'), corrpars = 1.5,
                  corr = matern.gc(kappa = 0.5, nugget = FALSE),
                  distscale = 0.001, effort = malaria$size, method = 'GHK')
summary(Fitmalaria)

## Fit a real spatial binary dataset with 333 locations using probit link
data(OilWell)
Oilest1 <- mlegc(y = OilWell[,3], x = NULL, locs = OilWell[,1:2],
               marginal = binomial.gc(link = 'probit'),
               corr = matern.gc(nugget = TRUE), method = 'GHK')
summary(Oilest1)
plot(Oilest1, col = 2)

## End(Not run)

```

---

mvnintGHK

*Computing Multivariate Normal Rectangle Probability*


---

## Description

Computes the multivariate normal rectangle probability for arbitrary limits and covariance matrices using (reordered) sequential importance sampling.

## Usage

```

mvnintGHK(mean, sigma, lower, upper, nrep = 5000, log = TRUE,
          reorder = TRUE)

```

**Arguments**

mean	the numeric vector of mean of length n.
sigma	the covariance matrix of dimension n.
lower	the numeric vector of lower limits of length n.
upper	the numeric vector of upper limits of length n.
nrep	a positive integer of Monte Carlo size.
log	if TRUE then return the log of the probability. If FALSE return the probability.
reorder	if TRUE then variable reordering algorithm is applied. If FALSE then original ordering is used.

**Details**

This program implemented the Geweke-Hajivassiliou-Keane simulator of computing the multivariate normal rectangle probability. For more details see Keane (1994). Also a variable reordering algorithm in Gibson, etal (1994) was implemented.

Note that both  $-\text{Inf}$  and  $\text{Inf}$  may be specified in lower and upper.

**Value**

A list of the following two components:

value	the value of the integral. If log = TRUE then output the log of the integral.
error	the Monte Carlo standard deviation.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

Gibson GJ., Glasbey CA. and Elston DA. (1994) Monte Carlo evaluation of multivariate normal integrals and sensitivity to variate ordering. *Advances in Numerical Methods and Applications, World Scientific Publishing, River Edge.*

Keane, M. (1994) A computationally practical simulation estimator for panel data. *Econometrica*, 62:95-116.

**See Also**

[pmvnorm](#)

**Examples**

```
mvnintGHK(mean = rep(0, 51), sigma = diag(0.2, 51) + matrix(0.8, 51, 51),
           lower = rep(-2,51), upper = rep(2,51), nrep = 10000)
```

negbin.gc

*The Negative Binomial Marginal of Class* [marginal.gc](#)**Description**

The negative binomial marginal parameterized in terms of its mean and overdispersion.

By default, this function is used for likelihood inference and spatial prediction in functions `mlegc` and `predgc` of the package `gcKrig`. When all marginal parameters are given, the function is used for simulation and computing correlation in a trans-Gaussian random field in functions `simgc` and `corrTG`.

**Usage**

```
negbin.gc(link = "log", mu = NULL, od = NULL)
```

**Arguments**

<code>link</code>	the model link function.
<code>mu</code>	a non-negative scalar of the mean parameter.
<code>od</code>	a non-negative scalar of the overdispersion parameter.

**Details**

The negative binomial distribution with parameters  $\mu = a$  and  $od = 1/b$  has density

$$\frac{\Gamma(y + b)}{\Gamma(b)y!} \left(\frac{b}{b + a}\right)^b \left(1 - \frac{b}{b + a}\right)^y$$

which is called NB2 by Cameron and Trivedi (2013). Under this parameterization,  $var(Y) = \mu + od * \mu^2$ , where  $\mu$  is the mean parameter and  $od$  is the overdispersion parameter. For more details see Han and De Oliveira (2016).

**Value**

An object of class `marginal.gc` representing the marginal component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

- Cameron,A.C. and Trivedi,P.K. (2013) Regression Analysis of Count Data. *Cambridge University Press, 2nd Edition*.
- Han, Z. and De Oliveira, V. (2016) On the correlation structure of Gaussian copula models for geostatistical count data. *Australian and New Zealand Journal of Statistics*, 58:47-69.

**See Also**

[marginal.gc](#), [beta.gc](#), [binomial.gc](#), [gm.gc](#), [gaussian.gc](#), [poisson.gc](#), [weibull.gc](#), [zip.gc](#)

---

OilWell

*Location of Successful and Dry Wells*

---

**Description**

A dataset recording locations of successful and unsuccessful drilling oil wells in the northwest shelf of Delaware basin in New Mexico, a region that is densely drilled but has some sparsely drilled areas. The original dataset was transformed to a central area of about 65 square kilometers, see Hohn (1999), Chapter 6.

**Usage**

```
data(OilWell)
```

**Format**

A data frame with 333 observations and 3 variables.

Easting Cartesian x-coordinate of the locations.

Northing Cartesian y-coordinate of the locations.

Success A binary variable indicating the success of the drill at given locations. 1 for successful drilling oil wells and 0 for unsuccess.

**References**

Hohn, M. (1999) Geostatistics and petroleum geology, Second Edition. *Springer Science & Business Media, APA*

**Examples**

```
data(OilWell)  
str(OilWell)
```

---

plot.mlegc

*Plot Geostatistical Data and Fitted Mean*


---

**Description**

Four plots can be generated: the 2-D level plot or 3-D scatterplot with the number of counts or fitted values.

**Usage**

```
## S3 method for class 'mlegc'
plot(x, plotdata = "Observed", plottype = "2D", xlab = "xloc", ylab = "yloc",
      xlim = NULL, ylim = NULL, pch = 20, textcex = 0.8, plotcex = 1,
      angle = 60, col = 4, col.regions = gray(90:0/100),...)
```

**Arguments**

x	an object of class <code>mlegc</code> inherited from function <code>mlegc</code> .
plotdata	the data to be plotted. Can be either "Observed" if the original counts are used or "Fitted" if the fitted mean at different locations are used.
plottype	the type of the plot. Can be either "2D" for 2-D level plot or "3D" for 3-D scatterplot.
xlab, ylab	a title for the x and y axis.
xlim, ylim	numeric vectors of length 2, giving the x and y coordinates ranges. if they equal to NULL then they will be adjusted from the data.
pch	plotting character, i.e., the symbol to use in the 3-D scatter plot.
textcex	a numerical value giving the amount by which plotting text should be magnified relative to the default.
plotcex	a numerical value giving the amount by which plotting symbols should be magnified relative to the default.
angle	angle between x and y axis.
col	color of the text.
col.regions	color vector to be used reflecting magnitude of the dataset at different locations. The general idea is that this should be a color vector of gradually varying color.
...	further arguments passed to plot and panel settings.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[plot.simgc](#), [plot.predgc](#)

---

plot.predgc

*Plot Geostatistical Data at Sampling and Prediction Locations*


---

### Description

Five plots can be generated. A level plot with the number of counts at both observed and prediction locations; a level plot with predicted means (intensity); a level plot with the predicted counts; a level plot with estimated variances of the prediction; a 3-D scatter plot with both observed and predicted counts.

### Usage

```
## S3 method for class 'predgc'
plot(x, plottype = "2D", xlab = "xloc", ylab = "yloc", xlim = NULL,
      ylim = NULL, pch = 20, textcex = 0.6, plotcex = 1, angle = 60,
      col = c(2, 4), col.regions = gray(90:0/100),...)
```

### Arguments

x	an object of class predgc inherited from function <a href="#">predgc</a> .
plottype	can be one of the following: "2D", "Predicted Counts", "Predicted Mean", "Predicted Variance" or "3D". Default is "2D" which generates a 2-D contour plot with both observed and predicted counts. With arguments "Predicted Counts", "Predicted Mean" and "Predicted Variance", a 2-D level plot will be generated with the corresponding data. When "3D" is used, a 3-D scatter plot will be displayed with observed and predicted counts.
xlab, ylab	a title for the x and y axis.
xlim, ylim	numeric vectors of length 2, giving the x and y coordinates ranges. if they equal to NULL then they will be adjusted from the data.
pch	plotting character, i.e., symbol to use in the 3-D scatter plot.
textcex	a numerical value giving the amount by which plotting text should be magnified relative to the default.
plotcex	a numerical value giving the amount by which plotting symbols should be magnified relative to the default.
angle	angle between x and y axis.
col	a numeric vector of length 2 indicating color of the plot at sampling and prediction locations.
col.regions	color vector to be used reflecting magnitude of the dataset at different locations. The general idea is that this should be a color vector of gradually varying color.
...	further arguments passed to plot and panel settings.

### Author(s)

Zifei Han <hanzifei1@gmail.com>

**See Also**

[plot.simgc](#), [plot.mlegc](#), [mlegc](#), [predgc](#)

---

plot.simgc

*Plot Geostatistical Data Simulated From Gaussian Copula*

---

**Description**

Three plots will be generated. A level plot with the number of counts at given locations; a level plot with point referenced locations and varying colors and a 3-D scatter plot.

**Usage**

```
## S3 method for class 'simgc'
plot(x, index = 1, plottype = "Text", xlab = "xloc", ylab = "yloc",
      xlim = NULL, ylim = NULL, pch = 20, textcex = 0.8, plotcex = 1,
      angle = 60, col = 4, col.regions = gray(90:0/100),...)
```

**Arguments**

x	an object of class <code>simgc</code> , typically generated from function <a href="#">simgc</a> .
index	the index of the simulated data, need to be specified since <code>simgc</code> can simulate multiple datasets simultaneously.
plottype	the type of the printed plot, can be "Text", "Dot", or "3D". When <code>plottype = "Text"</code> , a 2-D plot is generated with exact counts at observed locations. When <code>plottype = "Dot"</code> , a 2-D dot plot is generated and when <code>plottype = "3D"</code> a 3-D scatter plot is printed.
xlab, ylab	a title for the x and y axis.
xlim, ylim	numeric vectors of length 2, giving the x and y coordinates ranges. if they equal to NULL then they will be adjusted from the data.
pch	plotting character, i.e., symbol to use in the 3-D scatter plot.
textcex	a numerical value giving the amount by which plotting text should be magnified relative to the default.
plotcex	a numerical value giving the amount by which plotting symbols should be magnified relative to the default.
angle	angle between x and y axis.
col	color of the text.
col.regions	color vector to be used reflecting magnitude of the dataset at different locations. The general idea is that this should be a color vector of gradually varying color.
...	further arguments passed to plot and panel settings.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[plot.mlegc](#), [plot.predgc](#)

---

plotgc

*Plot Geostatistical Count Data*

---

**Description**

This function generates two plots describing a geostatistical count data. The first plot is a bubble plot with size proportional to the response. The second plot is a lattice plot with text describing the number of counts.

**Usage**

```
plotgc(data = NULL, locs = NULL, bdry = NULL, col = 2, pch = 1,
       textcex = 1, col.regions = gray(90:0/100), size=c(0.3, 2.7), ...)
```

**Arguments**

<code>data</code>	the geostatistical count response.
<code>locs</code>	a $n$ by 2 matrix or data frame that indicates the coordinates of locations.
<code>bdry</code>	a list containing the coordinates of boundaries.
<code>col</code>	the color used for response variable in both plots.
<code>pch</code>	the shape used for response variable in the first plot.
<code>textcex</code>	a numerical value giving the amount by which plotting text should be magnified relative to the default.
<code>col.regions</code>	color vector to be used reflecting magnitude of the dataset at different locations. The general idea is that this should be a color vector of gradually varying color.
<code>size</code>	the minimum and maximum of the sizes in the first plot.
<code>...</code>	other parameters that control the plotting.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[plot.simgc](#) [plot.mlegc](#), [plot.predgc](#)



---

`poisson.gc`*The Poisson Marginal of Class [marginal.gc](#)*

---

**Description**

The Poisson marginal parameterized in terms of its mean.

By default, this function is used for likelihood inference and spatial prediction in function `mlegc` and `predgc` of the package `gcKrig`. When all marginal parameters are given, the function is used for simulation and computing correlation in a trans-Gaussian random field in function `simgc` and `corrTG`.

**Usage**

```
poisson.gc(link = "log", lambda = NULL)
```

**Arguments**

<code>link</code>	the model link function.
<code>lambda</code>	a non-negative scalar of the mean parameter.

**Value**

An object of class `marginal.gc` representing the marginal component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[marginal.gc](#), [beta.gc](#), [binomial.gc](#), [gm.gc](#), [gaussian.gc](#), [negbin.gc](#), [weibull.gc](#), [zip.gc](#)

---

`powerexp.gc`*The Powered Exponential Correlation Function of Class [corr.gc](#)*

---

**Description**

The powered exponential correlation function in spatial statistics.

By default, range parameter is not available, so this function is used for likelihood inference and spatial prediction in function `mlegc` and `predgc`. Users need to specify the shape parameter `kappa` and if the correlation model includes a nugget effect `nugget = TRUE` or not `nugget = FALSE`.

When both range and nugget parameters are given, the function is used for simulation with function `simgc` in package `gcKrig`.

**Usage**

```
powerexp.gc(range = NULL, kappa = 1, nugget = TRUE)
```

**Arguments**

range	a non-negative scalar of the range parameter in powered exponential correlation function.
kappa	a scalar between 0 and 2; the value of the shape parameter in the powered exponential correlation function.
nugget	the nugget effect of the correlation function. If specified, it must be a scalar between 0 and 1.

**Details**

The powered exponential correlation function with a nugget  $\tau^2$  is of the form:

$$\rho(h) = (1 - \tau^2) \exp((-h/\phi)^\kappa)$$

when  $h > 0$  and  $\rho(h) = 1$  when  $h = 0$ . Here  $h$  is distance,  $\phi$  is range parameter,  $\kappa$  is the shape parameter and  $\tau^2$  is the nugget effect.

When using the powered exponential correlation function, note that  $0 < \kappa \leq 2$ .

**Value**

An object of class `corr.gc` representing the correlation component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[matern.gc](#), [spherical.gc](#)

---

predgc

*Prediction at Unobserved Locations in Gaussian Copula Models for Geostatistical Count Data*

---

**Description**

Computes the plug-in prediction at unobserved sites. Two methods are implemented. If `method = 'GHK'` then the maximum simulated likelihood estimates are computed and the sequential importance sampling method is used in the integral evaluation. If `method = 'GQT'` then the maximum surrogate likelihood estimates are computed and the generalized quantile transform method is used in integral approximation.

**Usage**

```
predgc(obs.y, obs.x = NULL, obs.locs, pred.x = NULL, pred.locs,
       longlat = FALSE, distscale = 1, marginal, corr, obs.effort = 1,
       pred.effort = 1, method = "GHK", estpar = NULL, corrpars = NULL,
       pred.interval = NULL, parallel = FALSE,
       ghkoptions = list(nrep = c(100,1000), reorder = FALSE, seed = 12345),
       paralleloptions = list(n.cores = 2, cluster.type = "SOCK"))
```

**Arguments**

obs.y	a non-negative integer vector of observed response with its length equals to the number of observed locations.
obs.x	a numeric matrix or data frame of covariates at observed locations, with its number of rows equals to the number of observed locations. If no covariates then obs.x = NULL.
obs.locs	a numeric matrix or data frame of observed locations. The first column is <i>x</i> or longitude, the second column is <i>y</i> or latitude. The number of observed locations is equal to the number of rows.
pred.x	a numeric matrix or data frame of covariates at prediction locations, with its number of rows equals to the number of prediction locations. If no covariates then pred.x = NULL.
pred.locs	a numeric matrix or data frame of prediction locations. First column is <i>x</i> or longitude, second column is <i>y</i> or latitude. The number of prediction locations equals to the number of rows.
longlat	if FALSE, use Euclidean distance, if TRUE use great circle distance. The default is FALSE.
distscale	a numeric scaling factor for computing distance. If original distance is in kilometers, then distscale = 1000 will convert it to meters.
marginal	an object of class <code>marginal.gc</code> specifying the marginal distribution.
corr	an object of class <code>corr.gc</code> specifying the correlation function.
obs.effort	sampling effort at observed locations. For binomial marginal it is the size parameter (number of trials). See details.
pred.effort	sampling effort at prediction locations. For binomial marginal it is the size parameter (number of trials). See details.
method	two methods are implemented. If method = 'GHK' then the maximum simulated likelihood estimates are computed, if method = 'GQT' then the maximum surrogate likelihood estimates are computed.
estpar	if estpar = NULL then the likelihood estimates will be computed first, then plug-in into the predictive density. When all estimates are available, it is suggested to specify estpar with the parameter estimates so re-fitting is not needed. If so, the sequence of the input values for estpar is: regression parameters, overdispersion (if any), and correlation parameters (range and nugget, if applicable).
corrpars	the starting value of correlation parameters in optimization procedure. If corrpars = NULL then initial range is set to be half of the median distance in distance matrix, and initial nugget (if nugget = TRUE) is 0.2.

pred.interval	a number between 0 and 1 representing confidence level of the prediction interval. The program will output two types of the prediction intervals, see detail. If pred.interval = NULL then no prediction interval will be computed.
parallel	if TRUE then parallel computing is used to predict multiple prediction locations simultaneously. If FALSE then a serial version will be called.
ghkoptions	a list of three elements that only need to be specified if method = 'GHK'. nrep is the Monte Carlo size of the importance sampling algorithm for likelihood approximation. It can be a vector with increasing positive integers so that the model is fitted with a sequence of different Monte Carlo sizes, and the starting values for optimization are taken from the previous fitting. The default value is 100 for the first optimization and 1000 for the second and definitive optimization. reorder indicates whether the integral will be reordered every iteration in computation according to the algorithm in Gibson, etal (1994), default is FALSE. seed is seed of the pseudorandom generator used in Monte Carlo simulation.
paralleloptions	a list of two elements that only need to be specified if parallel = TRUE. n.cores is the number of cores to be used in parallel prediction. cluster.type is type of cluster to be used for parallel computing; can be "SOCK", "MPI", "PVM", or "NWS".

## Details

This program implemented two methods in predicting the response at unobserved sites. See [mlegc](#). The argument obs.effort and pred.effort are the sampling effort (known). It can be used to consider heterogeneity of the measurement time or area at different locations. The default is 1 for all locations. See Han and De Oliveira (2016) for more details.

The program computes two types of prediction intervals at a given confidence level. The shortest prediction interval is obtained from evaluating the highest to lowest prediction densities; the equal tail prediction interval has equal tail probabilities.

## Value

A list of class "predgc" with the following elements:

obs.locs	observed locations.
obs.y	observed values at observed locations.
pred.locs	prediction locations.
predValue	the expectation of the conditional predictive distribution.
predCount	predicted counts; the closest integer that predValue rounded to.
predVar	estimated variance of the prediction at prediction locations.
ConfidenceLevel	confidence level (between 0 to 1) if prediction interval is computed.
predInterval.EqualTail	equal-tail prediction interval.
predInterval.Shortest	shortest length prediction interval.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

- Han, Z. and De Oliveira, V. (2016) On the correlation structure of Gaussian copula models for geostatistical count data. *Australian and New Zealand Journal of Statistics*, 58:47-69.
- Kazianka, H. and Pilz, J. (2010) Copula-based geostatistical modeling of continuous and discrete data including covariates. *Stoch Environ Res Risk Assess* 24:661-673.
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- Masarotto, G. and Varin, C. (2012) Gaussian copula marginal regression. *Electronic Journal of Statistics* 6:1517-1549. <https://projecteuclid.org/euclid.ejs/1346421603>.
- Masarotto, G. and Varin C. (2017). Gaussian Copula Regression in R. *Journal of Statistical Software*, 77(8), 1–26. doi: [10.18637/jss.v077.i08](https://doi.org/10.18637/jss.v077.i08).
- Han, Z. and De Oliveira, V. (2018) gcKrig: An R Package for the Analysis of Geostatistical Count Data Using Gaussian Copulas. *Journal of Statistical Software*, 87(13), 1–32. doi: [10.18637/jss.v087.i13](https://doi.org/10.18637/jss.v087.i13).

**See Also**

[gcmr](#); [mlegc](#)

**Examples**

```
## Not run:
## For fast check predict at four locations only
data(Weed95)
weedobs <- Weed95[Weed95$dummy==1, ]
weedpred <- Weed95[Weed95$dummy==0, ]
predweed1 <- predgc(obs.y = weedobs$weedcount, obs.x = weedobs[,4:5], obs.locs = weedobs[,1:2],
                   pred.x = weedpred[1:4,4:5], pred.locs = weedpred[1:4,1:2],
                   marginal = negbin.gc(link = 'log'), pred.interval = 0.9,
                   corr = matern.gc(kappa = 0.5, nugget = TRUE), method = 'GHK')
#summary(predweed1)
#plot(predweed1)

## Time consuming examples
## Weed prediction at 200 locations using parallel programming
predweed2 <- predgc(obs.y = weedobs$weedcount, obs.x = weedobs[,4:5], obs.locs = weedobs[,1:2],
                   pred.x = weedpred[,4:5], pred.locs = weedpred[,1:2],
                   marginal = negbin.gc(link = 'log'),
                   corr = matern.gc(kappa = 0.5, nugget = TRUE), method = 'GHK',
                   pred.interval = 0.95, parallel = TRUE,
                   paralleloptions = list(n.cores = 4))
#summary(predweed2)
#plot(predweed2)
```

```

## A more time consuming example for generating a prediction map at a fine grid
data(OilWell)
gridstep <- seq(0.5, 30.5, length = 40)
locOilpred <- data.frame(Easting = expand.grid(gridstep, gridstep)[,1],
                        Northing = expand.grid(gridstep, gridstep)[,2])
PredOil <- predgc(obs.y = OilWell[,3], obs.locs = OilWell[,1:2], pred.locs = locOilpred,
                 marginal = binomial.gc(link = 'logit'),
                 corr = matern.gc(nugget = FALSE), obs.effort = 1,
                 pred.effort = 1, method = 'GHK',
                 parallel = TRUE, paralleloptions = list(n.cores = 4))
PredMat <- summary(PredOil)

## To generate better prediction maps
library(colorspace)
filled.contour(seq(0.5,30.5,length=40), seq(0.5,30.5,length=40),
              matrix(PredMat$predMean,40,), zlim = c(0, 1), col=rev(heat_hcl(12)),
              nlevels=12, xlab = "Eastings", ylab = "Northings",
              plot.axes = {axis(1); axis(2); points(OilWell[,1:2], col = 1,
              cex = 0.25 + 0.25*OilWell[,3])})

filled.contour(seq(0.5,30.5,length=40), seq(0.5,30.5,length=40),
              matrix(PredMat$predVar,40,),
              zlim = c(0, 0.3), col = rev(heat_hcl(12)), nlevels = 10,
              xlab = "Eastings", ylab = "Northings",
              plot.axes = {axis(1); axis(2); points(OilWell[,1:2], col = 1,
              cex = 0.25 + 0.25*OilWell[,3])})

## End(Not run)

```

---

profile.mlegc

*Profile Likelihood Based Confidence Interval of Parameters for Gaussian Copula Models in Geostatistical Count Data*


---

## Description

This function computes the (approximate) profile likelihood based confidence interval. The algorithm starts by choosing two starting points at different sides of the MLE and using an iterative process to find the approximate lower and upper bound.

## Usage

```

## S3 method for class 'mlegc'
profile(fitted, par.index, alpha = 0.05, start.point = NULL,
       method = 'GQT', nrep = 1000, seed = 12345, ...)

```

**Arguments**

fitted	an object of class mlegc, typically inherited from function <code>mlegc</code> .
par.index	the index of the parameter which should be profiled.
alpha	the significance level, default is 0.05 which corresponds to 95 percent confidence interval.
start.point	numeric vector of length 2 indicating the starting points for finding the left and right bound. If <code>start.point = NULL</code> then the default starting points will be used.
method	Two methods are implemented. If <code>method = 'GHK'</code> then the simulated likelihood will be used, if <code>method = 'GQT'</code> then the surrogate likelihood will be used.
nrep	the Monte Carlo size of the importance sampling algorithm for likelihood approximation; only need to be specified if <code>method = 'GHK'</code> .
seed	seed of the pseudorandom generator used in Monte Carlo simulation; only need to be specified if <code>method = 'GHK'</code> .
...	other arguments passed.

**Value**

Lower and upper bounds of the approximate confidence interval.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

- Masarotto, G. and Varin, C. (2012) Gaussian copula marginal regression. *Electronic Journal of Statistics* 6:1517-1549. <https://projecteuclid.org/euclid.ejs/1346421603>.
- Masarotto, G. and Varin C. (2017). Gaussian Copula Regression in R. *Journal of Statistical Software*, 77(8), 1–26. doi: [10.18637/jss.v077.i08](https://doi.org/10.18637/jss.v077.i08).
- Han, Z. and De Oliveira, V. (2018) gcKrig: An R Package for the Analysis of Geostatistical Count Data Using Gaussian Copulas. *Journal of Statistical Software*, 87(13), 1–32. doi: [10.18637/jss.v087.i13](https://doi.org/10.18637/jss.v087.i13).

**See Also**

[mlegc](#)

**Examples**

```
## Not run:
data(LansingTrees)
Treefit4 <- mlegc(y = LansingTrees[,3], x = LansingTrees[,4],
                locs = LansingTrees[,1:2], marginal = zip.gc(link = 'log'),
                corr = matern.gc(kappa = 0.5, nugget = TRUE), method = 'GHK')
summary(Treefit4)

profile(Treefit4, 1, 0.05, method = 'GHK', nrep = 1000, seed = 12345)
```

```

profile(Treefit4, 2, 0.05, method = 'GHK', nrep = 1000, seed = 12345)
profile(Treefit4, 3, 0.05, method = 'GHK', nrep = 1000, seed = 12345)
profile(Treefit4, 4, 0.05, method = 'GHK', nrep = 1000, seed = 12345)
profile(Treefit4, 5, 0.05, method = 'GHK', nrep = 1000, seed = 12345)

## End(Not run)

```

---

simgc

---

*Simulate Geostatistical Data from Gaussian Copula Model at Given Locations*


---

### Description

Simulate geostatistical data from Gaussian copula model at given locations. This function can simulate multiple datasets simultaneously.

### Usage

```
simgc(locs, sim.n = 1, marginal, corr, longlat = FALSE)
```

### Arguments

locs	a numeric matrix or data frame of $n$ - $D$ points with row denoting points. First column is $x$ or longitude, second column is $y$ or latitude. The number of locations is equal to the number of rows.
sim.n	the number of simulation samples required.
marginal	an object of class <code>marginal.gc</code> specifying the marginal distribution.
corr	an object of class <code>corr.gc</code> specifying the correlation function.
longlat	if FALSE, use Euclidean distance, if TRUE use great circle distance. Default is FALSE.

### Value

A list of two elements:

data	a numeric matrix with each row denoting a simulated data.
locs	the location of the simulated data, same as the input locs.

### Author(s)

Zifei Han <hanzifei1@gmail.com>



**Examples**

```

grid <- seq(0.05, 0.95, by = 0.1)
xloc <- expand.grid(x = grid, y = grid)[,1]
yloc <- expand.grid(x = grid, y = grid)[,2]
set.seed(12345)
sim1 <- simgc(locs = cbind(xloc,yloc), sim.n = 10, marginal = negbin.gc(mu = 5, od = 1),
              corr = matern.gc(range = 0.3, kappa = 0.5, nugget = 0.1))
#plot(sim1, index = 1)

```

spherical.gc

*The Spherical Correlation Function of Class `corr.gc`***Description**

The spherical correlation function in spatial statistics.

By default, range parameter is not available, so this function is used for likelihood inference and spatial prediction in function `mlegc` and `predgc`. Users need to specify if the correlation model includes a nugget effect `nugget = TRUE` or not `nugget = FALSE`.

When both range and nugget parameters are given, the function is used for simulation with function `simgc` in package `gcKrig`.

**Usage**

```
spherical.gc(range = NULL, nugget = TRUE)
```

**Arguments**

range	a non-negative scalar of the range parameter in the spherical correlation function.
nugget	the nugget effect of the correlation function. If specified, it must be a scalar between 0 and 1.

**Details**

The spherical correlation function with a nugget  $\tau^2$  is of the form:

$$\rho(h) = (1 - \tau^2)(1 - 1.5(h/\phi) + 0.5(-h/\phi)^3)$$

when  $h > 0$  and  $\rho(h) = 1$  when  $h = 0$ ,  $h$  is distance.

**Value**

An object of class `corr.gc` representing the correlation component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[matern.gc](#), [spherical.gc](#)

---

summary.mlegc	<i>Methods for Extracting Information from Fitted Object of Class mlegc</i>
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---

**Description**

Return a summary table of results from model fitting.

**Usage**

```
## S3 method for class 'mlegc'
summary(object, ...)
```

**Arguments**

object	an object of class mlegc inherited from function <a href="#">mlegc</a> .
...	additional arguments, but currently not used.

**Value**

A table summary of the estimates, standard error, z-value and several information criteria.

**Author(s)**

Zifei Han <[hanzifei1@gmail.com](mailto:hanzifei1@gmail.com)>

**See Also**

[mlegc](#)

---

summary.predgc	<i>Methods for Extracting Information from Fitted Object of Class predgc</i>
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---

**Description**

Output a summary data frame.

**Usage**

```
## S3 method for class 'predgc'
summary(object,...)
```

**Arguments**

object            an object of class `predgc` inherited from function `predgc`.  
 ...              further arguments.

**Value**

A table including the following information:

`pred.locs`        prediction locations.  
`predMean`        the expectation of the conditional predictive distribution.  
`predCount`       predicted counts; the closest integer that `predMean` rounded to.  
`predVar`         estimated variance of the prediction at prediction locations.  
`predInterval.EqualTail`  
                   equal-tail prediction interval; computed only if `ConfidenceLevel = TRUE`.  
`predInterval.Shortest`  
                   shortest length prediction interval; computed only if `ConfidenceLevel = TRUE`.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[mlegc](#), [predgc](#)

---

vcov.mlegc

*Covariance Matrix of the Maximum Likelihood Estimates*

---

**Description**

Calculate covariance and correlation matrix.

**Usage**

```
## S3 method for class 'mlegc'
vcov(object, digits = max(3, getOption("digits") - 3), ...)
```

**Arguments**

object            an object of class `mlegc` inherited from function `mlegc`.  
 digits            integer indicating the number of decimal places (round) or significant digits (significant) to be used.  
 ...              other arguments passed to `vcov`.

**Value**

The estimated variance-covariance matrix and estimated correlation matrix.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[mlegc](#)

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Weed95

*Counts of Weed Plants on a Field*

---

**Description**

The weed species *Viola Arvensis* was counted within circular frames each of area 0.25 square meter except for 10 missing sites in the first row, from a 20 by 14 rectangular grid, so the total number of locations is 270. Also, the percentages of organic matter in a soil sample are collected. The data was studied by Christensen and Waagepetersen (2002) to investigate whether weed occurrence could be predicted from observations of soil texture and soil chemical properties.

**Usage**

```
data(Weed95)
```

**Format**

A data frame with 270 observations and 6 variables.

`xloc` Cartesian x-coordinate of the locations (in meter).

`yloc` Cartesian y-coordinate of the locations (in meter).

`weedcount` Number of weed collected at the given site.

`scaled Y coord` The scaled Y coordinate with range -1 to 1 as a covariate in regression.

`organic` Another chemical component indicating the organic matter of the soil.

`dummy` A dummy variable taking values 0 or 1. If 0 it is treated as observed location and 1 treated as predicted location in Christensen and Waagepetersen (2002).

**References**

Christensen, O. and Waagepetersen, R. (2002) Bayesian Prediction of Spatial Count Data Using Generalized Linear Mixed Models. *Biometrics*, 58:280-286

**Examples**

```
data(Weed95)
str(Weed95)
```

---

`weibull.gc`*The Weibull Marginal of Class `marginal.gc`*

---

**Description**

The Weibull marginal used for simulation and computing correlation in the trans-Gaussian random field in function `simgc` and `corrTG` of the package `gcKrig`. It cannot be used in function `mlegc` nor `predgc` to make model inferences.

**Usage**

```
weibull.gc(shape = 1, scale = 1)
```

**Arguments**

<code>shape</code>	a positive scalar of shape parameter in the Weibull distribution.
<code>scale</code>	a positive scalar of scale parameter in the Weibull distribution.

**Details**

The Weibull distribution with shape parameter  $a$  and scale parameter  $b$  has density given by

$$(a/b)(x/b)^{a-1} \exp(-(x/b)^a)$$

**Value**

An object of class `marginal.gc` representing the marginal component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**See Also**

[marginal.gc](#), [beta.gc](#), [binomial.gc](#), [gm.gc](#), [gaussian.gc](#), [negbin.gc](#), [poisson.gc](#), [zip.gc](#)

zip.gc

*The Zero-inflated Poisson Marginal of Class* [marginal.gc](#)**Description**

The zero-inflated Poisson marginal parameterized in terms of its mean and overdispersion.

By default, this function is used for likelihood inference and spatial prediction in function `mlegc` and `predgc` of the package `gcKrig`. When all marginal parameters are given, the function is used for simulation and computing correlation in a trans-Gaussian random field in function `simgc` and `corrTG`.

**Usage**

```
zip.gc(link = "log", mu = NULL, od = NULL)
```

**Arguments**

<code>link</code>	the model link function.
<code>mu</code>	a non-negative scalar of the mean parameter.
<code>od</code>	a non-negative scalar of the overdispersion parameter.

**Details**

The zero-inflated Poisson distribution with parameters  $\mu = a$  and  $od = b$  has density

$$b/(1 + b) + \exp(-(a + ab))/(1 + b)$$

when  $y = 0$ , and

$$\exp(-(a + ab)) * (a + ab)^y / ((1 + b)y!)$$

when  $y = 1, 2, \dots$

Under this parameterization,  $\text{var}(Y) = \mu + od * \mu^2$ , where  $\mu$  is the mean parameter and  $od$  is the overdispersion parameter. For more details see Han and De Oliveira (2016).

**Value**

An object of class [marginal.gc](#) representing the marginal component.

**Author(s)**

Zifei Han <hanzifei1@gmail.com>

**References**

Han, Z. and De Oliveira, V. (2016) On the correlation structure of Gaussian copula models for geostatistical count data. *Australian and New Zealand Journal of Statistics*, 58:47-69.

**See Also**

[marginal.gc](#), [beta.gc](#), [binomial.gc](#), [gm.gc](#), [gaussian.gc](#), [negbin.gc](#), [poisson.gc](#), [weibull.gc](#)

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