Package ‘RcppCensSpatial’

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Type Package

Title Spatial Estimation and Prediction for Censored/Missing Responses

Version 0.3.0

Description It provides functions to estimate parameters in linear spatial models with censored/missing responses via the Expectation-Maximization (EM), the Stochastic Approximation EM (SAEM), or the Monte Carlo EM (MCEM) algorithm. These algorithms are widely used to compute the maximum likelihood (ML) estimates in problems with incomplete data. The EM algorithm computes the ML estimates when a closed expression for the conditional expectation of the complete-data log-likelihood function is available. In the MCEM algorithm, the conditional expectation is substituted by a Monte Carlo approximation based on many independent simulations of the missing data. In contrast, the SAEM algorithm splits the E-step into simulation and integration steps. This package also approximates the standard error of the estimates using the Louis method. Moreover, it has a function that performs spatial prediction in new locations.

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CovMat

Covariance matrix for spatial models

Description
It computes the spatial variance-covariance matrix considering exponential, gaussian, matérn, or power exponential correlation function.

Usage
CovMat(phi, tau2, sig2, coords, type = "exponential", kappa = NULL)

Arguments
phi
Spatial scaling parameter.

tau2
Nugget effect parameter.

sig2
Partial sill parameter.

coords
2D spatial coordinates of dimensions \( n \times 2 \).

type
Type of spatial correlation function: 'exponential', 'gaussian', 'matern', and 'pow.exp' for exponential, gaussian, matérn, and power exponential, respectively.

kappa
Parameter for some spatial correlation functions. For exponential and gaussian kappa=NULL, for power exponential \( 0 < \kappa \leq 2 \), and for matérn correlation function \( \kappa > 0 \).
The spatial covariance matrix is given by
\[ \Sigma = [\text{Cov}(s_i, s_j)] = \sigma^2 R(\phi) + \tau^2 I_n, \]
where \( \sigma^2 > 0 \) is the partial sill, \( \phi > 0 \) is the spatial scaling parameter, \( \tau^2 > 0 \) is known as the nugget effect in the geostatistical framework, \( R(\phi) \) is the \( n \times n \) correlation matrix computed from a correlation function, and \( I_n \) is the \( n \times n \) identity matrix.

The spatial correlation functions available are:

**Exponential:** \( \text{Corr}(d) = \exp(-d/\phi) \),

**Gaussian:** \( \text{Corr}(d) = \exp(-(d/\phi)^2) \),

**Matérn:** \( \text{Corr}(d) = \frac{1}{\Gamma(\kappa-1/2)} \left( \frac{d}{\phi} \right)^\kappa K_\kappa \left( \frac{d}{\phi} \right) \),

**Power exponential:** \( \text{Corr}(d) = \exp(-(d/\phi)^\kappa) \),

where \( d \geq 0 \) is the Euclidean distance between two observations, \( \Gamma(.) \) is the gamma function, \( \kappa \) is the smoothness parameter, and \( K_\kappa(.) \) is the modified Bessel function of the second kind of order \( \kappa \).

**Value**

An \( n \times n \) spatial covariance matrix.

**Author(s)**

Katherine L. Valeriano, Alejandro Ordoñez, Christian E. Galarza, and Larissa A. Matos.

**See Also**

dist2Dmatrix, EM.sclm, MCEM.sclm, SAEM.sclm

**Examples**

```r
set.seed(1000)
n = 20
cords = round(matrix(runif(2*n, 0, 10), n, 2), 5)
Cov = CovMat(phi=5, tau2=0.8, sig2=2, coords=cords, type="exponential")
```

**Description**

It computes the Euclidean distance matrix for a set of coordinates.

**Usage**

dist2Dmatrix(coords)
Arguments

coords 2D spatial coordinates of dimensions $n \times 2$.

Value

An $n \times n$ distance matrix.

Author(s)

Katherine L. Valeriano, Alejandro Ordoñez, Christian E. Galarza, and Larissa A. Matos.

Examples

```r
n = 100
set.seed(1000)
x = round(runif(n,0,10), 5)  # X coordinate
y = round(runif(n,0,10), 5)  # Y coordinate
Mdist = dist2Dmatrix(cbind(x, y))
```

Description

It fits the left, right, or interval spatial censored linear model using the Expectation-Maximization (EM) algorithm. It provides estimates and standard errors of the parameters and supports missing values on the dependent variable.

Usage

```r
EM.sclm(y, x, ci, lcl = NULL, ucl = NULL, coords, phi0, nugget0,
    type = "exponential", kappa = NULL, lower = c(0.01, 0.01),
    upper = c(30, 30), MaxIter = 300, error = 1e-04, show_se = TRUE)
```

Arguments

y vector of responses of length $n$.

x design matrix of dimensions $n \times q$, where $q$ is the number of fixed effects, including the intercept.

ci vector of censoring indicators of length $n$. For each observation: 1 if censored/missing, 0 otherwise.

lcl, ucl vectors of length $n$ representing the lower and upper bounds of the interval, which contains the true value of the censored observation. Default =NULL, indicating no-censored data. For each observation: lcl=-Inf and ucl=c (left censoring); lcl=c and ucl=Inf (right censoring); and lcl and ucl must be finite for interval censoring. Moreover, missing data could be defined by setting lcl=-Inf and ucl=Inf.
EM.sclm

coords 2D spatial coordinates of dimensions \( n \times 2 \).

phi0 initial value for the spatial scaling parameter.

nugget0 initial value for the nugget effect parameter.

type type of spatial correlation function: 'exponential', 'gaussian', 'matern', and 'pow.exp' for exponential, gaussian, matérn, and power exponential, respectively.

kappa parameter for some spatial correlation functions. See CovMat.

lower, upper vectors of lower and upper bounds for the optimization method. If unspecified, the default is \( c(0.01,0.01) \) for lower and \( c(30,30) \) for upper.

MaxIter maximum number of iterations for the EM algorithm. By default =300.

error maximum convergence error. By default =1e-4.

show_se logical. It indicates if the standard errors should be estimated by default =TRUE.

Details

The spatial Gaussian model is given by
\[
Y = X\beta + \xi,
\]
where \( Y \) is the \( n \times 1 \) response vector, \( X \) is the \( n \times q \) design matrix, \( \beta \) is the \( q \times 1 \) vector of regression coefficients to be estimated, and \( \xi \) is the error term. Which is normally distributed with zero-mean and covariance matrix \( \Sigma = \sigma^2 R(\phi) + \tau^2 I_n \). We assume that \( \Sigma \) is non-singular and \( X \) has a full rank (Diggle and Ribeiro 2007).

The estimation process is performed via the EM algorithm, initially proposed by Dempster et al. (1977). The conditional expectations are computed using the function meanvarTMD available in the package MomTrunc.

Value

An object of class "sclm". Generic functions print and summary have methods to show the results of the fit. The function plot can extract convergence graphs for the parameter estimates.

Specifically, the following components are returned:

Theta estimated parameters in all iterations, \( \theta = (\beta, \sigma^2, \phi, \tau^2) \).

theta final estimation of \( \theta = (\beta, \sigma^2, \phi, \tau^2) \).

beta estimated \( \beta \).

sigma2 estimated \( \sigma^2 \).

phi estimated \( \phi \).

tau2 estimated \( \tau^2 \).

EY first conditional moment computed in the last iteration.

EYY second conditional moment computed in the last iteration.

SE vector of standard errors of \( \theta = (\beta, \sigma^2, \phi, \tau^2) \).

InfMat observed information matrix.

loglik log-likelihood for the EM method.
AIC  Akaike information criterion.
BIC  Bayesian information criterion.
Iter  number of iterations needed to converge.
time  processing time.
call  RcppCensSpatial call that produced the object.
tag  table of estimates.
critFin  selection criteria.
range  effective range.
ncens  number of censored/missing observations.
MaxIter  maximum number of iterations for the EM algorithm.

Note

The EM final estimates correspond to the estimates obtained at the last iteration of the EM algorithm.
To fit a regression model for non-censored data, just set ci as a vector of zeros.

Author(s)

Katherine L. Valeriano, Alejandro Ordoñez, Christian E. Galarza, and Larissa A. Matos.

References


See Also

MCEM.sclm, SAEM.sclm, predict.sclm

Examples

# Simulated example: 10% of left-censored observations
set.seed(1000)
n = 50  # Test with another values for n
coords = round(matrix(runif(2*n,0,15),n,2), 5)
x = cbind(rnorm(n), runif(n))
data = rCensSp(c(-1,3), 2, 0.5, x, coords, "left", 0.10, 0, "gaussian")

fit = EM.sclm(y=data$y, x=x, ci=data$ci, lcl=data$lcl, ucl=data$ucl,
              coords=coords, phi0=3, nugget0=1, type="gaussian")
fit
**ML estimation of spatial censored linear models via the MCEM algorithm**

**Description**

It fits the left, right, or interval spatial censored linear model using the Monte Carlo EM (MCEM) algorithm. It provides estimates and standard errors of the parameters and supports missing values on the dependent variable.

**Usage**

```r
MCEM.sclm(y, x, ci, lcl = NULL, ucl = NULL, coords, phi0, nugget0,
        type = "exponential", kappa = NULL, lower = c(0.01, 0.01),
        upper = c(30, 30), MaxIter = 500, nMin = 20, nMax = 5000,
        error = 1e-04, show_se = TRUE)
```

**Arguments**

- `y`: vector of responses of length `n`.
- `x`: design matrix of dimensions `n × q`, where `q` is the number of fixed effects, including the intercept.
- `ci`: vector of censoring indicators of length `n`. For each observation: 1 if censored/missing, 0 otherwise.
- `lcl`, `ucl`: vectors of length `n` representing the lower and upper bounds of the interval, which contains the true value of the censored observation. Default = NULL, indicating no-censored data. For each observation: `lcl=-Inf` and `ucl=c` (left censoring); `lcl=c` and `ucl=Inf` (right censoring); and `lcl` and `ucl` must be finite for interval censoring. Moreover, missing data could be defined by setting `lcl=-Inf` and `ucl=Inf`.
- `coords`: 2D spatial coordinates of dimensions `n × 2`.
- `phi0`: initial value for the spatial scaling parameter.
- `nugget0`: initial value for the nugget effect parameter.
- `type`: type of spatial correlation function: 'exponential', 'gaussian', 'matern', and 'pow.exp' for exponential, gaussian, matérn, and power exponential, respectively.
- `kappa`: parameter for some spatial correlation functions. See `CovMat`.
- `lower`, `upper`: vectors of lower and upper bounds for the optimization method. If unspecified, the default is `c(0.01, 0.01)` for lower and `c(30,30)` for upper.
- `MaxIter`: maximum number of iterations for the MCEM algorithm. By default = 500.
- `nMin`: initial sample size for Monte Carlo integration. By default = 20.
- `nMax`: maximum sample size for Monte Carlo integration. By default = 5000.
- `error`: maximum convergence error. By default = 1e-4.
- `show_se`: logical. It indicates if the standard errors should be estimated by default = TRUE.
Details

The spatial Gaussian model is given by

\[ Y = X\beta + \xi, \]

where \( Y \) is the \( n \times 1 \) response vector, \( X \) is the \( n \times q \) design matrix, \( \beta \) is the \( q \times 1 \) vector of regression coefficients to be estimated, and \( \xi \) is the error term. Which is normally distributed with zero-mean and covariance matrix \( \Sigma = \sigma^2 R(\phi) + \tau^2 I_n \). We assume that \( \Sigma \) is non-singular and \( X \) has a full rank (Diggle and Ribeiro 2007).

The estimation process is performed via the MCEM algorithm, initially proposed by Wei and Tanner (1990). The Monte Carlo (MC) approximation starts with a sample of size \( n_{\text{Min}} \); at each iteration, the sample size increases \((n_{\text{Max}}-n_{\text{Min}})/\text{MaxIter}\), and at the last iteration, the sample size is \( n_{\text{Max}} \). The random observations are sampled through the slice sampling algorithm available in package `relliptical`.

Value

An object of class "sclm". Generic functions `print` and `summary` have methods to show the results of the fit. The function `plot` can extract convergence graphs for the parameter estimates.

Specifically, the following components are returned:

- **Theta**: estimated parameters in all iterations, \( \theta = (\beta, \sigma^2, \phi, \tau^2) \).
- **theta**: final estimation of \( \theta = (\beta, \sigma^2, \phi, \tau^2) \).
- **beta**: estimated \( \beta \).
- **sigma2**: estimated \( \sigma^2 \).
- **phi**: estimated \( \phi \).
- **tau2**: estimated \( \tau^2 \).
- **EY**: MC approximation of the first conditional moment.
- **EYY**: MC approximation of the second conditional moment.
- **SE**: vector of standard errors of \( \theta = (\beta, \sigma^2, \phi, \tau^2) \).
- **InfMat**: observed information matrix.
- **loglik**: log-likelihood for the MCEM method.
- **AIC**: Akaike information criterion.
- **BIC**: Bayesian information criterion.
- **Iter**: number of iterations needed to converge.
- **time**: processing time.
- **call**: RcppCensSpatial call that produced the object.
- **tab**: table of estimates.
- **critFin**: selection criteria.
- **range**: effective range.
- **ncens**: number of censored/missing observations.
- **MaxIter**: maximum number of iterations for the MCEM algorithm.
Note

The MCEM final estimates correspond to the mean of the estimates obtained at each iteration after deleting the half and applying a thinning of 3.

To fit a regression model for non-censored data, just set ci as a vector of zeros.

Author(s)

Katherine L. Valeriano, Alejandro Ordoñez, Christian E. Galarza, and Larissa A. Matos.

References


See Also

EM.sclm, SAEM.sclm, predict.sclm

Examples

```r
# Example 1: left censoring data
set.seed(1000)
n = 50  # Test with another values for n
coords = round(matrix(runif(2*n,0,15),n,2), 5)
x = cbind(rnorm(n), rnorm(n))
data = rCensSp(c(2,-1), 2, 3, 0.70, x, coords, "left", 0.08, 0, "matern", 1)

fit = MCEM.sclm(y=data$y, x=x, ci=data$ci, lcl=data$lcl, ucl=data$ucl,
                coords, phi0=2.50, nugget0=0.75, type="matern",
                kappa=1, MaxIter=30, nMax=1000)
fit$tab

# Example 2: left censoring and missing data
yMiss = data$y
yMiss[20] = NA
ci = data$ci
ci[20] = 1
ucl = data$ucl
ucl[20] = Inf

fit1 = MCEM.sclm(y=yMiss, x=x, ci=ci, lcl=data$lcl, ucl=ucl, coords,
                 phi0=2.50, nugget0=0.75, type="matern", kappa=1,
                 MaxIter=300, nMax=1000)
summary(fit1)
plot(fit1)
```
Missouri  

TCDD concentration data

Description
The level of dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin or TCDD) data was collected in November 1983 by the U.S. Environmental Protection Agency (EPA) in several areas of a highway in Missouri, USA. The TCDD measurement was subject to a limit of detection (cens); thereby, the TCDD data is left-censored. Only the locations used in the geostatistical analysis by Zirschky and Harris (1986) are shown.

Usage

data("Missouri")

Format
A data frame with 127 observations and five variables:

- xcoord x coordinate of the start of each transect (ft).
- ycoord y coordinate of the start of each transect (ft).
- TCDD TCDD concentrations (mg/kg).
- transect transect length (ft).
- cens indicator of censoring (left-censored observations).

Source

See Also
EM.sclm, MCEM.sclm, SAEM.sclm

Examples

data("Missouri")
y = log(Missouri$TCDD)
cc = Missouri$cens
coord = cbind(Missouri$xcoord/100, Missouri$ycoord)
x = matrix(1, length(y), 1)
lcl = rep(-Inf, length(y))
ucl = y

## SAEM fit
set.seed(83789)
fit1 = SAEM.sclm(y, x, cc, lcl, ucl, coord, 5, 1, lower=c(1e-5,1e-5),
upper=c(50,50))
### predict.sclm

It performs spatial prediction in a set of new spatial locations.

#### Description

It performs spatial prediction in a set of new spatial locations.

#### Usage

```r
## S3 method for class 'sclm'
predict(object, locPre, xPre, ...)
```

#### Arguments

- **object**: object of class 'sclm' given as output of `EM.sclm`, `MCEM.sclm`, or `SAEM.sclm` function.
- **locPre**: matrix of coordinates for which prediction is performed.
- **xPre**: matrix of covariates for which prediction is performed.
- **...**: further arguments passed to or from other methods.

#### Details

This function predicts using the mean squared error (MSE) criterion, which takes the conditional expectation E(Y|X) as the best linear predictor.

#### Value

The function returns a list with:

- **coord**: matrix of coordinates.
- **predValues**: predicted values.
- **sdPred**: predicted standard deviations.

#### Author(s)

Katherine L. Valeriano, Alejandro Ordoñez, Christian E. Galarza, and Larissa A. Matos.
rCensSp

Censored spatial data simulation

Description
It simulates censored spatial data with a linear structure for an established censoring rate.

Usage
rCensSp(beta, sigma2, phi, nugget, x, coords, cens = "left", pcens = 0.1, npred = 0, cov.model = "exponential", kappa = NULL)
Arguments

- **beta**: linear regression parameters.
- **sigma2**: partial sill parameter.
- **phi**: spatial scaling parameter.
- **nugget**: nugget effect parameter.
- **x**: design matrix of dimensions $n \times q$.
- **coords**: 2D spatial coordinates of dimensions $n \times 2$.
- **cens**: 'left' or 'right' censoring. By default = 'left'.
- **pcens**: desired censoring rate. By default = 0.10.
- **npred**: number of simulated data used for cross-validation (Prediction). By default = 0.
- **cov.model**: type of spatial correlation function: 'exponential', 'gaussian', 'matern', and 'pow. exp' for exponential, gaussian, matérn, and power exponential, respectively.
- **kappa**: parameter for some spatial correlation functions. For exponential and gaussian $\text{kappa} = \text{NULL}$, for power exponential $0 < \text{kappa} \leq 2$, and for matérn correlation function $\text{kappa} > 0$.

Value

If $\text{npred} > 0$, it returns two lists: Data and TestData; otherwise, it returns a list with the simulated data.

**Data**

- **y**: response vector.
- **ci**: censoring indicator.
- **lcl**: lower censoring bound.
- **uc1**: upper censoring bound.
- **coords**: coordinates matrix.
- **x**: design matrix.

**TestData**

- **y**: response vector.
- **coords**: coordinates matrix.
- **x**: design matrix.

Author(s)

Katherine L. Valeriano, Alejandro Ordoñez, Christian E. Galarza, and Larissa A. Matos.
Examples

```r
n = 100
set.seed(1000)
coords = round(matrix(runif(2*n,0,15),n,2), 5)
x = cbind(1, rnorm(n))
data = rCensSp(beta=c(5,2), sigma2=2, phi=4, nugget=0.70, x=x,
            coords=coords, cens="left", pcens=0.10, npred=10,
            cov.model="gaussian")
data$Data
data$TestData
```

**SAEM.sclm**

*ML estimation of spatial censored linear models via the SAEM algorithm*

**Description**

It fits the left, right, or interval spatial censored linear model using the Stochastic Approximation EM (SAEM) algorithm. It provides estimates and standard errors of the parameters and supports missing values on the dependent variable.

**Usage**

```r
SAEM.sclm(y, x, ci, lcl = NULL, ucl = NULL, coords, phi0, nugget0,
     type = "exponential", kappa = NULL, lower = c(0.01, 0.01),
     upper = c(30, 30), MaxIter = 300, M = 20, pc = 0.2, error = 1e-04,
     show_se = TRUE)
```

**Arguments**

- `y` vector of responses of length `n`.
- `x` design matrix of dimensions `n x q`, where `q` is the number of fixed effects, including the intercept.
- `ci` vector of censoring indicators of length `n`. For each observation: 1 if censored/missing, 0 otherwise.
- `lcl, ucl` vectors of length `n` representing the lower and upper bounds of the interval, which contains the true value of the censored observation. Default =NULL, indicating no-censored data. For each observation: lcl=-Inf and ucl=Inf (left censoring); lcl=c and ucl=Inf (right censoring); and lcl and ucl must be finite for interval censoring. Moreover, missing data could be defined by setting lcl=-Inf and ucl=Inf.
- `coords` 2D spatial coordinates of dimensions `n x 2`.
- `phi0` initial value for the spatial scaling parameter.
- `nugget0` initial value for the nugget effect parameter.
type: type of spatial correlation function: 'exponential', 'gaussian', 'matern', and 'pow.exp' for exponential, gaussian, matérn, and power exponential, respectively.

kappa: parameter for some spatial correlation functions. See `CovMat`.

lower, upper: vectors of lower and upper bounds for the optimization method. If unspecified, the default is c(0.01, 0.01) for lower and c(30, 30) for upper.

MaxIter: maximum number of iterations of the SAEM algorithm. By default =300.

M: number of Monte Carlo samples for stochastic approximation. By default =20.

pc: percentage of initial iterations of the SAEM algorithm with no memory. It is recommended that 50<MaxIter*pc<100. By default =0.20.

error: maximum convergence error. By default =1e-4.

show_se: logical. It indicates if the standard errors should be estimated by default =TRUE.

Details

The spatial Gaussian model is given by

\[ Y = X\beta + \xi, \]

where \( Y \) is the \( n \times 1 \) response vector, \( X \) is the \( n \times q \) design matrix, \( \beta \) is the \( q \times 1 \) vector of regression coefficients to be estimated, and \( \xi \) is the error term which is normally distributed with zero-mean and covariance matrix \( \Sigma = \sigma^2 R(\phi) + \tau^2 I_n \). We assume that \( \Sigma \) is non-singular and \( X \) has full rank (Diggle and Ribeiro 2007).

The estimation process is performed via the SAEM algorithm, initially proposed by Delyon et al. (1999). The spatial censored (SAEM) algorithm was previously proposed by Lachos et al. (2017) and Ordoñez et al. (2018) and is available in the package `CensSpatial`. These packages differ in the random number generation and optimization procedure.

This model is also a particular case of the spatio-temporal model defined by Valeriano et al. (2021) when the number of temporal observations is equal to one. The computing codes of the spatio-temporal SAEM algorithm are available in the package `StempCens`.

Value

An object of class "sclm". Generic functions `print` and `summary` have methods to show the results of the fit. The function `plot` can extract convergence graphs for the parameter estimates.

Specifically, the following components are returned:

- **Theta**: estimated parameters in all iterations, \( \theta = (\beta, \sigma^2, \phi, \tau^2) \).
- **theta**: final estimation of \( \theta = (\beta, \sigma^2, \phi, \tau^2) \).
- **beta**: estimated \( \beta \).

- **sigma2**: estimated \( \sigma^2 \).
- **phi**: estimated \( \phi \).
- **tau2**: estimated \( \tau^2 \).

- **EY**: stochastic approximation of the first conditional moment.
- **EYY**: stochastic approximation of the second conditional moment.
SE vector of standard errors of $\theta = (\beta, \sigma^2, \phi, \tau^2)$.

InfMat observed information matrix.

loglik log-likelihood for the SAEM method.

AIC Akaike information criterion.

BIC Bayesian information criterion.

Iter number of iterations needed to converge.

time processing time.

call RcppCensSpatial call that produced the object.

tab table of estimates.

critFin selection criteria.

range effective range.

ncens number of censored/missing observations.

MaxIter maximum number of iterations for the SAEM algorithm.

Note

The SAEM final estimates correspond to the estimates obtained at the last iteration of the algorithm.

To fit a regression model for non-censored data, just set ci as a vector of zeros.

Author(s)

Katherine L. Valeriano, Alejandro Ordoñez, Christian E. Galarza, and Larissa A. Matos.

References


See Also

EM.sclm, MCEM.sclm, predict.sclm
Examples

# Example 1: 8% of right-censored observations
set.seed(1000)
n = 50  # Test with another values for n
coords = round(matrix(runif(2*n,0,15),n,2), 5)
x = cbind(rnorm(n), rnorm(n))
data = rCensSp(c(4,-2), 1, 3, 0.50, x, coords, "right", 0.08)

fit = SAEM.sclm(y=data$y, x=x, ci=data$ci, lcl=data$lcl, ucl=data$ucl, 
coords, phi0=2, nugget0=1, type="exponential", M=10, 
pc=0.18)
fit

# Example 2: censored and missing observations
set.seed(123)
n = 200
coords = round(matrix(runif(2*n,0,20),n,2), 5)
x = cbind(runif(n), rnorm(n), rexp(n))
data = rCensSp(c(1,4,-1), 2, 3, 0.50, x, coords, "left", 0.05, 0, 
"matern", 3)
data$y[c(10,120)] = NA
data$ci[c(10,120)] = 1
data$ucl[c(10,120)] = Inf

fit2 = SAEM.sclm(y=data$y, x=x, ci=data$ci, lcl=data$lcl, ucl=data$ucl, 
coords, phi0=2, nugget0=1, type="matern", kappa=3, 
M=10, pc=0.18)
fit2$tab
plot(fit2)
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