Package 'BayHaz'

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Title R Functions for Bayesian Hazard Rate Estimation

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Description A suite of R functions for Bayesian estimation of smooth hazard rates via Compound Poisson Process (CPP) and Bayesian Penalized Spline (BPS) priors.

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BayHaz-package *R Functions for Bayesian Hazard Rate Estimation*

Description

A suite of R functions for Bayesian estimation of smooth hazard rates via Compound Poisson Process (CPP) and Bayesian Penalized Spline (BPS) priors.

Details

Package:	BayHaz
Type:	Package
Version:	0.1-3
Date:	2007-10-07
License:	GPL Version 2 or later

This package provides UseRs with functions to use CPP prior distributions for Bayesian analysis of times to event; see La Rocca (2005). It also handles first order autoregressive BPS hazard rates, based on Hennerfeind *et al.* (2006). Prior elicitation, posterior computation, and visualization are dealt with. For illustrative purposes, a data set in the field of earthquake statistics is supplied. Package 'coda' is suggested for output diagnostics.

Author(s)

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References

La Rocca, L. (2005). On Bayesian Nonparametric Estimation of Smooth Hazard Rates with a View to Seismic Hazard Assessment. *Research Report* n. 38-05, Department of Social, Cognitive and Quantitative Sciences, Reggio Emilia, Italy.

Hennerfeind, A., Brezger, A. \& Fahrmeir, L. (2006). Geoadditive survival models. *Journal of the American Statistical Association* 101, 1065–1075.

See Also

`CPPpriorElicit`, `CPPpostSample`, `CPPplotHR`, `BPSpriorElicit`, `BPSpostSample`, `BPSplotHR`, `earthquakes`, `CPPpost2mcmc`, `BPSpost2mcmc`

Examples

```
# the following analysis uses CPP hazard rates but can be easily adapted to BPS hazard rates
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a CPP prior distribution (with default number of CPP jumps)
hypars<-CPPpriorElicit(r0 = 0.1, H = 1, T00 = 50, M00 = 2, extra = 0)

# plot some sample prior hazard rates
CPPplotHR(CPPpriorSample(ss = 10, hyp = hypars), tu = ”Year”)

# load a data set
data(earthquakes)

# generate a posterior sample
post<-CPPpostSample(hypars, times = earthquakes$ti, obs = earthquakes$ob)

# check that no additional CPP jumps are needed:
# if this probability is not negligible,
# go back to prior selection stage and increase 'extra'
ecdf(post$sgm[,post$hyp$F])(post$hyp$T00+3*post$hyp$sd)

# plot some posterior hazard rate summaries
CPPplotHR(post , tu = ”Year”)

# save the posterior sample to file for later use
save(post, file = ”post.rda”)

# convert the posterior sample into an MCMC object
post<-CPPpost2mcmc(post)

# take advantage of package 'coda' for output diagnostics
pdf(”diagnostics.pdf”)
traceplot(post)
autocorr.plot(post, lag.max = 5)
par(las = 2) # for better readability of the cross-correlation plot
crosscorr.plot(post)
dev.off()
```

BPSevalHR *Function to Evaluate BPS Hazard Rates*

Description

A function to evaluate a (prior or posterior) sample of first order autoregressive BPS hazard rates on a grid of time points.

Usage

```
BPSevalHR(time, sample)
```

Arguments

`time` vector of time points where the hazard rates in the sample should be evaluated

`sample` sample of BPS hazard rates (as generated by `BPSpriorSample` or `BPSpostSample`)

Value

A matrix with as many rows as hazard rates in the sample and as many columns as time points in the grid.

See Also

`BPSplotHR`

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a BPS prior distribution
hypars<-BPSpriorElicit(r0 = 0.1, H = 1, T00 = 50, ord = 4, G = 3, c = 0.9)
# generate a sample of ten hazard rates
prior<-BPSpriorSample(ss = 10, hyp = hypars)

# evaluate the ten hazard rates at year multiples
BPSevalHR(time = seq(0,50), sample = prior)
```

`BPSplotHR` *Function to Plot BPS Hazard Rates*

Description

A function to plot a (prior or posterior) sample of first order autoregressive BPS hazard rates.

Usage

```
BPSplotHR(sample = BPSpriorSample(0), npts = 101, tu = "Time Unit", title = NULL)
```

Arguments

`sample` sample of BPS hazard rates (as generated by `BPSpriorSample` or `BPSpostSample`)

`npts` number of time points where the hazard rates in the sample should be evaluated

`tu` name of the time unit to be used for labelling the time axis

`title` main title for the plot

Details

For a prior sample, the individual trajectories are plotted (as solid lines) and dashed lines are added to represent the pointwise prior mean and +/- one standard deviation band.

For a posterior sample, the pointwise posterior mean and equal tail 95% credible band are drawn (as solid lines) and dashed lines are added to represent the analogous posterior summaries for the constant hazard rate model (using a conjugate gamma prior and letting its shape and rate parameters tend to zero). Furthermore, the observations are marked on the time axis ("x" for exact observations, "o" for censored observations).

The range spanned by the time axis always goes from the origin to `sample$hyp$T00`.

Value

Always `NULL`.

See Also

`BayHaz-package`, `BPSevalHR`

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a BPS prior distribution
hypars<-BPSpriorElicit(r0 = 0.1, H = 1, T00 = 50, ord = 4, G = 3, c = 0.9)
# generate a sample of ten hazard rates
prior<-BPSpriorSample(ss = 10, hyp = hypars)

# plot the ten hazard rates
BPSplotHR(prior, tu = "Year")
```

`BPSpost2mcmc` *Function to Convert BPS Posterior Samples into MCMC Objects*

Description

A function to convert a first order autoregressive BPS posterior sample into an MCMC object, so that package 'coda' can be used for output diagnostics.

Usage

```
BPSpost2mcmc(sampost)
```

Arguments

`sampost`	posterior sample of BPS hazard rates (as generated by `BPSpostSample`)

Value

An MCMC object, complete with burn-in and thinning information.

Note

If package 'coda' is not available, a matrix with meaningful column names is returned.

See Also

BayHaz-package, BPSpostSample

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a BPS prior distribution
hypars<-BPSpriorElicit(r0 = 0.1, H = 1, T00 = 50, ord = 4, G = 3, c = 0.9)
# load a data set
data(earthquakes)
# generate a posterior sample
post<-BPSpostSample(hypars, times = earthquakes$ti, obs = earthquakes$ob)

# convert the posterior sample into an MCMC object
MCMCpost<-BPSpost2mcmc(post)
```

BPSpostSample *Function to Sample Hazard Rates from BPS Posteriors*

Description

A function to generate a random sample of hazard rates from the posterior distribution originated by a first order autoregressive BPS prior through the observation of a sequence of possibly right censored times to event.

Usage

```
BPSpostSample(hyp, times, obs = NULL, mclen = 10, burnin = 0, thin = 1, df = 10, etastar = NULL)
```

Arguments

`hyp`	list of hyperparameters (as generated by BPSpriorElicit)
`times`	vector of (possibly right censored) times to event
`obs`	vector of censoring indicators (0 = censored, 1 = exact)
`mclen`	requested sample size
`burnin`	burn-in parameter
`thin`	thinning parameter

`df` degrees of freedom for the multivariate Student-t proposal distribution

`etastar` posterior mode and corresponding hessian in list format (as generated by `optim` with `hessian = TRUE`)

Details

A Markov chain sample of length `mclen` from the posterior distribution originated by `hyp` through the observation of `times` and `obs` is generated using a taylored proposal density Metropolis-Hastings sampler (starting at the posterior mode); see Chib \& Greenberg (1995).

The first `burnin` states of the Markov chain are discarded, then one every `thin` is kept.

If `obs` is `NULL`, it is assumed that all observations are exact (no censoring).

Value

A list with seven components:

`hyp` list of hyperparameters identifying the BPS prior that originated the posterior distribution from which the sample was extracted (copy of the input argument)

`dat` dataframe with two variables (`times` and `obs`) containing the observations on which the posterior distribution is based

`burnin` burn-in parameter used (copy of the input argument)

`thin` thinning parameter used (copy of the input argument)

`df` degrees of freedom used for the multivariate Student-t proposal distribution (copy of the input argument)

`etastar` posterior mode and corresponding hessian in list format (copy of the input argument or computed via `optim` if the input argument was NULL)

`eta` matrix with `mclen` rows (and `length(hyp$knots)-hyp$ord` columns) containing the spline weights

Note

If `mclen` is equal to zero `eta` will be a chain of length one containing the posterior mode.

References

Chib, S. \& E. Greenberg (1995). Understanding the Metropolis-Hastings algorithm. *American Statistician* 49, 327–335.

See Also

`BayHaz-package`, `BPSevalHR`, `BPSplotHR`, `BPSpost2mcmc`

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a BPS prior distribution
hypars<-BPSpriorElicit(r0 = 0.1, H = 1, T00 = 50, ord = 4, G = 3, c = 0.9)
# load a data set
data(earthquakes)

# find the posterior mode
postmode<-BPSpostSample(hypars, times = earthquakes$ti, obs = earthquakes$ob, mclen = 0)
# evaluate the posterior mode hazard rate at year multiples
BPSevalHR(time = seq(0,50), sample = postmode)

# generate a posterior sample
post<-BPSpostSample(hypars, times = earthquakes$ti, obs = earthquakes$ob, etastar = postmode$etastar)
# plot some posterior hazard rate summaries
BPSplotHR(post, tu = "Year")
```

`BPSpriorElicit` *Function to Set Hyperparameters of BPS Priors*

Description

A function to set the hyperparameters of a first order autoregressive BPS prior distribution, approximately assigning constant prior mean hazard rate and corresponding coefficient of variation.

Usage

```
BPSpriorElicit(r0 = 1, H = 1, T00 = 1, ord = 4, G = 30, c = 0.9)
```

Arguments

`r0`	prior mean hazard rate (r_0)
`H`	corresponding coefficient of variation
`T00`	time-horizon of interest (T_∞)
`ord`	spline order (k)
`G`	number of internal spline knots
`c`	correlation coefficient between two consecutive spline weights

Details

A first order autoregressive BPS prior hazard rate is defined, for $0 < t < T_\infty$, by

$$\rho(t) = \exp\{\sum_{j=1}^{G+k-2} \eta_j B_j(t)\}$$

where:

- η_j is the j-th element of a normally distributed vector of spline weights (see below for details)
- $B_j(t)$ is the j-th B-spline basis function of order k, evaluated at t, defined on a grid of $G+2k-2$ equispaced knots with first internal knot at 0 and last internal knot at T_∞ (see `splineDesign` for details)

The spline weights form a stationary AR(1) process with mean m, variance w and lag-one autocorrelation c. The elicitation procedure takes $w = H^2$ and $m = \log r_0 - 0.5 * w$, based on the mean and variance formulas for the log-normal distribution. As B-spline basis functions form a partition of unity within internal nodes, the mean of $\rho(t)$ is approximately equal to $r0$, for $0 < t < T_\infty$, and its standard deviation to Hr_0.

Value

A list with nine components:

`r0` prior mean hazard rate (copy of the input argument)

`H` corresponding coefficient of variation (copy of the input argument)

`T00` time-horizon of interest (copy of the input argument)

`ord` spline order (copy of the input argument)

`G` number of internal spline knots (copy of the input argument)

`c` correlation coefficient between two consecutive spline weights (copy of the input argument)

`knots` full grid of spline knots

`m` mean of spline coefficients

`w` variance of spline coefficients

See Also

`BayHaz-package`, `BPSpriorSample`, `BPSpostSample`

Examples

```
# ten events per century with unit coefficient of variation and fifty year time horizon
# cubic splines with minimal number of knots and strongly correlated spline weights
hypars<-BPSpriorElicit(r0 = 0.1, H = 1, T00 = 50, ord = 4, G = 3, c = 0.9)
```

`BPSpriorSample` *Function to Sample Hazard Rates from BPS Priors*

Description

A function to generate a random sample of hazard rates from a first order autoregrssive BPS prior distribution.

Usage

```
BPSpriorSample(ss = 1, hyp = BPSpriorElicit())
```

Arguments

ss requested sample size

hyp list of hyperparameters (as generated by BPSpriorElicit)

Details

A random sample of ss hazard rates is extracted from the first order autoregressive BPS prior distribution identified by hyp.

Value

A list with two components:

hyp list of hyperparameters identifying the BPS prior distribution from which the sample was extracted (copy of the input argument)

eta matrix with ss rows (and length(hyp$knots)-hyp$ord columns) containing the spline weights

See Also

BPSevalHR, BPSplotHR

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a BPS prior distribution
hypars<-BPSpriorElicit(r0 = 0.1, H = 1, T00 = 50, ord = 4, G = 3, c = 0.9)

# generate a sample of ten hazard rates
prior<-BPSpriorSample(ss = 10, hyp = hypars)
```

CPPevalHR *Function to Evaluate CPP Hazard Rates*

Description

A function to evaluate a (prior or posterior) sample of CPP hazard rates on a grid of time points.

Usage

```
CPPevalHR(time, sample)
```

Arguments

`time`	vector of time points where the hazard rates in the sample should be evaluated
`sample`	sample of CPP hazard rates (as generated by `CPPpriorSample` or `CPPpostSample`)

Value

A matrix with as many rows as hazard rates in the sample and as many columns as time points in the grid.

See Also

`CPPplotHR`

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a CPP prior distribution
hypars<-CPPpriorElicit(r0 = 0.1, H = 1, T00 = 50, M00 = 2)
# generate a sample of ten hazard rates
prior<-CPPpriorSample(ss = 10, hyp = hypars)

# evaluate the ten hazard rates at year multiples
CPPevalHR(time = seq(0,50), sample = prior)

# load a data set
data(earthquakes)
# generate a posterior sample
post<-CPPpostSample(hypars, times = earthquakes$ti, obs = earthquakes$ob)

# evaluate the posterior hazard rates at year multiples
CPPevalHR(time = seq(0,50), sample = post)
```

`CPPplotHR` *Function to Plot CPP Hazard Rates*

Description

A function to plot a (prior or posterior) sample of CPP hazard rates.

Usage

```
CPPplotHR(sample = CPPpriorSample(0), npts = 101, tu = "Time Unit", title = NULL)
```

Arguments

`sample` sample of CPP hazard rates (as generated by `CPPpriorSample` or `CPPpostSample`)

`npts` number of time points where the hazard rates in the sample should be evaluated

`tu` name of the time unit to be used for labelling the time axis

`title` main title for the plot

Details

For a prior sample, the individual trajectories are plotted (as solid lines) and dashed lines are added to represent the pointwise prior mean and +/- one standard deviation band.

For a posterior sample, the pointwise posterior mean and equal tail 95% credible band are drawn (as solid lines) and dashed lines are added to represent the analogous posterior summaries for the constant hazard rate model (using a conjugate gamma prior and letting its shape and rate parameters tend to zero). Furthermore, the observations are marked on the time axis ("x" for exact observations, "o" for censored observations).

The range spanned by the time axis always goes from the origin to `sample$hyp$T00`.

Value

Always `NULL`.

See Also

`BayHaz-package`, `CPPevalHR`

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a CPP prior distribution
hypars<-CPPpriorElicit(r0 = 0.1, H = 1, T00 = 50, M00 = 2)
# generate a sample of ten hazard rates
prior<-CPPpriorSample(ss = 10, hyp = hypars)

# plot the ten hazard rates
CPPplotHR(prior, tu = "Year")

# load a data set
data(earthquakes)
# generate a posterior sample
post<-CPPpostSample(hypars, times = earthquakes$ti, obs = earthquakes$ob)

# plot some posterior hazard rate summaries
CPPplotHR(post, tu = "Year")
```

CPPpost2mcmc *Function to Convert CPP Posterior Samples into MCMC Objects*

Description

A function to convert a CPP posterior sample into an MCMC object, so that package 'coda' can be used for output diagnostics.

Usage

```
CPPpost2mcmc(sampost)
```

Arguments

`sampost`	posterior sample of CPP hazard rates (as generated by `CPPpostSample`)

Value

An MCMC object, complete with burn-in and thinning information.

Note

If package 'coda' is not available, a matrix with meaningful column names is returned.

See Also

`BayHaz-package`, `CPPpostSample`

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a CPP prior distribution
hypars<-CPPpriorElicit(r0 = 0.1, H = 1, T00 = 50, M00 = 2)
# load a data set
data(earthquakes)
# generate a posterior sample
post<-CPPpostSample(hypars, times = earthquakes$ti, obs = earthquakes$ob)

# convert the posterior sample into an MCMC object
MCMCpost<-CPPpost2mcmc(post)
```

CPPpostSample *Function to Sample Hazard Rates from CPP Posteriors*

Description

A function to generate a random sample of hazard rates from the posterior distribution originated by a CPP prior through the observation of a sequence of possibly right censored times to event.

Usage

```
CPPpostSample(hyp, times, obs = NULL, mclen = 10, burnin = 0, thin = 1, lab = FALSE)
```

Arguments

`hyp`	list of hyperparameters (as generated by `CPPpriorElicit`)
`times`	vector of (possibly right censored) times to event
`obs`	vector of censoring indicators (0 = censored, 1 = exact)
`mclen`	requested sample size
`burnin`	burn-in parameter
`thin`	thinning parameter
`lab`	logical: should latent labels be returned?

Details

A random scan (random start) Gibbs sampler (with slice sampling updating of jump-times) is used to generate a Markov chain sample of length `mclen` from the posterior distribution originated by `hyp` through the observation of `times` and `obs`; see La Rocca (2005).

The first `burnin` states of the Markov chain are discarded, then one every `thin` is kept.

If `obs` is `NULL`, it is assumed that all observations are exact (no censoring).

Value

A list with eight components:

`hyp`	list of hyperparameters identifying the CPP prior that originated the posterior distribution from which the sample was extracted (copy of the input argument)
`dat`	dataframe with two variables (`times` and `obs`) containing the observations on which the posterior distribution is based
`burnin`	burn-in parameter used (copy of the input argument)
`thin`	thinning parameter used (copy of the input argument)
`sgm`	matrix with `mclen` rows (and `hyp$F` columns) containing the CPP jump-times
`xi0`	matrix with `mclen` rows (and just one column) containing the jump-sizes in the origin
`csi`	matrix with `mclen` rows (and `hyp$F` columns) containing the CPP jump-sizes
`gam`	matrix with `mclen` rows (and `length(times)` columns) containing the latent labels (`NULL` if `lab` is `FALSE`)

Note

The latent label γ_i is equal to j when the i-th time to event is associated with the j-th CPP jump; it is only defined for exact observations, but for censored observations it is conventionally set equal to -1.

References

Luca La Rocca (2005). On Bayesian Nonparametric Estimation of Smooth Hazard Rates with a View to Seismic Hazard Assessment. *Research Report n. 38-05*, Department of Social, Cognitive and Quantitative Sciences, Reggio Emilia, Italy.

See Also

`BayHaz-package`, `CPPevalHR`, `CPPplotHR`, `CPPpost2mcmc`

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a CPP prior distribution
hypars<-CPPpriorElicit(r0 = 0.1, H = 1, T00 = 50, M00 = 2)
# load a data set
data(earthquakes)

# generate a posterior sample
post<-CPPpostSample(hypars, times = earthquakes$ti, obs = earthquakes$ob)
```

`CPPpriorElicit` *Function to Set Hyperparameters of CPP Priors*

Description

A function to set the hyperparameters of a CPP prior distribution, following the procedure described in La Rocca (2005).

Usage

```
CPPpriorElicit(r0 = 1, H = 1, T00 = 1, M00 = 1, extra = 0)
```

Arguments

`r0`	prior mean hazard rate (r_0)
`H`	corresponding coefficient of variation
`T00`	time-horizon of interest (T_∞)
`M00`	number of extremes within the time-horizon in a "typical" hazard rate trajectory (M_∞)
`extra`	number of additional CPP jumps (compared with default)

Details

A CPP prior hazard rate is defined, for $0 < t < T_\infty$, by

$$\rho(t) = \xi_0 k_0(t) + \sum_{j=1}^{F} \xi_j k(t - \sigma_j)$$

where:

- σ_j is the time of the j-th jump of a CPP process with gamma distributed jump-sizes
- ξ_j is the j-th jump-size of the above process
- k is a zero-mean Gaussian density (kernel)
- F is a positive integer such that (with high probability) σ_{F+1} is much larger than T_∞
- ξ_0 is an independent random variable with the same distribution as ξ_j
- k_0 is a suitable function such that the mean of $rho(t)$ does not depend on t

The elicitation procedure makes the mean of $rho(t)$ identically equal to r_0 and its standard deviation approximately equal to Hr_0. An exponential distribution is selected for the jump-sizes. The kernel bandwidth choice is based on M_∞ (and T_∞).

Value

A list with nine components:

`r0` prior mean hazard rate (copy of the input argument)

`H` corresponding coefficient of variation (copy of the input argument)

`T00` time-horizon of interest (copy of the input argument)

`M00` number of extremes within the time-horizon in a "typical" hazard rate trajectory (copy of the input argument)

`a` shape parameter of the jump-size distribution (always equal to 1)

`sd` standard deviation of the Gaussian kernel (bandwidth)

`q` expected number of CPP jumps per time unit

`b` rate parameter of the jump-size distribution

`F` maximum number of jumps within the time-horizon (with high probability)

Note

As the default value of `F` is computed *a priori*, additional jumps may be needed *a posteriori*.

References

Luca La Rocca (2005). On Bayesian Nonparametric Estimation of Smooth Hazard Rates with a View to Seismic Hazard Assessment. *Research Report n. 38-05*, Department of Social, Cognitive and Quantitative Sciences, Reggio Emilia, Italy.

See Also

BayHaz-package, CPPpriorSample, CPPpostSample

Examples

```
# ten events per century with unit coefficient of variation
# fifty year time horizon with a couple of extremes in a "typical" trajectory
hypars<-CPPpriorElicit(r0 = 0.1, H = 1, T00 = 50, M00 = 2)
```

CPPpriorSample *Function to Sample Hazard Rates from CPP Priors*

Description

A function to generate a random sample of hazard rates from a CPP prior distribution.

Usage

```
CPPpriorSample(ss = 1, hyp = CPPpriorElicit())
```

Arguments

`ss` requested sample size

`hyp` list of hyperparameters (as generated by CPPpriorElicit)

Details

A random sample of `ss` hazard rates is extracted from the CPP prior distribution identified by `hyp`.

Value

A list with four components:

`hyp` list of hyperparameters identifying the CPP prior distribution from which the sample was extracted (copy of the input argument)

`sgm` matrix with `ss` rows (and `hyp$F` columns) containing the CPP jump-times

`xi0` matrix with `ss` rows (and just one column) containing the jump-sizes in the origin

`csi` matrix with `ss` rows (and `hyp$F` columns) containing the CPP jump-sizes

See Also

CPPevalHR, CPPplotHR

Examples

```
# set RNG seed (for example reproducibility only)
set.seed(1234)

# select a CPP prior distribution
hypars<-CPPpriorElicit(r0 = 0.1, H = 1, T00 = 50, M00 = 2)

# generate a sample of ten hazard rates
prior<-CPPpriorSample(ss = 10, hyp = hypars)
```

---

earthquakes *Waiting Times between Strong Earthquakes in the Appennino Abruzzese*

Description

This data set gives the waiting times (in years) between earthquakes with moment maginitude greater than 5.1, in the Italian seismogenic zone 923, from year 1650 to year 2002, as obtained by La Rocca (2005) based on the catalogue by Gruppo di Lavoro CPTI (2004).

Usage

```
data(earthquakes)
```

Format

A data frame with 47 observations on the following 2 variables:

`ti` earthquake inter-event times (years)

`ob` censoring indicators (0 = right censored, 1 = exact)

Note

All observations are exact, except for the last one (a characteristic of this kind of data).

Source

Gruppo di Lavoro CPTI (2004). Catalogo Parametrico dei Terremoti Italiani, versione 2004 (CPTI04). INGV, Bologna, http://emidius.mi.ingv.it/CPTI. In Italian.

References

Luca La Rocca (2005). On Bayesian Nonparametric Estimation of Smooth Hazard Rates with a View to Seismic Hazard Assessment. *Research Report n. 38-05*, Department of Social, Cognitive and Quantitative Sciences, Reggio Emilia, Italy.

See Also

BayHaz-package

Examples

```
# load data set
data(earthquakes)

# show data set structure
str(earthquakes)
```

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