Package 'B2Z'

February 14, 2012

Type Package

Version 1.4

Date 2011-07-16

Title Bayesian Two-Zone Model

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Depends numDeriv, coda, mvtnorm

Description This package fits the Bayesian two-Zone Models.

License GPL-2

LazyLoad yes

Repository CRAN

Date/Publication 2011-07-18 18:37:35

R topics documented:

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B2Z-package *Bayesian Two-Zone Models (B2ZM)*

Description

The B2Z R-package fits the Bayesian two-zone model proposed by Zhang et al. (2009). Denote $CN(t)$ and $CF(t)$ by the concentrations at time t in the near and far fields, respectively. The deterministic equations in the two-zone modeling are given by:

$$(d/dt)CN(t) = Beta/VN(CF(t) - CN(t) + G/Beta)(1)$$

$$(d/dt)CF(t) = Beta/VF(CN(t) - (1 + Q/Beta)CF(t))(2)$$

where Beta is the interzonal air flow rate; Q is the supply and exhaust flow rate; and G is the contaminant emission rate. We assume that CN(0) = CF(0) = 0.

Denote $YN(t)$ and $YF(t)$ by the observed log concentrations at time (t) in the near and far fields, respectively. Zhang et al. (2009) assume that the joint probability distribution of $YN(t)$ and $YF(t)$ is a bivariate normal distribution where the mean is the solution of the differential equations (1) and (2), and the covariance matrix is composed by unknown parameters: $TauN$ (variance of the measurement error at the near field), $TauNF$ (covariance between the measurements at the near and far fields) and $TauF$ (variance of the measurement error at the far field). If the near and far field measurements error processes are independent, then $TauNF = 0$. Both dependent (default) and independent models are provided in this R-package.

Several options as prior distribution for $Beta$, Q and G are provided. In the independent model, the priors distributions for $TauN$ and $TauF$ are inverse gamma distributions; and in the dependent model the prior joint distribution of $TauN$, $TauNF$ and $TauF$ is the Inverse Wishart Distribution.

Three sample methods are available: Gibbs with Metropolis step, Incremental Mixture Importance Sampling (IMIS) and Sampling Importance Resampling (SIR). In addition, estimation using the Bayesian central limit theorem (Laplace approximation) is also available (BCLT). The user can fit the Bayesian two-zone model by using the function `B2ZM` and in this function specifying which sampler method to use OR using one of the functions: `B2ZM_MCMC`, `B2ZM_IMIS`, `B2ZM_SIR` and `B2ZM_BCLT`. In any case, the output is valid as an input for the functions `summary` and `plot`.

Details

Package:	B2Z
Type:	Package
Version:	1.4
Date:	2011-07-16
License:	GPL-2
LazyLoad:	yes

Author(s)

Joao Vitor Dias Monteiro, Sudipto Banerjee and Gurumurthy Ramachandran.

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References

Monteiro, J. V. D., Banerjee, S. and Ramachandran, G. (2011). B2Z: An R Package for Bayesian Two-Zone Models. *Journal of Statistical Software* 43 (2) 1–23. http://www.jstatsoft.org/v43/i02/

Raftery, A. E. and Bao, L. (2009). Estimating and Projecting Trends in HIV/AIDS Generalized Epidemics Using Incremental Mixture Importance Sampling. http://www.stat.washington.edu/research/reports/2009/tr560.pdf

Zhang, Y., Banerjee, S., Yang,R., Lungu,C. and Ramachandran, G. (2009). Bayesian Modeling of Exposure and Airflow Using Two-Zone Models. *The Annals of Occupational Hygiene*, **53**, 409-424. http://www.biostat.umn.edu/~sudiptob/ResearchPapers/ZBYLR.pdf

See Also

B2ZM, B2ZM_BCLT, B2ZM_IMIS, B2ZM_MCMC, B2ZM_SIR

B2ZM *Bayesian Two-Zone Models*

Description

B2ZM obtains random samples from the posterior distribution of parameters and exposure concentrations for the Bayesian two-zone model proposed by Zhang et al. (2009). Three sample methods are available: Gibbs with Metropolis step (MCMC), Incremental Mixture Importance Sampling (IMIS) and Sampling Importance Resampling (SIR). In addition, estimation using the Bayesian central limit theorem (Laplace approximation) is available. The user can choose whether the near and far field measurement error processes are dependent or not. In the independent model, 5 parameters are considered: 1) Beta: Interzonal air flow rate (m3); 2) Q: supply and exhaust flow rate (m3/min); 3) G: contaminant emission rate (mg/min); 4) Tau_N: variance of the measurement error at the near field; 5)Tau_F; variance of the measurement error at the far field. In the dependent model (default), one more parameter is considered: 6) Tau_NF: covariance between the measurements at the near and far field. Any prior distribution for Beta, Q and G can be chosen. In the independent model, the prior distributions for Tau_N and Tau_F are inverse gamma distributions; in the dependent model, the prior joint distribution of Tau_N, Tau_NF and Tau_F is the Inverse Wishart Distribution (see the Details section for more information on the parameterization of these distributions). The output from B2ZM is a list that belongs to one of the following classes: mcmc, imis, sir and bclt. This output is valid as an input for the functions summary and plot.

Usage

```
B2ZM (data = NULL, priorBeta, priorQ, priorG,
      v, S, tauN.sh, tauN.sc, tauF.sh, tauF.sc,
      VN, VF, indep.model = FALSE, cred = 95,
      sampler = c("MCMC", "BCLT", "IMIS", "SIR"),
      sir.control = list(m = 10000),
      bclt.control = list(m = 7000, sample_size = 2000),
      imis.control = list(N0 = 6000,B = 600,M = 3000,it.max=16),
      mcmc.control = list(NUpd = 10000, burnin = 1000, lag = 1,
                  initial = NULL, Sigma.Cand = NULL, m = 1000),
      figures = list(save = FALSE, type =c("ps", "eps","pdf",
                    "png", "jpg")))
```

Arguments

data	A 3-column matrix where the columns are time, concentrations at the near field, and concentrations at the far field, respectively. The time must be scaled in minutes (min), and the concentrations must be scaled in miligrams per cubic meter (mg/m3)
priorBeta	A string defining the prior distribution for the parameter Beta. To declare the prior distribution of Beta, use standard R nomenclature for probability distributions. For example, if the prior of Beta is a Uniform(0,20), declare it with "unif(0,20)"; if it is a Normal(0,1), declare it with "norm(0,1)". DO NOT put an "d" or "r" in front the name of the distributions. The options are: "unif(a,b)", "gamma(a,b)", "exp(a)", "norm(a,b)", "t(a)", "weibull(a,b)", "f(a,b)", "chisq(a,b)", "cauchy(a,b)" and "lnorm(a,b)".
priorQ	A string defining the prior distribution for Q (use the nomenclature as for priorBeta).
priorG	A string defining the prior distribution for G (use the nomenclature as for priorBeta).
v	Degrees of freedom for the Inverse Wishart distribution (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
S	A 2x2 positive definite matrix for the Inverse Wishart (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
tauN.sh	The shape parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).
tauN.sc	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).
tauF.sh	The shape parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).
tauF.sc	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).
VN	Volume of the near field in cubic meters (m3).
VF	Volume of the far field in cubic meters (m3).
indep.model	A logical value indicating whether the independent model should be considered. The default is FALSE.

`cred` A scalar between 0 and 100 indicating the credibility level for the posterior intervals of the parameters.

`sampler` A string indicating which sampler method should be used. The options are: "IMIS", "MCMC" (Metropolis within Gibbs) and "SIR". The default is "IMIS".

`sir.control` A list containing the SIR sampler specifications:

`m`: Number of samplings. The default is 10,000.

`bclt.control` A list containing the BCLT specifications:

`m`: Number of sampling values from the prior distribution used to estimate a good starting value that is used in the estimation of the posterior mode and covariance matrix. See the Details section for more information.

`sample_size`: Size of the sample from the posterior distribution of the parameters in model.

`imis.control` A list containing the IMIS sampler specifications:

`N0`: Initial number of inputs from the prior joint distribution of Beta, G, Q, Tau_N, Tau_F, and Tau_NF (if the dependent model is considered). The default is 6,000.

`B`: Number of inputs to be chosen in the Importance Sampling Stage. The default is 600.

`M`: Number of resamplings in the Resample Stage. The default is 3,000.

`it.max`: Maximum number of iterations in the Importance Sampling Stage to be tolerated, in case the stop condition suggested by Raftery and Bao (2009) takes too many time. The default is 16.

For details see Raftery and Bao (2009).

`mcmc.control` A list containing the Gibbs Sampling with Metropolis step sampler specifications:

`NUpd`: Number of updates. The default is 10,000.

`burnin`: Period of burn-in. The default is 1,000.

`lag`: Thin interval. The default is 1.

`initial`: A vector containing the initial values for the parameters: Beta, Q and G (exactly in this order).

`Sigma.Cand`: A 3x3 covariance matrix for the normal multivariate proposal distribution of Beta, Q and G. The default is NULL, and in this case, the covariance matrix used is the negative inverse of the hessian matrix of the log posterior distribution at the estimated posterior mode.

`m`: Number of sampling values from the prior distribution used to estimate a good starting value that is used in the estimation of `Sigma.Cand`. It is used only if `Sigma.Cand` is not declared. See the Details section for more information.

`figures` The command `plot(obj)` produces several plots, where `obj` is the output from `B2ZM`. Using `figures`, those plots are built internally and saved as eps, pdf, ps, png or jpg format. `figures` is a list containing the following parameters:

`save`: a logical value indicating that the figures are to be saved. The default is FALSE.

`type`: a string that indicates the image file type. The default is "ps".

Details

Parameterization priors: The inverse gamma and the inverse Wishart distributions used in `B2ZM` are from the package `MCMCpack`. The inverse gamma distribution with shape a and scale b has mean $b/(a-1)$ ($a>1$) and variance $(b^2)/((a-1)^2(a-2))$ ($a>2$). The inverse Wishart with v degrees of freedom and scalar matrix S has mean $S/(v-p-1)$, where p is the number of rows of S.

Covariance Matrix for the proposal distribution: If the covariance matrix for the multivariate normal poposal distribution is NULL for the Metropolis within Gibbs sampler the covariance matrix used is the negative inverse of the hessian matrix of the log posterior distribution at the estimated posterior mode. To estimate the posterior mode, the function `nlm` is used. The values of the estimated posterior mode depends on the starting parameter values. `m` is the number of sampling values from the prior distributions of Beta, Q and G. The vector (among the m sampled) with largest likelihood value is used as starting parameter values.

The covariance matrix is estimated using the function `hessian` from the package `numDeriv`, where the parameter vector is the estimated posterior mode.

Covariance Matrix estimation using BCLT: Similarly to the MCMC, the covariance matrix is estimated as the negative inverse of the hessian matrix of the log posterior distribution at the estimated posterior mode. To estimate the posterior mode, the function `nlminb` is used. The values of the estimated posterior mode depends on the starting parameter values. `m` is the number of sampling values from the prior distributions of Beta, Q and G. The vector (among the m sampled) with largest log posterior value is used as starting parameter values.

Value

`B2ZM` returns a list that belongs to one of the four classes: `bclt`, `mcmc`, `imis` and `sir`. The output from `B2ZM` contains the objects:

`Beta`	a vector containing the sampled values from the joint posterior distribution for the parameter Beta.
`Q`	a vector containing the sampled values from the joint posterior distribution for the parameter Q.
`G`	a vector containing the sampled values from the joint posterior distribution for the parameter G.
`tauN`	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_N.
`tauF`	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_F.
`tauNF`	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_NF (if the dependent model is used).
`Y`	a matrix containing the log of the observed concentrations.
`DIC`	deviance information criterion.
`ESS`	effective sample size.
`indep`	a logical value indicating whether the independent model was used.
`times`	a vector containing the times when the observed concentrations were measured.
`cred`	credibility of the posterior intervals.

prop	proportion of different points in the sampled values from the joint posterior distribution (only for 'sir' class).
weigths	weights used in the SIR method (only for 'sir' class).
maxw	maximum weight used in the SIR method (only for 'sir' class).
expfrac	expected fraction of unique points (only for 'imis' class)
V.hat	variance of the rescaled importance weights (only for 'imis' class)
U.hat	entropy of importance weights relative to uniformity (only for 'imis' class)
Q.hat	expected number of unique points after re-sampling (only for 'imis' class)
maxw	maximum importance weight (only for 'imis' class)
w	importance weights (only for 'imis' class)
AR	acceptance rate in the metropolis step (only for 'mcmc' class).
Sigma.Cand	covariance matrix used in the proposal distribution (only for 'mcmc' class).
initial	a vector containing the initial points (only for 'mcmc' class).
NUpd	number of updates (only for 'mcmc' class).
burnin	burn-in period (only for 'mcmc' class).
lag	thin interval (only for 'mcmc' class).

Methods defined for B2ZM objects are `summary` and `plot`.

Author(s)

Joao Vitor Dias Monteiro, Sudipto Banerjee and Gurumurthy Ramachandran.

References

Monteiro, J. V. D., Banerjee, S. and Ramachandran, G. (2011). B2Z: An R Package for Bayesian Two-Zone Models. *Journal of Statistical Software* 43 (2) 1–23. http://www.jstatsoft.org/v43/i02/

Raftery, A. E. and Bao, L. (2009). Estimating and Projecting Trends in HIV/AIDS Generalized Epidemics Using Incremental Mixture Importance Sampling. http://www.stat.washington.edu/research/reports/2009/tr560.pdf

Zhang, Y., Banerjee, S., Yang,R., Lungu,C. and Ramachandran, G. (2009). Bayesian Modeling of Exposure and Airflow Using Two-Zone Models. *The Annals of Occupational Hygiene*, **53**, 409-424. http://www.biostat.umn.edu/~sudiptob/ResearchPapers/ZBYLR.pdf

See Also

B2Z, B2ZM_MCMC, B2ZM_BCLT, B2ZM_IMIS, B2ZM_SIR

Examples

```
##################
#Dependent Model#
################

#Data 1:  100 simulated concentrations during the times
#between 0 and 4, using the parameters Beta = 5, Q = 13.8,
#G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1,
#Tau_NF = 0.5 and Tau_F = 0.64.
## Not run:
data(ex1)

#######
#BCLT#
#####

r <- B2ZM(data = ex1, priorBeta = "unif(0,10)",
         priorQ="unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
         v = 4, VN = pi*10^-3, VF = 3.8, sampler = "BCLT",
         bclt.control=list( m = 7000, sample_size=2000))


summary(r)
plot(r)


#########################
#METROPOLIS WITHIN GIBBS#
#########################

r <- B2ZM(data = ex1, priorBeta = "unif(0,10)",
     priorQ="unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
     v = 4, VN = pi*10^-3, VF = 3.8, sampler = "MCMC",
     mcmc.control = list(NUpd = 10000, burnin = 1000,
     lag = 1, m = 5000) )

summary(r)
plot(r)


#######
#IMIS#
#####

r <- B2ZM(data = ex1, priorBeta = "unif(0,10)",
     priorQ="unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
     v = 4, VN = pi*10^-3, VF = 3.8, sampler="IMIS",
     imis.control = list( N0 = 6000, B = 600, M = 3000, it.max = 12))

summary(r)
plot(r)
```

```
######
#SIR#
####

r <- B2ZM(data = ex1, priorBeta = "unif(0,10)",
     priorQ="unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
     v = 4, VN = pi*10^-3, VF = 3.8, sampler="SIR",
     sir.control = list(m = 10000) )

plot(r)
summary(r)

#############################################################################

#####################
#Independent Model #
###################

#Data 2:  100 simulated concentrations during the times
#between 0 and 4, using the parameters Beta = 5, Q = 13.8,
#G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1,
#Tau_NF = 0 and Tau_F = 0.64.

data(ex2)

#######
#BCLT#
#####

r <- B2ZM(data = ex2,  priorBeta = "unif(0,10)",
     priorQ="unif(11,17)", priorG = "unif(281,482)",
     tauN.sh = 5 , tauN.sc = 4 , tauF.sh = 5, tauF.sc = 7,
     VN = pi*10^-3,  VF = 3.8, sampler = "BCLT",
     indep.model = TRUE, bclt.control=list(m = 7000,
     sample_size=2000))

summary(r)
plot(r)


########################
#METROPOLIS WITHIN GIBBS#
########################

r <- B2ZM(data = ex2, indep.model = TRUE,
     priorBeta = "unif(0,10)", priorQ="unif(11,17)",
     priorG = "unif(281,482)", tauN.sh = 5 , tauN.sc = 4 , tauF.sh = 5,
     tauF.sc = 7 , VN = pi*10^-3, VF = 3.8, sampler = "MCMC",
     mcmc.control = list(NUpd = 10000,  burnin = 1000, lag = 1,
     m = 10000))
```

```
summary(r)
plot(r)


#######
#IMIS#
#####

r <- B2ZM(data = ex2, indep.model = TRUE,
     priorBeta = "unif(0,10)", priorQ="unif(11,17)",
     priorG = "unif(281,482)", tauN.sh = 5 , tauN.sc = 4 , tauF.sh = 5,
     tauF.sc = 7 , VN = pi*10^-3, VF = 3.8, sampler = "IMIS",
     imis.control = list(N0 = 5000, B = 500, M =  3000,  it.max = 12))

summary(r)
plot(r)


######
#SIR#
####

r <- B2ZM(data = ex2, indep.model = TRUE,
     priorBeta = "unif(0,10)", priorQ="unif(11,17)",
     priorG = "unif(281,482)", tauN.sh = 5 , tauN.sc = 4 , tauF.sh = 5,
     tauF.sc = 7 , VN = pi*10^-3, VF = 3.8, sampler = "SIR",
     sir.control = list(m = 10000))

plot(r)
summary(r)

## End(Not run)
```

B2ZM_BCLT *Bayesian Two-Zone Models: using Bayesian Central Limit Theorem (BCLT) - Laplace Approximation*

Description

B2ZM_BCLT obtains random samples from the posterior distribution of the parameters and exposure concentrations for the Bayesian two-zone model proposed by Zhang et al. (2009) using the Bayesian Central Limit Theorem (Laplace Approximation). The user can choose whether the near and far field measurement error processes are dependent or not. In the independent model, 5 parameters are considered: 1) Beta: Interzonal air flow rate (m3); 2) Q: supply and exhaust flow rate (m3/min); 3) G: contaminant emission rate (mg/min); 4) Tau_N: variance of the measurement error at the near field; 5)Tau_F; variance of the measurement error at the far field. In the dependent model (default), one more parameter is considered: 6) Tau_NF: covariance between the measurements at the near

and far field. Any prior distribution for Beta, Q and G can be chosen. In the independent model, the prior distributions for Tau_N and Tau_F are inverse gamma distributions; in the dependent model, the prior joint distribution of Tau_N, Tau_NF and Tau_F is the Inverse Wishart Distribution (see the Details section for more information on the parameterization of these distributions). The output from `B2ZM_BCLT` is a list that belongs to the class `bclt`. This output is valid as an input for the functions `summary` and `plot`.

Usage

```
B2ZM_BCLT (data = NULL, priorBeta, priorQ, priorG,
                      v, S, tauN.sh, tauN.sc, tauF.sh, tauF.sc,
                      VN, VF, indep.model = FALSE, cred = 95,
                      m = 7000, sample_size=2000,
                      figures = list(save = FALSE,
                      type = c("ps", "eps","pdf", "png", "jpg")))
```

Arguments

`data`	A 3-column matrix where the columns are time, concentrations at the near field, and concentrations at the far field, respectively. The time must be scaled in minutes (min), and the concentrations must be scaled in miligrams per cubic meter (mg/m3)
`priorBeta`	A string defining the prior distribution for the parameter Beta. To declare the prior distribution of Beta, use standard R nomenclature for probability distributions. For example, if the prior of Beta is a Uniform(0,20), declare it with "unif(0,20)"; if it is a Normal(0,1), declare it with "norm(0,1)". DO NOT put an "d" or "r" in front the name of the distributions. The options are: "unif(a,b)", "gamma(a,b)", "exp(a)", "norm(a,b)", "t(a)", "weibull(a,b)", "f(a,b)", "chisq(a,b)", "cauchy(a,b)" and "lnorm(a,b)".
`priorQ`	A string defining the prior distribution for Q (use the nomenclature as for `priorBeta`).
`priorG`	A string defining the prior distribution for G (use the nomenclature as for `priorBeta`).
`v`	Degrees of freedom for the Inverse Wishart distribution (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
`S`	A 2x2 positive definite matrix for the Inverse Wishart (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
`tauN.sh`	The shape parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).
`tauN.sc`	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).
`tauF.sh`	The shape parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).
`tauF.sc`	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).
`VN`	Volume of the near field in cubic meters (m3).
`VF`	Volume of the far field in cubic meters (m3).

`indep.model` A logical value indicating whether the independent model should be considered. The default is FALSE.

`cred` A scalar between 0 and 100 indicating the credibility level for the posterior intervals of the parameters.

`m` Number of sampling values from the prior distribution used to estimate a good starting value that is used in the estimation of the posterior mode and covariance matrix. See the Details section for more information.

`sample_size` Size of the sample from the posterior distribution of the parameters in model.

`figures` The command `plot(obj)` produces several plots, where `obj` is the output from `B2ZM_BCLT`. Using `figures`, those plots are built internally and saved as eps, pdf, ps, png or jpg format. `figures` is a list containing the following parameters:

`save`: a logical value indicating that the figures are to be saved. The default is FALSE.

`type`: a string that indicates the image file type. The default is "ps".

Details

Parameterization priors: The inverse gamma distribution with shape a and scale b has mean $b/(a-1)$ ($a>1$) and variance $(b^2)/((a-1)^2(a-2))$ ($a>2$). The inverse Wishart with v degrees of freedom and scalar matrix S has mean $S/(v-p-1)$, where p is the number of rows of S.

Covariance Matrix estimation: The covariance matrix is estimated as the negative inverse of the hessian matrix of the log posterior distribution at the estimated posterior mode. To estimate the posterior mode, the function `nlminb` is used. The values of the estimated posterior mode depends on the starting parameter values. `m` is the number of sampling values from the prior distributions of Beta, Q and G. The vector (among the m sampled) with largest log posterior value is used as starting parameter values.

The covariance matrix is estimated using the function `hessian` from the package `numDeriv`, where the parameter vector is the estimated posterior mode.

Value

`B2ZM_BCLT` returns a list that belongs to the class `bclt`. The output from `B2ZM_BCLT` contains the objects:

`Beta` a vector containing the sampled values from the joint posterior distribution for the parameter Beta.

`Q` a vector containing the sampled values from the joint posterior distribution for the parameter Q.

`G` a vector containing the sampled values from the joint posterior distribution for the parameter G.

`tauN` a vector containing the sampled values from the joint posterior distribution for the parameter Tau_N.

`tauF` a vector containing the sampled values from the joint posterior distribution for the parameter Tau_F.

`tauNF` a vector containing the sampled values from the joint posterior distribution for the parameter Tau_NF (if the dependent model is used).

Y	a matrix containing the log of the observed concentrations.
DIC	deviance information criterion.
pD	effective number of parameters.
Dbar	Deviance expectation.
indep	a logical value indicating whether the independent model was used.
times	a vector containing the times when the observed concentrations were measured.
cred	credibility of the posterior intervals.

Methods defined for B2ZM_BCLT object are summary and plot.

Author(s)

Joao Vitor Dias Monteiro, Sudipto Banerjee and Gurumurthy Ramachandran.

References

Monteiro, J. V. D., Banerjee, S. and Ramachandran, G. (2011). B2Z: An R Package for Bayesian Two-Zone Models. *Journal of Statistical Software* 43 (2) 1–23. http://www.jstatsoft.org/v43/i02/

Zhang, Y., Banerjee, S., Yang,R., Lungu,C. and Ramachandran, G. (2009). Bayesian Modeling of Exposure and Airflow Using Two-Zone Models. *The Annals of Occupational Hygiene*, **53**, 409-424. http://www.biostat.umn.edu/~sudiptob/ResearchPapers/ZBYLR.pdf

See Also

B2Z, B2ZM, B2ZM_IMIS,B2ZM_MCMC, B2ZM_SIR

Examples

```
#####################
#Independent Model #
###################

#Data 1:  100 simulated concentrations during the times between

#0 and 4, using the parameters Beta = 5, Q = 13.8, G = 351.5,

#VN = pi*10^-3 VF = 3.8, Tau_N = 1, Tau_NF = 0.5

#and Tau_F = 0.64.
## Not run:

data(ex1)

r <- B2ZM_BCLT(data = ex1, priorBeta = "unif(0,10)",
               priorQ="unif(11,17)", priorG = "unif(281,482)",
               S = diag(10,2), v = 4, VN = pi*10^-3, VF = 3.8,
               m = 7000, sample_size=2000)
```

```
summary(r)
plot(r)


#####################
#Independent Model #
###################

#Data 2:  100 simulated concentrations during the times between

#0 and 4, using the parameters Beta = 5, Q = 13.8, G = 351.5,

#VN = pi*10^-3, VF = 3.8, Tau_N = 1, Tau_NF = 0

#and Tau_F = 0.64.

data(ex2)


r <- B2ZM_BCLT(data = ex2, priorBeta = "unif(0,10)",
               priorQ="unif(11,17)", priorG = "unif(281,482)",
               tauN.sh = 5 , tauN.sc = 4 , tauF.sh = 5,
               tauF.sc = 7, VN = pi*10^-3, VF = 3.8,
               indep.model = TRUE, m = 7000, sample_size=2000)

summary(r)
plot(r)

## End(Not run)
```

B2ZM_IMIS *Bayesian Two-Zone Models: using IMIS sampler*

Description

B2ZM_IMIS obtains random samples from the posterior distribution of the parameters and exposure concentrations for the Bayesian two-zone model proposed by Zhang et al. (2009) using the Incremental Mixture Importance Sampling (IMIS). The user can choose whether the near and far field measurement error processes are dependent or not. In the independent model, 5 parameters are considered: 1) Beta: Interzonal air flow rate (m3); 2) Q: supply and exhaust flow rate (m3/min); 3) G: contaminant emission rate (mg/min); 4) Tau_N: variance of the measurement error at the near field; 5)Tau_F; variance of the measurement error at the far field. In the dependent model (default), one more parameter is considered: 6) Tau_NF: covariance between the measurements at the near and far field. Any prior distribution for Beta, Q and G can be chosen. In the independent model, the prior distributions for Tau_N and Tau_F are inverse gamma distributions; in the dependent model, the prior joint distribution of Tau_N, Tau_NF and Tau_F is the Inverse Wishart Distribution (see the Details section for more information on the parameterization of these distributions). The output from B2ZM_IMIS is a list that belongs to the class imis. This output is valid as an input for the functions summary and plot.

Usage

```
B2ZM_IMIS(data, priorBeta,
                priorQ, priorG, v, S, tauN.sh, tauN.sc,
                tauF.sh, tauF.sc,  VN,
                VF, indep.model = FALSE, cred = 95,
                N0 = 6000, B = 600, M = 3000, it.max = 16,
                figures = list(save = FALSE, type =c("ps",
                "eps","pdf", "png", "jpg")))
```

Arguments

data	A 3-column matrix where the columns are time, concentrations at the near field, and concentrations at the far field, respectively. The time must be scaled in minutes (min), and the concentrations must be scaled in miligrams per cubic meter (mg/m3)
priorBeta	A string defining the prior distribution for the parameter Beta. To declare the prior distribution of Beta, use standard R nomenclature for probability distributions. For example, if the prior of Beta is a Uniform(0,20), declare it with "unif(0,20)"; if it is a Normal(0,1), declare it with "norm(0,1)". DO NOT put an "d" or "r" in front the name of the distributions. The options are: "unif(a,b)", "gamma(a,b)", "exp(a)", "norm(a,b)", "t(a)", "weibull(a,b)", "f(a,b)", "chisq(a,b)", "cauchy(a,b)" and "lnorm(a,b)".
priorQ	A string defining the prior distribution for Q (use the nomenclature as for priorBeta).
priorG	A string defining the prior distribution for G (use the nomenclature as for priorBeta).
v	Degrees of freedom for the Inverse Wishart distribution (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
S	A 2x2 positive definite matrix for the Inverse Wishart (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
tauN.sh	The shape parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).
tauN.sc	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).
tauF.sh	The shape parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).
tauF.sc	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).
VN	Volume of the near field in cubic meters m3.
VF	Volume of the far field in cubic meters m3.
indep.model	A logical value indicating whether the independent model should be considered. The default is FALSE.
cred	A scalar between 0 and 100 indicating the credibility level for the posterior intervals of the parameters.

N0	Initial number of inputs from the prior joint distribution of Beta, G, Q, Tau_N, Tau_F, and Tau_NF (if the dependent model is considered). The default is 6,000.
B	Number of inputs to be chosen in the Importance Sampling Stage. The default is 600.
M	Number of resamplings in the Resample Stage. The default is 3,000.
it.max	Maximum number of iterations in the Importance Sampling Stage to be tolerated, in case the stop condition suggested by Raftery and Bao (2009) takes too many time. The default is 16.
figures	The command `plot(obj)` produces several plots, where `obj` is the output from `B2ZM_IMIS`. Using `figures`, those plots are built internally and saved as eps, pdf, ps, png or jpg format. `figures` is a list containing the following parameters: `save:` a logical value indicating that the figures are to be saved. The default is FALSE. `type:` a string that indicates the image file type. The default is "ps".

Details

Parameterization priors: The inverse gamma and inverse Wishart distributions used in `B2ZM_IMIS` are from the package `MCMCpack`. The inverse gamma distribution with shape a and scale b has mean $b/(a-1)$ ($a>1$) and variance $(b^2)/((a-1)^2(a-2))$ ($a>2$). The inverse Wishart with v degrees of freedom and scalar matrix S has mean $S/(v-p-1)$, where p is the number of rows of S.

Value

`B2ZM_IMIS` returns a list that belongs to the class `imis`. The output from `B2ZM_IMIS` contains the objects:

Beta	a vector containing the sampled values from the joint posterior distribution for the parameter Beta.
Q	a vector containing the sampled values from the joint posterior distribution for the parameter Q.
G	a vector containing the sampled values from the joint posterior distribution for the parameter G.
tauN	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_N.
tauF	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_F.
tauNF	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_NF (if the dependent model is used).
Y	a matrix containing the log of the observed concentrations.
DIC	deviance information criterion.
pD	effective number of parameters.
Dbar	Deviance expectation.
ESS	effective sample size.

indep	a logical value indicating whether the independent model was used.
times	a vector containing the times when the observed concentrations were measured.
cred	credibility of the posterior intervals.
expfrac	expected fraction of unique points.
V.hat	variance of the rescaled importance weights.
U.hat	entropy of importance weights relative to uniformity.
Q.hat	expected number of unique points after re-sampling.
maxw	maximum importance weight.
w	importance weights.

Methods defined for B2ZM_IMIS object are summary and plot.

Note

In the Examples section, N0, B, M and it.max are small just for a quick demonstration. We suggest that N0 = 6,000; B = 600; M= 3,000 and it.max greater than 10.

Author(s)

Joao Vitor Dias Monteiro, Sudipto Banerjee and Gurumurthy Ramachandran.

References

Monteiro, J. V. D., Banerjee, S. and Ramachandran, G. (2011). B2Z: An R Package for Bayesian Two-Zone Models. *Journal of Statistical Software* 43 (2) 1–23. http://www.jstatsoft.org/v43/i02/

Raftery, A. E. and Bao, L. (2009). Estimating and Projecting Trends in HIV/AIDS Generalized Epidemics Using Incremental Mixture Importance Sampling. http://www.stat.washington.edu/research/reports/2009/tr560.pdf

Zhang, Y., Banerjee, S., Yang,R., Lungu,C. and Ramachandran, G. (2009). Bayesian Modeling of Exposure and Airflow Using Two-Zone Models. *The Annals of Occupational Hygiene*, **53**, 409-424. http://www.biostat.umn.edu/~sudiptob/ResearchPapers/ZBYLR.pdf

See Also

B2Z, B2ZM,B2ZM_BCLT,B2ZM_MCMC,B2ZM_SIR

Examples

```
##################
#Dependent Model#
################

#Data 1:  100 simulated concentrations during the times
#between 0 and 4, using the parameters Beta = 5, Q = 13.8,
#G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1,
#Tau_NF = 0.5 and Tau_F = 0.64.
```

```
data(ex1)

r <- B2ZM_IMIS(data = ex1, priorBeta = "unif(0,10)",
     priorQ="unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
     v = 4, VN = pi*10^-3, VF = 3.8, N0 = 500, B = 50, M = 250,
     it.max = 4)

plot(r)
summary(r)

#Saving figures with .pdf extension
## Not run:
r <- B2ZM_IMIS(data = ex1, priorBeta = "unif(0,10)",
     priorQ = "unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
     v = 4, VN = pi*10^-3, VF = 3.8, N0 = 6000, B = 600, M = 3000,
     it.max = 12, figures = list(save = TRUE, type ="pdf"))

## End(Not run)


######################
#Independent Model #
####################

#Data 2:  100 simulated concentrations during the times
#between 0 and 4, using the parameters Beta = 5, Q = 13.8,
#G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1,
#Tau_NF = 0 and Tau_F = 0.64.

## Not run:
data(ex2)

r <- B2ZM_IMIS(data = ex2, indep.model = TRUE,
     priorBeta = "unif(0,10)", priorQ="unif(11,17)",
     priorG = "unif(281,482)", tauN.sh = 5 , tauN.sc = 4 ,
     tauF.sh = 5, tauF.sc = 7 , VN = pi*10^-3, VF = 3.8,
     N0 = 5000, B = 500, M =  3000,  it.max = 12)

plot(r)
summary(r)
## End(Not run)
```

B2ZM_MCMC *Bayesian Two-Zone Models: using Gibbs with Metropolis step*

Description

B2ZM_MCMC obtains random samples from the posterior distribution of parameters and exposure

concentrations for the Bayesian two-zone model proposed by Zhang et al. (2009) using Gibbs with Metropolis step. The user can choose whether the near and far field measurement error processes are dependent or not. In the independent model, 5 parameters are considered: 1) Beta: Interzonal air flow rate (m3); 2) Q: supply and exhaust flow rate (m3/min); 3) G: contaminant emission rate (mg/min); 4) Tau_N: variance of the measurement error at the near field; 5)Tau_F; variance of the measurement error at the far field. In the dependent model (default), one more parameter is considered: 6) Tau_NF: covariance between the measurements at the near and far field. Any prior distribution for Beta, Q and G can be chosen. In the independent model, the prior distributions for Tau_N and Tau_F are inverse gamma distributions; in the dependent model, the prior joint distribution of Tau_N, Tau_NF and Tau_F is the Inverse Wishart Distribution (see the Details section for more information on the parameterization of these distributions). The output from `B2ZM_MCMC` is a list that belongs to the classe `gibbs`. This output is valid as an input for the functions `summary` and `plot`.

Usage

```
B2ZM_MCMC (data, priorBeta, priorQ, priorG, v, S,
                      tauN.sh, tauN.sc, tauF.sh, tauF.sc,
                      VN, VF, indep.model = FALSE, cred = 95,
                      NUpd = 10000, burnin = 1000, lag = 1,
                      initial = NULL, Sigma.Cand = NULL,
                      m = 6000, figures = list(save = FALSE,
                      type =c("ps", "eps","pdf", "png", "jpg")))
```

Arguments

`data`	A 3-column matrix where the columns are time, concentrations at the near field, and concentrations at the far field, respectively. The time must be scaled in minutes (min), and the concentrations must be scaled in miligrams per cubic meter (mg/m3)
`priorBeta`	A string defining the prior distribution for the parameter Beta. To declare the prior distribution of Beta, use standard R nomenclature for probability distributions. For example, if the prior of Beta is a Uniform(0,20), declare it with "unif(0,20)"; if it is a Normal(0,1), declare it with "norm(0,1)". DO NOT put an "d" or "r" in front the name of the distributions. The options are: "unif(a,b)", "gamma(a,b)", "exp(a)", "norm(a,b)", "t(a)", "weibull(a,b)", "f(a,b)", "chisq(a,b)", "cauchy(a,b)" and "lnorm(a,b)".
`priorQ`	A string defining the prior distribution for Q (use the nomenclature as for `priorBeta`).
`priorG`	A string defining the prior distribution for G (use the nomenclature as for `priorBeta`).
`v`	Degrees of freedom for the Inverse Wishart distribution (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
`S`	A 2x2 positive definite matrix for the Inverse Wishart (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
`tauN.sh`	The shape parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).

tauN.sc	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).
tauF.sh	The shape parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).
tauF.sc	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).
VN	Volume of the near field in cubic meters (m3).
VF	Volume of the far field in cubic meters (m3).
indep.model	A logical value indicating whether the independent model should be considered. The default is FALSE.
cred	A scalar between 0 and 100 indicating the credibility level for the posterior intervals of the parameters.
NUpd	Number of updates. The default is 10,000.
burnin	Period of burn-in. The default is 1,000.
lag	Thin interval. The default is 1.
initial	A vector containing the initial values for the parameters: Beta, Q and G (exactly in this order).
Sigma.Cand	A 3x3 covariance matrix for the normal multivariate proposal distribution of Beta, Q and G. The default is NULL, and in this case, the covariance matrix used is the negative inverse of the hessian matrix of the log posterior distribution at the estimated posterior mode.
m	Number of sampling values from the prior distribution used to estimate a good starting value that is used in the estimation of Sigma.Cand. It is used only if Sigma.Cand is not declared. See the Details section for more information.
figures	The command plot(obj) produces several plots, where obj is the output from B2ZM_MCMC. Using figures, those plots are built internally and saved as eps, pdf, ps, png or jpg format. figures is a list containing the following parameters: save: a logical value indicating that the figures are to be saved. The default is FALSE. type: a string that indicates the image file type. The default is "ps".

Details

Parameterization priors: The inverse gamma distribution with shape *a* and scale *b* has mean *b/(a-1)* (*a*>1) and variance *(b^2)/((a-1)^2(a-2))* (*a>2*). The inverse Wishart with *v* degrees of freedom and scalar matrix *S* has mean *S/(v-p-1)*, where *p* is the number of rows of *S*.

Covariance Matrix for the proposal distribution: If the covariance matrix for the multivariate normal poposal distribution is NULL for the Metropolis sampler the covariance matrix used is the negative inverse of the hessian matrix of the log posterior distribution at the estimated posterior mode. To estimate the posterior mode, the function nlm is used. The values of the estimated posterior mode depends on the starting parameter values. m is the number of sampling values from the prior distributions of Beta, Q and G. The vector (among the m sampled) with largest likelihood value is used as starting parameter values.

The covariance matrix is estimated using the function hessian from the package numDeriv, where the parameter vector is the estimated posterior mode.

Value

B2ZM_MCMC returns a list that belongs to the class gibbs. The output from B2ZM contains the objects:

Beta	a vector containing the sampled values from the joint posterior distribution for the parameter Beta.
Q	a vector containing the sampled values from the joint posterior distribution for the parameter Q.
G	a vector containing the sampled values from the joint posterior distribution for the parameter G.
tauN	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_N.
tauF	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_F.
tauNF	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_NF (if the dependent model is used).
Y	a matrix containing the log of the observed concentrations.
DIC	deviance information criterion.
pD	effective number of parameters.
Dbar	Deviance expectation.
ESS	effective sample size.
indep	a logical value indicating whether the independent model was used.
times	a vector containing the times when the observed concentrations were measured.
cred	credibility of the posterior intervals.
AR	acceptance rate in the metropolis step.
Sigma.Cand	covariance matrix used in the proposal distribution.
initial	a vector containing the initial points.
NUpd	number of updates.
burnin	burn-in period.
lag	thin interval.

Methods defined for B2ZM_MCMC object are summary and plot.

Note

In the Examples section, NUpd and m are small just for a quick demonstration. We suggest that NUpd be greater than 10,000 and m be around 4,000.

Author(s)

Joao Vitor Dias Monteiro, Sudipto Banerjee and Gurumurthy Ramachandran.

References

Monteiro, J. V. D., Banerjee, S. and Ramachandran, G. (2011). B2Z: An R Package for Bayesian Two-Zone Models. *Journal of Statistical Software* 43 (2) 1–23. http://www.jstatsoft.org/v43/i02/

Zhang, Y., Banerjee, S., Yang,R., Lungu,C. and Ramachandran, G. (2009). Bayesian Modeling of Exposure and Airflow Using Two-Zone Models. *The Annals of Occupational Hygiene*, **53**, 409-424. http://www.biostat.umn.edu/~sudiptob/ResearchPapers/ZBYLR.pdf

See Also

B2Z, B2ZM, B2ZM_BCLT,B2ZM_IMIS,B2ZM_SIR

Examples

```
##################
#Dependent Model#
################

#Data 1:  100 simulated concentrations during the times
#between 0 and 4, using the parameters Beta = 5, Q = 13.8,
#G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1,
#Tau_NF = 0.5 and Tau_F = 0.64.

data(ex1)
#Without specifying the initial values and
#the covariance matrix in the proposal distribution

## Not run:
r <- B2ZM_MCMC(data = ex1, priorBeta = "unif(0,10)",
     priorQ="unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
     v = 4, VN = pi*10^-3, VF = 3.8, NUpd = 10000, burnin = 1000,
     lag = 1, m = 5000)

summary(r)
plot(r)

## End(Not run)

#Specifying the initial values and the covariance matrix in the proposal distribution
initial <- c(5.338671,  14.147149, 379.591927)

Sigma.Cand <- matrix(c(0.51306,  0.54981,   14.4306,
                       0.54981,  1.75525,   35.5525,
                       14.4306,  35.5525, 1360.5119),3,3)

r <- B2ZM_MCMC(data = ex1, priorBeta = "unif(0,10)",
     priorQ = "unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
     v = 4, VN = pi*10^-3, VF = 3.8, NUpd = 1000, burnin = 100,
     lag = 1, m = 5000, initial = initial, Sigma.Cand = Sigma.Cand)
```

```
summary(r)
plot(r)

## Not run:
#Saving figures with .jpg extension
r <- B2ZM_MCMC(data = ex1, priorBeta = "unif(0,10)",
     priorQ = "unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
     v = 4, VN = pi*10^-3, VF = 3.8, NUpd = 10000, burnin = 1000,
     lag = 1, m = 5000, figures = list(save = TRUE, type ="jpg") )

## End(Not run)


#####################
#Independent Model #
###################

#Data 2:  100 simulated concentrations during the times
#between 0 and 4, using the parameters Beta = 5, Q = 13.8,
#G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1,
#Tau_NF = 0 and Tau_F = 0.64.

## Not run:
data(ex2)

#Without specifying the initial values and the
#covariance matrix in the proposal distribution

r <- B2ZM_MCMC(data = ex2, indep.model = TRUE,
     priorBeta = "unif(0,10)", priorQ="unif(11,17)",
     priorG = "unif(281,482)", tauN.sh = 5 , tauN.sc = 4 ,
     tauF.sh = 5, tauF.sc = 7 , VN = pi*10^-3, VF = 3.8,
     NUpd = 10000, burnin = 1000, lag = 1, m = 1000)

summary(r)
plot(r)

## End(Not run)
```

B2ZM_SIR *Bayesian Two-Zone Models: using SIR sampler*

Description

B2ZM_SIR obtains random samples from the posterior distribution of the parameters and exposure concentrations for the Bayesian two-zone model proposed by Zhang et al. (2009) using Sampling Importance Resampling (SIR). The user can choose whether the near and far field measurement error processes are dependent or not. In the independent model, 5 parameters are considered: 1) Beta: Interzonal air flow rate (m3); 2) Q: supply and exhaust flow rate (m3/min); 3) G: contaminant

emission rate (mg/min); 4) Tau_N: variance of the measurement error at the near field; 5)Tau_F; variance of the measurement error at the far field. In the dependent model (default), one more parameter is considered: 6) Tau_NF: covariance between the measurements at the near and far field. Any prior distribution for Beta, Q and G can be chosen. In the independent model, the prior distributions for Tau_N and Tau_F are inverse gamma distributions; in the dependent model, the prior joint distribution of Tau_N, Tau_NF and Tau_F is the Inverse Wishart Distribution (see the Details section for more information on the parameterization of these distributions). The output from `B2ZM_SIR` is a list that belongs to the class `sir`. This output is valid as an input for the functions `summary` and `plot`.

Usage

```
B2ZM_SIR(data, priorBeta, priorQ, priorG,
        v, S, tauN.sh, tauN.sc,
        tauF.sh, tauF.sc,  VN,
        VF, indep.model = FALSE,
        cred = 95,  m = 10000,
        figures = list(save = FALSE, type =c("ps",
        "eps","pdf", "png", "jpg")))
```

Arguments

`data`	A 3-column matrix where the columns are time, concentrations at the near field, and concentrations at the far field, respectively. The time must be scaled in minutes (min), and the concentrations must be scaled in miligrams per cubic meter (mg/m3)
`priorBeta`	A string defining the prior distribution for the parameter Beta. To declare the prior distribution of Beta, use standard R nomenclature for probability distributions. For example, if the prior of Beta is a Uniform(0,20), declare it with "unif(0,20)"; if it is a Normal(0,1), declare it with "norm(0,1)". DO NOT put an "d" or "r" in front the name of the distributions. The options are: "unif(a,b)", "gamma(a,b)", "exp(a)", "norm(a,b)", "t(a)", "weibull(a,b)", "f(a,b)", "chisq(a,b)", "cauchy(a,b)" and "lnorm(a,b)".
`priorQ`	A string defining the prior distribution for Q (use the nomenclature as for `priorBeta`).
`priorG`	A string defining the prior distribution for G (use the nomenclature as for `priorBeta`).
`v`	Degrees of freedom for the Inverse Wishart distribution (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
`S`	A 2x2 positive definite matrix for the Inverse Wishart (prior joint distribution for Tau_N, Tau_NF and Tau_F in the dependent model).
`tauN.sh`	The shape parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).
`tauN.sc`	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_N in the independent model).
`tauF.sh`	The shape parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).

tauF.sc	The scalar parameter in the inverse gamma distribution (prior distribution for Tau_F in the independent model).
VN	Volume of the near field in cubic meters (m3).
VF	Volume of the far field in cubic meters (m3).
indep.model	A logical value indicating whether the independent model should be considered. The default is FALSE.
cred	A scalar between 0 and 100 indicating the credibility level for the posterior intervals of the parameters.
m	Number of samplings. The default is 10,000.
figures	The command plot(obj) produces several plots, where obj is the output from B2ZM_SIR. Using figures, those plots are built internally and saved as eps, pdf, ps, png or jpg format. figures is a list containing the following parameters: save: a logical value indicating that the figures are to be saved. The default is FALSE. type: a string that indicates the image file type. The default is "ps".

Details

Parameterization priors: The inverse gamma distribution with shape *a* and scale *b* has mean *b/(a-1)* (*a*>1) and variance *(b^2)/((a-1)^2(a-2))* (*a>2*). The inverse Wishart with *v* degrees of freedom and scalar matrix *S* has mean *S/(v-p-1)*, where *p* is the number of rows of *S*.

Value

B2ZM_SIR returns a list that belongs to the class sir. The output from B2ZM_SIR contains the objects:

Beta	a vector containing the sampled values from the joint posterior distribution for the parameter Beta.
Q	a vector containing the sampled values from the joint posterior distribution for the parameter Q.
G	a vector containing the sampled values from the joint posterior distribution for the parameter G.
tauN	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_N.
tauF	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_F.
tauNF	a vector containing the sampled values from the joint posterior distribution for the parameter Tau_NF (if the dependent model is used).
Y	a matrix containing the log of the observed concentrations.
DIC	deviance information criterion.
pD	effective number of parameters.
Dbar	Deviance expectation.
ESS	effective sample size.

indep	a logical value indicating whether the independent model was used.
times	a vector containing the times when the observed concentrations were measured.
cred	credibility of the posterior intervals.
prop	proportion of different points in the sampled values from the joint posterior distribution.
weigths	weights used in the SIR method.
maxw	maximum weight used in the SIR method.

Methods defined for B2ZM_SIR object are summary and plot.

Note

In the Examples section, m is small just for a quick demonstration. We suggest that m be greater than 15,000.

Author(s)

Joao Vitor Dias Monteiro, Sudipto Banerjee and Gurumurthy Ramachandran.

References

Monteiro, J. V. D., Banerjee, S. and Ramachandran, G. (2011). B2Z: An R Package for Bayesian Two-Zone Models. *Journal of Statistical Software* 43 (2) 1–23. http://www.jstatsoft.org/v43/i02/

Zhang, Y., Banerjee, S., Yang,R., Lungu,C. and Ramachandran, G. (2009). Bayesian Modeling of Exposure and Airflow Using Two-Zone Models. *The Annals of Occupational Hygiene*, **53**, 409-424. http://www.biostat.umn.edu/~sudiptob/ResearchPapers/ZBYLR.pdf

See Also

B2Z, B2ZM, B2ZM_BCLT, B2ZM_IMIS, B2ZM_MCMC

Examples

```
##################
#Dependent Model#
################

#Data 1:  100 simulated concentrations during the times
#between 0 and 4, using the parameters Beta = 5, Q = 13.8,
#G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1,
#Tau_NF = 0.5 and Tau_F = 0.64.

data(ex1)

r <- B2ZM_SIR(data = ex1,  priorBeta = "unif(0,10)",
     priorQ="unif(11,17)", priorG = "unif(281,482)", S = diag(10,2),
     v = 4, VN = pi*10^-3, VF = 3.8, m = 100 )
```

```
#plot(r)
#summary(r)

#Saving figures with .png extension
## Not run:
r <- B2ZM_SIR(data = ex1, priorBeta = "unif(0,10)",
     priorQ = "unif(11,17)", priorG = "unif(281,482)",
     S = diag(10,2), v = 4, VN = pi*10^-3, VF = 3.8,
     m = 10000, figures = list(save = TRUE, type ="png"))

## End(Not run)


#####################
#Independent Model #
###################

#Data 2:  100 simulated concentrations during the times
#between 0 and 4, using the parameters Beta = 5, Q = 13.8,
#G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1,
#Tau_NF = 0 and Tau_F = 0.64.

## Not run:
data(ex2)

r <- B2ZM_SIR(data = ex2, indep.model = TRUE,
     priorBeta = "unif(0,10)", priorQ="unif(11,17)",
     priorG = "unif(281,482)", tauN.sh = 5 , tauN.sc = 4 ,
     tauF.sh = 5, tauF.sc = 7 , VN = pi*10^-3,
     VF = 3.8, m = 100)

plot(r)
summary(r)

## End(Not run)
```

---

ex1 *Example 1 Data Set*

Description

ex1 contains 100 simulated concentrations during the times between 0 and 4, using the parameters Beta = 5, Q = 13.8, G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1, Tau_NF = 0.5 and Tau_F = 0.64.

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See Also

ex2

---

ex2 *Example 2 Data Set*

Description

ex2 contains 100 simulated concentrations during the times between 0 and 4, using the parameters Beta = 5, Q = 13.8, G = 351.5, VN = pi*10^-3, VF = 3.8, Tau_N = 1, Tau_NF = 0 and Tau_F = 0.64.

Author(s)

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See Also

ex1

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