# Package ‘OBASpatial’

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**Type** Package

**Title** Objective Bayesian Analysis for Spatial Regression Models

**Version** 1.9

**Depends** R (>= 3.6.0)

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**Imports** stats,modeest,cubature,truncdist,invgamma,LaplacesDemon,HDInterval,mvtnorm

**Description**

It makes an objective Bayesian analysis of the spatial regression model using both the normal (NSR) and student-T (TSR) distributions. The functions provided give prior and posterior objective densities and allow default Bayesian estimation of the model regression parameters. Details can be found in Ordonez et al. (2020) <arXiv:2004.04341>.

**License** GPL (>= 2)

**NeedsCompilation** no

**Repository** CRAN

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## R topics documented:

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`dataca20` *Calcium Content In Soil Samples.*

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### Description

This data set contains the calcium content measured in soil samples taken from the 0-20cm layer at 178 locations within a certain study area divided in three sub-areas. The elevation at each location was also recorded.See `geoR` package for details.

### Usage

```
data("dataca20")
```

### Format

A data frame with 178 observations on the following 3 variables.

`east` X Coordinate.

`north` Y coordinate.

`calcont` Calcium content measured in $mmol_c/dm^3$.

`altitude` A vector with the elevation of each sampling location,in meters.

`area` A factor indicating the sub area to which the locations belongs.

### References

Oliveira, M. C. N. (2003). Metodos de estimacao de parametros em modelos geoestatisticos com diferentes estruturas de covariancias: uma aplicacao ao teor de calcio no solo. Ph.D. thesis, ESALQ/USP/Brasil.

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`dataelev` *Surface elevations*

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### Description

Surface elevation data taken from Davis (1972). An onject of the class geodata with elevation values at 52 locations.

### Usage

```
data("dataelev")
```

## Format

A data frame with 52 observations on the following 3 variables.

`x` X coordinate (multiple of 50 feet).

`y` Y coordinate (multiple of 50 feet).

`elevation` elevations (multiples of 10 feet).

## References

Davis, J.C. (1973) Statistics and Data Analysis in Geology. Wiley.

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`dnsrposoba` *Objective posterior density for the NSR model*

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## Description

It calculates the density function $\pi(\phi)$ (up to a proportionality constant) for the TSR model using the based reference, Jeffreys' rule, Jeffreys' independent and vague priors. In this context $\phi$ corresponds to the range parameter.

## Usage

```
dnsrposoba(x,formula,prior="reference",coords.col=1:2,
kappa=0.5,cov.model="exponential",data,asigma=2.1,intphi)
```

## Arguments

| | |
|---|---|
| `x` | The $\phi$ quantil value. |
| `formula` | A valid formula for a linear regression model. |
| `prior` | Objective prior densities avaiable for the TSR model: ( `reference`: Reference based, `jef.rul`: Jeffreys' rule, `jef.ind`: Jeffreys' independent). |
| `coords.col` | A vector with the column numbers corresponding to the spatial coordinates. |
| `kappa` | Shape parameter of the covariance function (fixed). |
| `cov.model` | Covariance functions available for the TSR model. `matern`: Matern, `pow.exp`: power exponential, `exponential`:exponential, `cauchy`: Cauchy, `spherical`: Spherical. |
| `data` | Data set with 2D spatial coordinates, the response and optional covariates. |
| `asigma` | Value of $a$ for vague prior. |
| `intphi` | An interval for $\phi$ used for vague prior. |

## Details

The posterior distribution is computed for this priors under the improper family $\frac{\pi(\phi)}{(\sigma^2)^a}$. For the vague prior, it was considered the structure where a priori, $\phi$ folows an uniform distribution on the interval `intphi`.

For the Jeffreys independent prior, this family of priors generates improper posterior distribution when intercept is considered for the mean function.

## Value

Posterior density of x=$\phi$.

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Berger, J.O, De Oliveira, V. and Sanso, B. (2001). Objective Bayesian Analysis of Spatially Correlated Data. Journal of the American Statistical Association., 96, 1361 – 1374.

## See Also

`dtsrposoba`,`dtsrprioroba`,`dnsrprioroba`

## Examples

```
data(dataelev)

######### Using reference prior ###########
dnsrposoba(x=5,prior="reference",formula=elevation~1,
kappa=1,cov.model="matern",data=dataelev)

######### Using Jeffreys' rule prior ###########
dnsrposoba(x=5,prior="jef.rul",formula=elevation~1,
kappa=1,cov.model="matern",data=dataelev)

######### Using vague independent prior ###########
dnsrposoba(x=5,prior="vague",formula=elevation~1,
kappa=0.3,cov.model="matern",data=dataelev,intphi=c(0.1,10))
```

dnsrprioroba *Objective prior density for the NSR model*

## Description

It calculates the density function $\pi(\phi)$ (up to a proportionality constant) for the NSR model using the based reference, Jeffreys' rule and Jeffreys' independent priors. In this context $\phi$ corresponds to the range parameter.

## Usage

```
dnsrprioroba(x,trend="cte",prior="reference",coords.col=1:2,
kappa=0.5,cov.model="exponential",data)
```

## Arguments

| | |
|---|---|
| `x` | The $\phi$ quantil value. |
| `trend` | Builds the trend matrix in accordance to a specification of the mean provided by the user. See `DETAILS` below. |
| `prior` | Objective prior densities avaiable for the TSR model: ( `reference`: Reference based, `jef.rul`: Jeffreys' rule, `jef.ind`: Jeffreys' independent). |
| `coords.col` | A vector with the column numbers corresponding to the spatial coordinates. |
| `kappa` | Shape parameter of the covariance function (fixed). |
| `cov.model` | Covariance functions available for the TSR model. `matern`: Matern, `pow.exp`: power exponential, `exponential`:exponential, `cauchy`: Cauchy, `spherical`: Spherical. |
| `data` | Data set with 2D spatial coordinates, the response and optional covariates. |

## Details

Denote as $\boldsymbol{c} = (c_1, c_2)$ the coordinates of a spatial location. `trend` defines the design matrix as:

- `0` (zero,without design matrix) Only valid for the Independent Jeffreys' prior
- `"cte"`, the design matrix is such that mean function $\mu(\boldsymbol{c}) = \mu$ is constant over the region.
- `"1st"`, the design matrix is such that mean function becames a first order polynomial on the coordinates:
$$\mu((c)) = \beta_0 + \beta_1 c_1 + \beta_2 c_2$$
- `"2nd"`, the design matrix is such that mean function $\mu(\boldsymbol{c}) = \mu$ becames a second order polynomial on the coordinates:
$$\mu((c)) = \beta_0 + \beta_1 c_1 + \beta_2 c_2 + \beta_3 c_1^2 + \beta_4 c_2^2 + \beta_5 c_1 c_2$$
- `~model` a model specification to include covariates (external trend) in the model.

## Value

Prior density of x=$\phi$

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Berger, J.O, De Oliveira, V. and Sanso, B. (2001). Objective Bayesian Analysis of Spatially Correlated Data. Journal of the American Statistical Association., 96, 1361 – 1374.

## See Also

dtsrposoba,dtsrprioroba,dnsrposoba

## Examples

```
data(dataelev)## data using by Berger et. al (2001)

######### Using reference prior ###########
dnsrprioroba(x=20,kappa=0.3,cov.model="matern",data=dataelev)


######### Using jef.rule prior###########
dnsrprioroba(x=20,prior="jef.rul",kappa=0.3,cov.model="matern",
data=dataelev)

######### Using  jef.ind prior ###########
dnsrprioroba(x=20,prior="jef.ind",trend=0,
kappa=0.3,cov.model="matern",data=dataelev)
```

---

dtsrposoba *Objective posterior density for the TSR model*

---

## Description

It calculates the density function $\pi(\phi,\nu)$ (up to a proportionality constant) for the TSR model using the based reference, Jeffreys' rule, Jeffreys' independent and vague priors. In this context $\phi$ corresponds to the range parameter and $\nu$ to the degrees of freedom.

## Usage

```
dtsrposoba(x,formula,prior="reference",coords.col=1:2,
kappa=0.5,cov.model="exponential",data,asigma=2.1,intphi,intnu)
```

### Arguments

| | |
|---|---|
| `x` | A vector with the quanties $(\phi, \nu)$. For the vague prior x must be a three dimension vector $(\phi, \nu, \lambda)$ with $\lambda$ a number in the interval $(0.02, 0.5)$. See `DETAILS` below. |
| `formula` | A valid formula for a linear regression model. |
| `prior` | Objective prior densities avaiable for the TSR model: ( `reference`: Reference based, `jef.rul`: Jeffreys' rule, `jef.ind`: Jeffreys' independent). |
| `coords.col` | A vector with the column numbers corresponding to the spatial coordinates. |
| `kappa` | Shape parameter of the covariance function (fixed). |
| `cov.model` | Covariance functions available for the TSR model. `matern`: Matern, `pow.exp`: power exponential, `exponential`:exponential, `cauchy`: Cauchy, `spherical`: Spherical. |
| `data` | Data set with 2D spatial coordinates, the response and optional covariates. |
| `asigma` | Value of $a$ for vague prior. |
| `intphi` | An interval for $\phi$ used for vague prior. |
| `intnu` | An interval for $\nu$ used for vague prior. |

### Details

The posterior distribution is computed for this priors under the improper family $\frac{\pi(\phi,\nu)}{(\sigma^2)^a}$. For the vague prior, it was considered the structure $\pi(\phi, \nu, \lambda) = \phi(\phi)\pi(\nu|\lambda)\pi(\lambda)$ where a priori, $\phi$ follows an uniform distribution on the interval `intphi`, $\nu|\lambda\ Texp(\lambda, A)$ with A the interval given by the argument `intnu` and $\lambda\ unif(0.02, 0.5)$.

For the Jeffreys independent prior, this family of priors generates improper posterior distribution when intercept is considered for the mean function.

### Value

Posterior density of x=$(\phi, \nu)$ for the reference based, Jeffreys' rule and Jeffreys' independent priors. For the vague the result is the posterior density of x=$(\phi, \nu, \lambda)$

### Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

### References

Ordonez, J.A, M.O. Prattes, L.A. Matos, and V.H. Lachos (2020+). Objective Bayesian analysis for spatial Student-t regression models (Submitted).

### See Also

`dnsrposoba`,`dtsrprioroba`,`dnsrprioroba`

### Examples

```
data(dataca20)

######### Using reference prior ###########
dtsrposoba(x=c(5,11),prior="reference",formula=calcont~altitude+area,
kappa=0.3,cov.model="matern",data=dataca20)

######### Using Jeffreys' rule prior ###########
dtsrposoba(x=c(5,11),prior="jef.rul",formula=calcont~altitude+area,
kappa=0.3,cov.model="matern",data=dataca20)


######### Using Jeffreys' independent prior ###########
dtsrposoba(x=c(5,11),prior="jef.ind",formula=calcont~altitude+area
,kappa=0.3,cov.model="matern",data=dataca20)

######### Using vague independent prior ###########
dtsrposoba(x=c(5,11,.3),prior="vague",formula=calcont~altitude+area,
kappa=0.3,cov.model="matern",data=dataca20,intphi=c(0.1,10),
intnu=c(4.1,30))
```

---

`dtsrprioroba` *Objective prior density for the TSR model*

---

### Description

It calculates the density function $\pi(\phi, \nu)$ (up to a proportionality constant) for the TSR model using the based reference, Jeffreys' rule and Jeffreys' independent priors. In this context $\phi$ corresponds to the range parameter and $\nu$ to the degrees of freedom.

### Usage

```
dtsrprioroba(x,trend="cte",prior="reference",coords.col=1:2,
kappa=0.5,cov.model="exponential",data)
```

### Arguments

| | |
|---|---|
| `x` | A vector with the quanties $(\phi, \nu)$ |
| `trend` | Builds the trend matrix in accordance to a specification of the mean provided by the user. See `DETAILS` below. |
| `prior` | Objective prior densities avaiable for the TSR model: ( `reference`: Reference based, `jef.rul`: Jeffreys' rule, `jef.ind`: Jeffreys' independent) |
| `coords.col` | A vector with the column numbers corresponding to the spatial coordinates. |
| `kappa` | Shape parameter of the covariance function (fixed) |
| `cov.model` | Covariance functions available for the TSR model. `matern`: Matern, `pow.exp`: power exponential, `exponential`:exponential, `cauchy`: Cauchy, `spherical`: Spherical |
| `data` | Data set with 2D spatial coordinates, the response and optional covariates |

## Details

Denote as $\boldsymbol{c} = (c_1, c_2)$ the coordinates of a spatial location. `trend` defines the design matrix as:

- `0` (zero,without design matrix) Only valid for the Independent Jeffreys' prior
- `"cte"`, the design matrix is such that mean function $\mu(\boldsymbol{c}) = \mu$ is constant over the region.
- `"1st"`, the design matrix is such that mean function becames a first order polynomial on the coordinates:
$$\mu((c)) = \beta_0 + \beta_1 c_1 + \beta_2 c_2$$
- `"2nd"`, the design matrix is such that mean function $\mu(\boldsymbol{c}) = \mu$ becames a second order polynomial on the coordinates:
$$\mu((c)) = \beta_0 + \beta_1 c_1 + \beta_2 c_2 + \beta_3 c_1^2 + \beta_4 c_2^2 + \beta_5 c_1 c_2$$
- `~model` a model specification to include covariates (external trend) in the model.

## Value

Density of x=$(\phi, \nu)$

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Ordonez, J.A, M.O. Prattes, L.A. Matos, and V.H. Lachos (2020+). Objective Bayesian analysis for spatial Student-t regression models (Submitted).

## See Also

dtsrposoba,dnsrprioroba,dnsrposoba

## Examples

```
data(dataca20)

######### Using reference prior and a constant trend###########
dtsrprioroba(x=c(6,100),kappa=0.3,cov.model="matern",data=dataca20)


######### Using jef.rule prior and 1st trend###########
dtsrprioroba(x=c(6,100),prior="jef.rul",trend=~altitude+area,
kappa=0.3,cov.model="matern",data=dataca20)

######### Using  jef.ind prior ###########
dtsrprioroba(x=c(6,100),prior="jef.ind",trend=0,
kappa=0.3,cov.model="matern",data=dataca20)
```

`intmnorm` *Marginal posterior density for a model.*

### Description

It calculates the marginal density density for a model $M$ (up to a proportionality constant) for the NSR model using the based reference, Jeffreys' rule, Jeffreys' independent and vague priors. In this context $\phi$ corresponds to the range parameter.

### Usage

```
intmnorm(formula,prior="reference",coords.col=1:2,kappa=0.5,
cov.model="exponential",data,asigma=2.1,intphi,maxEval)
```

### Arguments

| | |
|---|---|
| `formula` | A valid formula for a linear regression model. |
| `prior` | Objective prior densities avaiable for the TSR model: ( `reference`: Reference based, `jef.rul`: Jeffreys' rule, `jef.ind`: Jeffreys' independent). |
| `coords.col` | A vector with the column numbers corresponding to the spatial coordinates. |
| `kappa` | Shape parameter of the covariance function (fixed). |
| `cov.model` | Covariance functions available for the TSR model. `matern`: Matern, `pow.exp`: power exponential, `exponential`:exponential, `cauchy`: Cauchy, `spherical`: Spherical. |
| `data` | Data set with 2D spatial coordinates, the response and optional covariates. |
| `asigma` | Value of $a$ for vague prior. |
| `intphi` | An interval for $\phi$ used for vague prior. |
| `maxEval` | Maximum number of iterations for the integral computation. |

### Details

Let $m_k$ a parametric model with parameter vector $\theta_k$. Under the TSR model and the prior density proposal:

$$\frac{\pi(\phi)}{(\sigma^2)^a}$$

we have that the marginal density is given by:

$$\int L(\theta_{m_k})\pi(m_k)dm_k$$

This quantity can be useful as a criteria for model selection. The computation of $m_k$ could be compute demanding depending on the number of iterations in `maxEval`.

## Value

Marginal density of the model $m_k$ for the reference based, Jeffreys' rule, Jeffreys' independent and vague priors.

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Berger, J.O, De Oliveira, V. and Sanso, B. (2001). Objective Bayesian Analysis of Spatially Correlated Data. Journal of the American Statistical Association., 96, 1361 – 1374.

## See Also

dnsrposoba,dtsrprioroba,dnsrprioroba

## Examples

```
data(dataca20)

set.seed(25)
data(dataelev)## data using by Berger et. al (2001)

######### Using reference prior ###########
m1=intmnorm(prior="reference",formula=elevation~1,
kappa=0.5,cov.model="matern",data=dataelev,maxEval=1000)

log(m1)


######### Using reference prior kappa=1 ###########
m2=intmnorm(prior="reference",formula=elevation~1,
kappa=1,cov.model="matern",data=dataelev,maxEval=1000)
log(m2)

######### Using reference prior kappa=1.5 ###########
m3=intmnorm(prior="reference",formula=elevation~1
,kappa=1.5,cov.model="matern",data=dataelev,maxEval=1000)
log(m3)

tot=m1+m2+m3

########posterior probabilities: higher probability:
#########prior="reference", kappa=1
p1=m1/tot
```

```
p2=m2/tot
p3=m3/tot
```

---

`intmT` *Marginal posterior density for a model.*

---

## Description

It calculates the marginal density density for a model $M$ (up to a proportionality constant) for the TSR model using the based reference, Jeffreys' rule, Jeffreys' independent and vague priors. In this context $\phi$ corresponds to the range parameter and $\nu$ to the degrees of freedom.

## Usage

```
intmT(formula,prior="reference",coords.col=1:2,kappa=0.5,
cov.model="exponential",data,asigma,intphi="default",intnu=c(4.1,Inf),maxEval)
```

## Arguments

| | |
|---|---|
| `formula` | A valid formula for a linear regression model. |
| `prior` | Objective prior densities avaiable for the TSR model: ( `reference`: Reference based, `jef.rul`: Jeffreys' rule, `jef.ind`: Jeffreys' independent). |
| `coords.col` | A vector with the column numbers corresponding to the spatial coordinates. |
| `kappa` | Shape parameter of the covariance function (fixed). |
| `cov.model` | Covariance functions available for the TSR model. `matern`: Matern, `pow.exp`: power exponential, `exponential`:exponential, `cauchy`: Cauchy, `spherical`: Spherical. |
| `data` | Data set with 2D spatial coordinates, the response and optional covariates. |
| `asigma` | Value of $a$ for vague prior. |
| `intphi` | An interval for $\phi$ used for vague prior. |
| `intnu` | An interval for $\nu$ used for vague prior. |
| `maxEval` | Maximum number of iterations for the integral computation. |

## Details

Let $m_k$ a parametric model with parameter vector $\theta_k$. Under the TSR model and the prior density proposal:

$$\frac{\pi(\phi,\nu)}{(\sigma^2)^a}$$

we have that the marginal density is given by:

$$\int L(\theta_{m_k})\pi(m_k)dm_k$$

This quantity can be useful as a criteria for model selection. The computation of $m_k$ could be compute demanding depending on the number of iterations in `maxEval`.

## Value

Marginal density of the model $m_k$ for the reference based, Jeffreys' rule, Jeffreys' independent and vague priors.

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Ordonez, J.A, M.O. Prattes, L.A. Matos, and V.H. Lachos (2020+). Objective Bayesian analysis for spatial Student-t regression models (Submitted).

## See Also

dnsrposoba,dtsrprioroba,dnsrprioroba

## Examples

```
set.seed(25)
data(dataca20)



######### Using reference prior ###########
m1=intmT(prior="reference",formula=calcont~altitude+area,
kappa=0.3,cov.model="matern",data=dataca20,maxEval=1000)

######### Using Jeffreys' rule prior ###########
m1j=intmT(prior="jef.rul",formula=calcont~altitude+area,
kappa=0.3,cov.model="matern",data=dataca20,maxEval=1000)


######### Using Jeffreys' independent prior ###########
m1ji=intmT(prior="jef.ind",formula=calcont~altitude+area
,kappa=0.3,cov.model="matern",data=dataca20,maxEval=1000)

m1v=intmT(prior="vague",formula=calcont~altitude+area
,kappa=0.3,cov.model="matern",data=dataca20,maxEval=1000,intphi="default")



tot=m1+m1j+m1ji+m1v

########posterior probabilities: higher probability:
#########prior="reference", kappa=0.3
```

```
p1=m1/tot
pj=m1j/tot
pji=m1ji/tot
pv=m1v/tot
```

---

nsroba *Bayesian estimation for the NSR model.*

---

### Description

This function performs Bayesian estimation of $\theta = (\boldsymbol{\beta}, \sigma^2, \phi)$ for the NSR model using the based reference, Jeffreys' rule ,Jeffreys' independent and vague priors.

### Usage

```
nsroba(formula, method="median",
prior = "reference",coords.col = 1:2,kappa = 0.5,
cov.model = "matern", data,asigma=2.1, intphi = "default",
ini.pars, burn=500, iter=5000, thin=10,
cprop = NULL)
```

### Arguments

| | |
|---|---|
| `formula` | A valid formula for a linear regression model. |
| `method` | Method to estimate $(\boldsymbol{beta}, \sigma, \phi)$. The methods availables are `"mean"`,`"median"` and `"mode"`. |
| `prior` | Objective prior densities avaiable for the TSR model: ( `reference`: Reference based, `jef.rul`: Jeffreys' rule, `jef.ind`: Jeffreys' independent, `vague`, Vague). |
| `coords.col` | A vector with the column numbers corresponding to the spatial coordinates. |
| `kappa` | Shape parameter of the covariance function (fixed). |
| `cov.model` | Covariance functions available for the TSR model. `matern`: Matern, `pow.exp`: power exponential, `exponential`:exponential, `cauchy`: Cauchy, `spherical`: Spherical. |
| `data` | Data set with 2D spatial coordinates, the response and optional covariates. |
| `asigma` | Value of $a$ for the vague prior. |
| `intphi` | An interval for $\phi$ used for the uniform proposal. See `DETAILS` below. |
| `ini.pars` | Initial values for $(\sigma^2, \phi)$ in that order. |
| `burn` | Number of observations considered in the burning process. |
| `iter` | Number of iterations for the sampling procedure. |
| `thin` | Number of observations considered in the thin process. |
| `cprop` | A constant related to the acceptance probability (Default = NULL indicates that cprop is computed as the interval length of intphi). See `DETAILS` below. |

## Details

For the "unif" proposal, it was considered the structure where a priori, $\phi$ follows an uniform distribution on the interval intphi. By default, this interval is computed using the empirical range of data as well as the constant cprop.

For the Jeffreys independent prior, the sampling procedure generates improper posterior distribution when intercept is considered for the mean function.

## Value

| | |
|---|---|
| $dist | Joint sample (matrix object) obtaining for $(\boldsymbol{beta}, \sigma^2, \phi)$. |
| $betaF | Sample obtained for $\boldsymbol{beta}$. |
| $sigmaF | Sample obtained for $\sigma^2$. |
| $phiF | Sample obtained for $\phi$. |
| $coords | Spatial data coordinates. |
| $kappa | Shape parameter of the covariance function. |
| $X | Design matrix of the model. |
| $type | Covariance function of the model. |
| $theta | Bayesian estimator of $(\boldsymbol{beta}, \sigma, \phi)$. |
| $y | Response variable. |
| $prior | Prior density considered. |

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Berger, J.O, De Oliveira, V. and Sanso, B. (2001). Objective Bayesian Analysis of Spatially Correlated Data. Journal of the American Statistical Association., 96, 1361 – 1374.

## See Also

dnsrposoba,dtsrprioroba,dnsrprioroba, tsroba

## Examples

```
set.seed(25)
data(dataelev)
```

```
######covariance matern: kappa=0.5
res=nsroba(elevation~1, kappa = 0.5, cov.model = "matern", data=dataelev,
ini.pars=c(10,390))

summary(res)

######covariance matern: kappa=1
res1=nsroba(elevation~1, kappa = 1, cov.model = "matern", data=dataelev,
ini.pars=c(10,390))

summary(res1)

######covariance matern: kappa=1.5
res2=nsroba(elevation~1, kappa = 1.5, cov.model = "matern", data=dataelev,
ini.pars=c(10,390))

summary(res2)
```

---

nsrobapred1 *Prediction under Normal Objective Bayesian Analysis (OBA).*

---

## Description

This function uses the sampling distribution of parameters obtained from the function `tsroba` to predict values at unknown locations.

## Usage

```
nsrobapred1(xpred, coordspred, obj)
```

## Arguments

| | |
|---|---|
| `xpred` | Values of the X design matrix for prediction coordinates. |
| `coordspred` | Points coordinates to be predicted. |
| `obj` | object of the class "nsroba" (see `nsroba` function). |

## Details

This function predicts using the sampling distribution of parameters obtained from the function `nsroba` and the conditional normal distribution of the predicted values given the data.

## Value

This function returns a vector with the predicted values at the specified locations.

### Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

### References

Berger, J.O, De Oliveira, V. and Sanso, B. (2001). Objective Bayesian Analysis of Spatially Correlated Data. Journal of the American Statistical Association., 96, 1361 – 1374.

Diggle, P. and P. Ribeiro (2007).Model-Based Geostatistics. Springer Series in Statistics.

### See Also

nsroba,tsrobapred

### Examples

```
set.seed(25)
data(dataelev)
d1=dataelev[1:42,]

reselev=nsroba(elevation~1, kappa = 0.5, cov.model = "matern", data=d1,
ini.pars=c(10,3),intphi=c(0.8,10))

datapred1=dataelev[43:52,]
coordspred1=datapred1[,1:2]
nsrobapred1(obj=reselev,coordspred=coordspred1,xpred=rep(1,10))
```

---

## summary.nsroba — *Summary of a nsroba object*

---

### Description

`summary` method for class "nsroba".

### Usage

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

### Arguments

| | |
|---|---|
| `object` | object of the class "nsroba" (see nsroba function). |
| `...` | Additional arguments. |

## Value

| | |
|---|---|
| mean.str | Estimates for the mean structure parameters $\boldsymbol{beta}$. |
| var.str | Estimates for the variance structure parameters $\sigma^2, \phi$. |
| betaF | Sample obtained for $\boldsymbol{beta}$. |
| sigmaF | Sample obtained for $\sigma^2$. |
| phiF | Sample obtained for $\phi$. |

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Berger, J.O, De Oliveira, V. and Sanso, B. (2001). Objective Bayesian Analysis of Spatially Correlated Data. Journal of the American Statistical Association., 96, 1361 – 1374.

## See Also

dnsrposoba,dtsrprioroba,dnsrprioroba, tsroba

## Examples

```
set.seed(25)
data(dataelev)


######covariance matern: kappa=0.5
res=nsroba(elevation~1, kappa = 0.5, cov.model = "matern", data=dataelev,
ini.pars=c(10,3))

summary(res)
```

---

`summary.tsroba` *Summary of a nsroba object*

---

## Description

`summary` method for class "tsroba".

## Usage

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

## Arguments

| | |
|---|---|
| `object` | object of the class "tsroba" (see `tsroba` function). |
| `...` | Additional arguments. |

## Value

| | |
|---|---|
| `mean.str` | Estimates for the mean structure parameters $\boldsymbol{beta}$. |
| `var.str` | Estimates for the variance structure parameters $\sigma^2, \phi, \nu$. |
| `betaF` | Sample obtained for $\boldsymbol{beta}$. |
| `sigmaF` | Sample obtained for $\sigma^2$. |
| `phiF` | Sample obtained for $\phi$. |
| `nuF` | Sample obtained for $\nu$. |

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Ordonez, J.A, M.O. Prattes, L.A. Matos, and V.H. Lachos (2020+). Objective Bayesian analysis for spatial Student-t regression models. (Submitted)

## See Also

`dnsrposoba`,`dtsrprioroba`,`dnsrprioroba`,`tsroba`

## Examples

```
set.seed(25)
data(dataca20)
d1=dataca20[1:158,]

xpred=model.matrix(calcont~altitude+area,data=dataca20[159:178,])
xobs=model.matrix(calcont~altitude+area,data=dataca20[1:158,])
coordspred=dataca20[159:178,1:2]

######covariance matern: kappa=0.3 prior:reference
res=tsroba(calcont~altitude+area, kappa = 0.3, data=d1,
           ini.pars=c(10,3,10))

summary(res)
```

---

`tsroba` *Bayesian estimation for the TSR model.*

---

## Description

This function performs Bayesian estimation of $\theta = (\boldsymbol{\beta}, \sigma^2, \phi)$ for the TSR model using the based reference, Jeffreys' rule ,Jeffreys' independent and vague priors.

## Usage

```
tsroba(formula, method="median",sdnu=1,
prior = "reference",coords.col = 1:2,kappa = 0.5,
cov.model = "matern", data,asigma=2.1, intphi = "default",
intnu="default",ini.pars,burn=500, iter=5000,thin=10,cprop = NULL)
```

## Arguments

| | |
|---|---|
| `formula` | A valid formula for a linear regression model. |
| `method` | Method to estimate $(\boldsymbol{beta}, \sigma, \phi, \nu)$. The methods availables are `"mean"`,`"median"` and `"mode"`. |
| `sdnu` | Standard deviation logarithm for the lognormal proposal for $\nu$ |
| `prior` | Objective prior densities avaiable for the TSR model: ( `reference`: Reference based, `jef.rul`: Jeffreys' rule, `jef.ind`: Jeffreys' independent,`vague`: Vague). |
| `coords.col` | A vector with the column numbers corresponding to the spatial coordinates. |
| `kappa` | Shape parameter of the covariance function (fixed). |

| | |
|---|---|
| `cov.model` | Covariance functions available for the TSR model. `matern`: Matern, `pow.exp`: power exponential, `exponential`:exponential, `cauchy`: Cauchy, `spherical`: Spherical. |
| `data` | Data set with 2D spatial coordinates, the response and optional covariates. |
| `asigma` | Value of $a$ for vague prior. |
| `intphi` | An interval for $\phi$ used for the uniform proposal. See `DETAILS` below. |
| `intnu` | An interval for $\nu$ used for the uniform proposal. See `DETAILS` below. |
| `ini.pars` | Initial values for $(\sigma^2, \phi, \nu)$ in that order. |
| `burn` | Number of observations considered in burning process. |
| `iter` | Number of iterations for the sampling procedure. |
| `thin` | Number of observations considered in thin process. |
| `cprop` | A constant related to the acceptance probability (Default = NULL indicates that cprop is computed as the interval length of intphi). See `DETAILS` below. |

## Details

For the prior proposal, it was considered the structure $\pi(\phi, \nu, \lambda) = \phi(\phi)\pi(\nu|\lambda)\pi(\lambda)$. For the vague prior, $\phi$ follows an uniform distribution on the interval `intphi`, by default, this interval is computed using the empirical range of data as well as the constant `cprop`. On the other hand, $\nu|\lambda\, Texp(\lambda, A)$ with A the interval given by the argument `intnu` and $\lambda\, unif(0.02, 0.5)$

For the Jeffreys independent prior, the sampling procedure generates improper posterior distribution when intercept is considered for the mean function.

## Value

| | |
|---|---|
| `dist` | Joint sample (matrix object) obtaining for $(\boldsymbol{beta}, \sigma^2, \phi)$. |
| `betaF` | Sample obtained for $\boldsymbol{beta}$. |
| `sigmaF` | Sample obtained for $\sigma^2$. |
| `phiF` | Sample obtained for $\phi$. |
| `nuF` | Sample obtained for $\phi$. |
| `coords` | Spatial data coordinates. |
| `kappa` | Shape parameter of the covariance function. |
| `$X` | Design matrix of the model. |
| `$type` | Covariance function of the model. |
| `$theta` | Bayesian estimator of $(\boldsymbol{beta}, \sigma, \phi)$. |
| `$y` | Response variable. |
| `$prior` | Prior density considered. |

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Ordonez, J.A, M.O. Prattes, L.A. Matos, and V.H. Lachos (2020+). Objective Bayesian analysis for spatial Student-t regression models. (Submitted)

## See Also

dnsrposoba,dtsrprioroba,dnsrprioroba,tsroba

## Examples

```
set.seed(25)
data(dataca20)
d1=dataca20[1:158,]

xpred=model.matrix(calcont~altitude+area,data=dataca20[159:178,])
xobs=model.matrix(calcont~altitude+area,data=dataca20[1:158,])
coordspred=dataca20[159:178,1:2]

######covariance matern: kappa=0.3 prior:reference
res=tsroba(calcont~altitude+area, kappa = 0.3, data=d1,
           ini.pars=c(10,390,10),iter=11000,burn=1000,thin=10)

summary(res)

######covariance matern: kappa=0.3 prior:jef.rul
res1=tsroba(calcont~altitude+area, kappa = 0.3,
            data=d1,prior="jef.rul",ini.pars=c(10,390,10),
            iter=11000,burn=1000,thin=10)

summary(res1)

######covariance matern: kappa=0.3 prior:jef.ind
res2=tsroba(calcont~altitude+area, kappa = 0.3, data=d1,
            prior="jef.ind",ini.pars=c(10,390,10),iter=11000,
            burn=1000,thin=10)

summary(res2)

######covariance matern: kappa=0.3 prior:vague
res3=tsroba(calcont~altitude+area, kappa = 0.3,
     data=d1,prior="vague",ini.pars=c(10,390,10),,iter=11000,
     burn=1000,thin=10)

summary(res3)

####obtaining posterior probabilities
```

```
###(just comparing priors with kappa=0.3).
###the real aplication (see Ordonez et.al) consider kappa=0.3,0.5,0.7.

######### Using reference prior ###########
m1=intmT(prior="reference",formula=calcont~altitude+area,
kappa=0.3,cov.model="matern",data=dataca20,maxEval=1000)

######### Using Jeffreys' rule prior ###########
m1j=intmT(prior="jef.rul",formula=calcont~altitude+area,
kappa=0.3,cov.model="matern",data=dataca20,maxEval=1000)


######### Using Jeffreys' independent prior ###########
m1ji=intmT(prior="jef.ind",formula=calcont~altitude+area
,kappa=0.3,cov.model="matern",data=dataca20,maxEval=1000)

m1v=intmT(prior="vague",formula=calcont~altitude+area
,kappa=0.3,cov.model="matern",data=dataca20,maxEval=1000,intphi="default")


tot=m1+m1j+m1ji+m1v

####posterior probabilities#####
p1=m1/tot
pj=m1j/tot
pji=m1ji/tot
pv=m1v/tot


##########MSPE#######################################

pme=tsrobapred(res,xpred=xpred,coordspred=coordspred)
pme1=tsrobapred(res1,xpred=xpred,coordspred=coordspred)
pme2=tsrobapred(res2,xpred=xpred,coordspred=coordspred)
pme3=tsrobapred(res3,xpred=xpred,coordspred=coordspred)

mse=mean((pme-dataca20$calcont[159:178])^2)
mse1=mean((pme1-dataca20$calcont[159:178])^2)
mse2=mean((pme2-dataca20$calcont[159:178])^2)
mse3=mean((pme3-dataca20$calcont[159:178])^2)
```

## tsrobapred — *Prediction under Student-t Objective Bayesian Analysis (OBA).*

### Description

This function uses the sampling distribution of parameters obtained from the function `tsroba` to predict values at unknown locations.

## Usage

```
tsrobapred(obj,xpred,coordspred)
```

## Arguments

| | |
|---|---|
| `obj` | object of the class "tsroba" (see `tsroba` function). |
| `xpred` | Values of the X design matrix for prediction coordinates. |
| `coordspred` | Points coordinates to be predicted. |

## Details

This function predicts using the sampling distribution of parameters obtained from the function `tsroba` and the conditional Student-t distribution of the predicted values given the data.

## Value

This function returns a vector with the predicted values at the specified locations.

## Author(s)

Jose A. Ordonez, Marcos O. Prates, Larissa A. Matos, Victor H. Lachos.

## References

Diggle, P. and P. Ribeiro (2007).Model-Based Geostatistics. Springer Series in Statistics.

Ordonez, J.A, M.O. Prattes, L.A. Matos, and V.H. Lachos (2020+). Objective Bayesian analysis for spatial Student-t regression models. (Submitted)

## See Also

`tsroba`,`nsrobapred1`

## Examples

```
set.seed(25)
data(dataca20)
d1=dataca20[1:158,]

######covariance matern: kappa=0.3 prior:reference
res=tsroba(calcont~altitude+area, kappa = 0.3, data=d1,
ini.pars=c(10,3,10),iter=50,thin=1,burn=5)

datapred=dataca20[159:178,]
formula=calcont~altitude+area
xpred=model.matrix(formula,data=datapred)

tsrobapred(res,xpred=xpred,coordspred=dataca20[159:178,1:2])
```

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