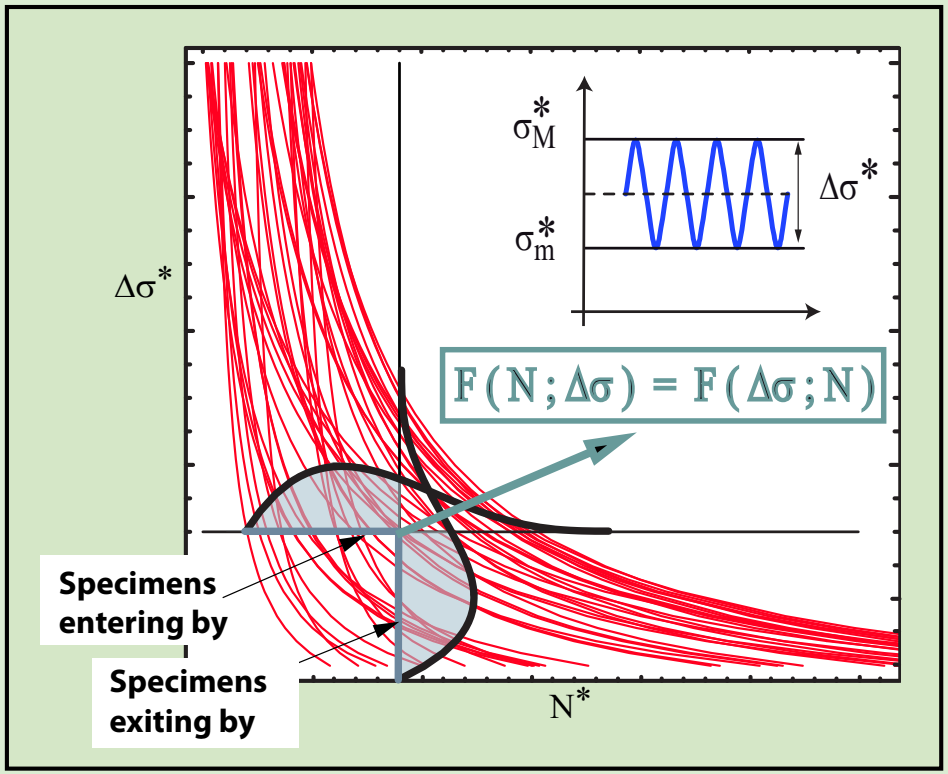
The fatigue model

OpenBUGS

The S-N Fatigue Model



$$F(N;\Delta\sigma) = F(\Delta\sigma;N)$$

$$F(N;\Delta\sigma) = 1 - \exp\left[-\left(\frac{\left(\log\frac{N}{N_0}\right)\left(\log\frac{\Delta\sigma}{\Delta\sigma_0}\right) - \lambda}{\delta}\right)^{\beta}\right];\ \left(\log\frac{N}{N_0}\right)\left(\log\frac{\Delta\sigma}{\Delta\sigma_0}\right) \geq \lambda$$

The Maennig data

The Model Commands

```
model {
# Model and data
    C <- 100 # this just be large enough to ensure all phi[i]s > 0
    for(i in 1:M) {
        zzeros[i] ~dpois(phi[i])
        phi[i] <- -log(beta)+pow((x[i]-lambda)/delta,beta)
        -(beta-1)*log((x[i]-lambda)/delta)+log(delta)+C
        x[i]<-log(N[i]/N0)*log(deltasigma[i]/Delta0)
    }
# priors
    N0~dunif(minN0,maxN0)
    Delta0~dunif(minDelta,maxDelta)
    beta~dunif(minbeta,maxbeta)
    lambda~dunif(minlambda,maxlambda)
    delta~dunif(mindelta,maxdelta)
}
```

How to simulate a given cdf

One interesting trick to simulate a given cumulative distribution function is to simulate a Poisson distribution with null observations and choosing the Poisson parameter to have identical likelihoods for the Poisson and the simulated models.

The Poisson likelihood $p(x;\phi)$ and the likelihood $p(0,\phi)$ for a zero observation (x=0), respectively, are:

$$p(x;\phi) = \frac{\phi^x e^{-\phi}}{x!}; \quad p(0,\phi) = e^{-\phi},$$

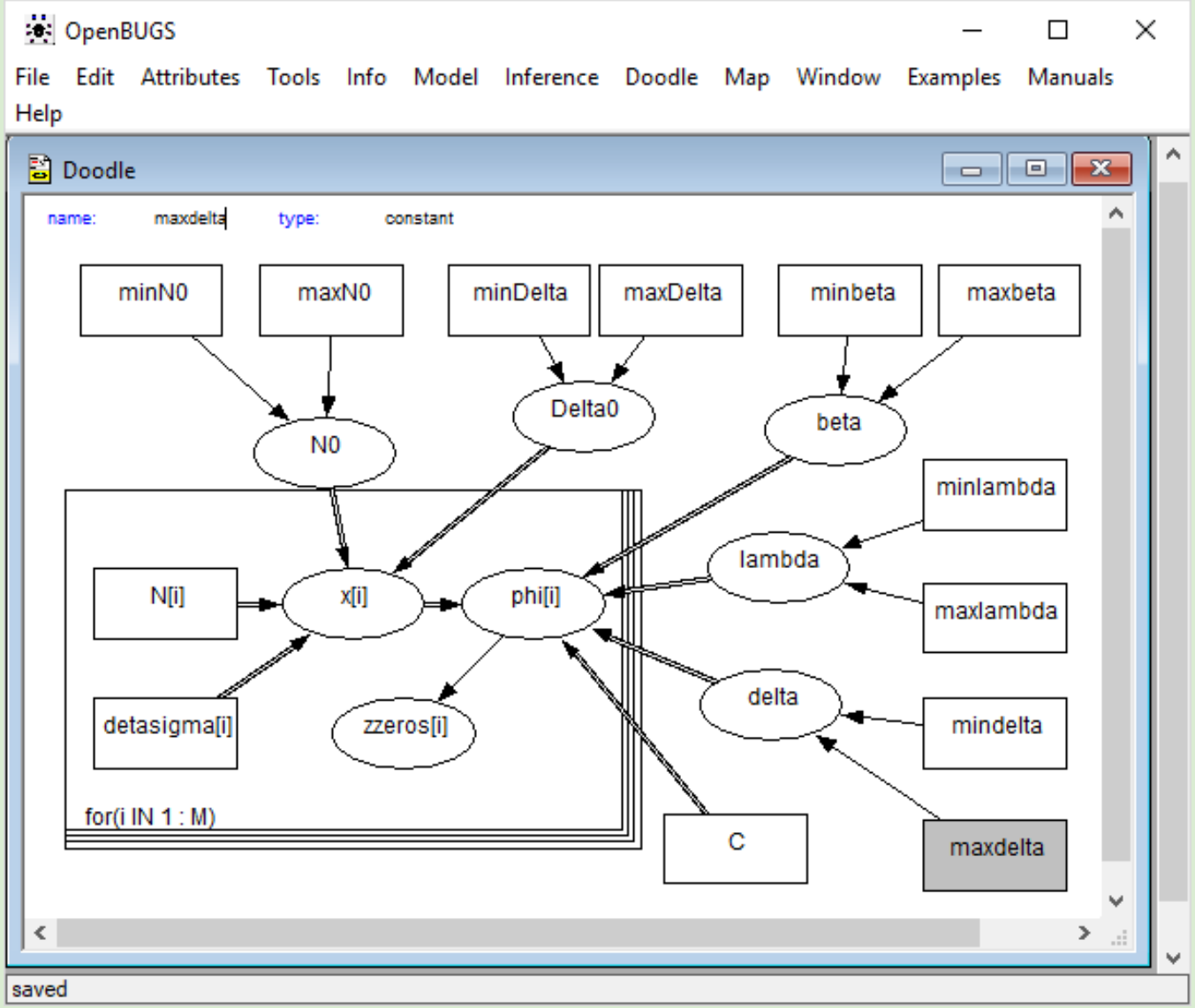
For example, the Weibull model has cdf $F(x)$ and pdf $f(x)$:

$$F(x) = 1 - \exp\left[-\left(\frac{x-\lambda}{\delta}\right)^{\beta}\right]; \quad f(x) = \frac{\beta}{\delta}\exp\left[-\left(\frac{x-\lambda}{\delta}\right)^{\beta}\right]\left(\frac{x-\lambda}{\delta}\right)^{\beta-1}$$

and equating $f(x) = p(0,\phi)$, we get the expression we have used in the fatigue model:

$$\phi = -\log\left\{\frac{\beta}{\delta}\exp\left[-\left(\frac{x-\lambda}{\delta}\right)^{\beta}\right]\left(\frac{x-\lambda}{\delta}\right)^{\beta-1}\right\}$$

The Fatigue Problem Doodle Bayesian Network



This is an example of the fatigue model obtained with Doodle.

Loading the Commands

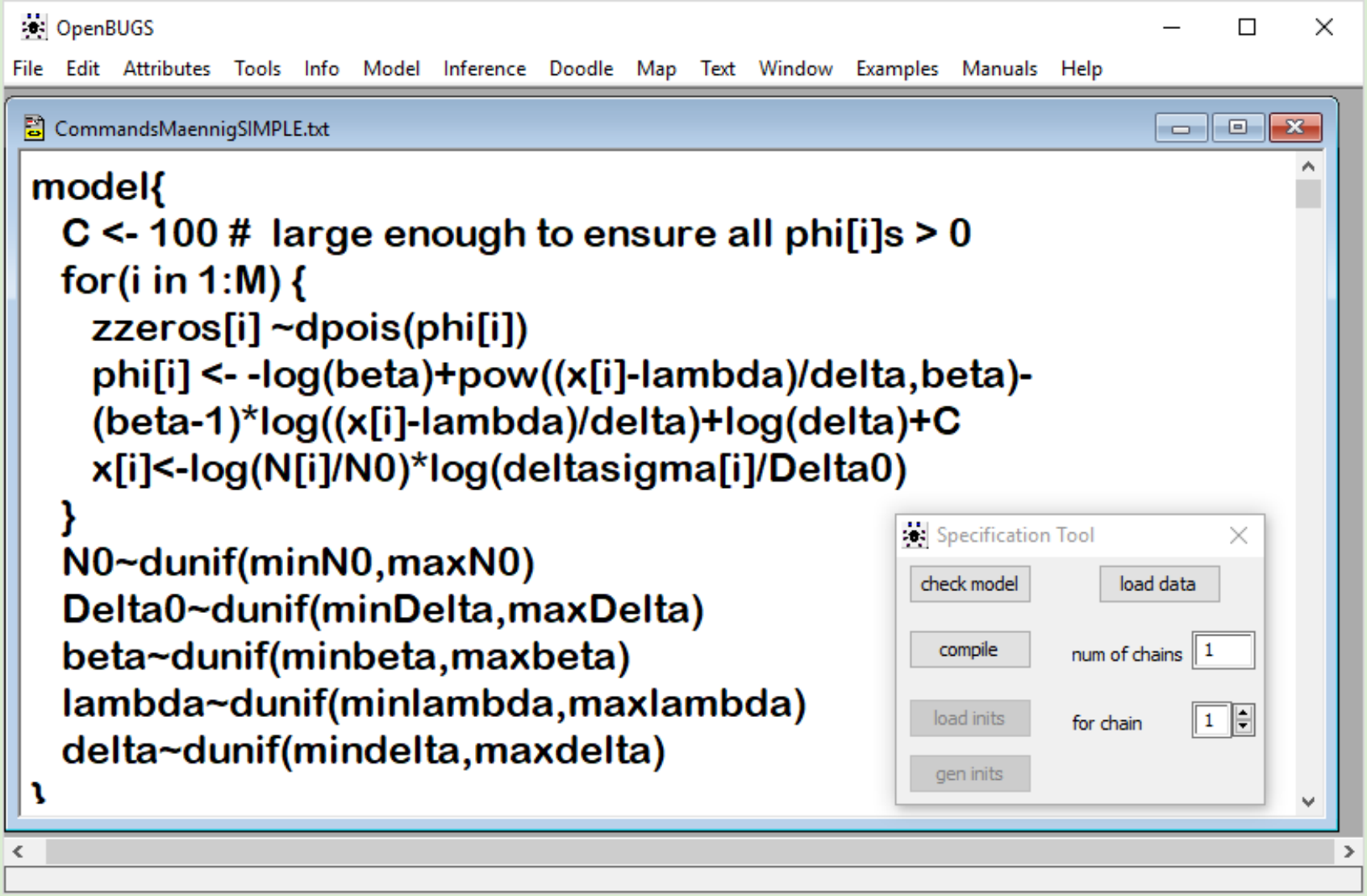


Illustration of how to load the model commands.

Loading and Compiling The Model Data

OpenBUGS

File Edit Attributes Tools Info Model Inference Doodle Map Text Window Examples Manuals Help

DataMaennigSIMPLE.txt

```
list(M=360,minlambda=0.272,maxlambda=0.34,minDelta=206.305,maxDelta=257.881,minbeta=2.376,maxbeta=3.564,
mindelta=0.448,maxdelta=0.672,minN0=11966.400000000001000,maxN0=14958.000000000000000,

zzeros=c(    0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,
0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,
0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,
0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,    0.000000000000,
....   0.000000000000),

deltasigma=c(   385.000000000000,   385.000000000000,   385.000000000000,   385.000000000000,   385.000000000000,
385.000000000000,   385.000000000000,   385.000000000000,   385.000000000000,   385.000000000000,   385.000000000000,
 385.000000000000,   385.000000000000,   385.000000000000,   385.000000000000,   385.000000000000,   385.000000000000,
  385.000000000000,   385.000000000000,   385.000000000000,   380.000000000000,   380.000000000000,   380.000000000000,
   380.000000000000,   380.000000000000,   380.000000000000,   380.000000000000,   380.000000000000,
295.000000000000,   290.000000000000,   290.000000000000,   285.000000000000),

N=c( 51000.000000000000, 57000.000000000000, 60000.000000000000, 67000.000000000000, 68000.000000000000,
69000.000000000000, 75000.000000000000, 76000.000000000000, 82000.000000000000, 83000.000000000000,
87000.000000000000, 95000.000000000000, 106000.000000000000, 109000.000000000000, 111000.000000000000,
119000.000000000000, 122000.000000000000, 128000.000000000000, 132000.000000000000, 140000.000000000000,
59000.000000000000, 66000.000000000000, 69000.000000000000, 80000.000000000000, 87000.000000000000, ...
055000.000000000000,1369000.000000000000,1220000.000000000000)
)
```

Specification Tool

check model | load data

compile | num of chains 1

load inits | for chain 1

gen inits

Illustration of how to load the data and compile the model.

Loading Initial Values

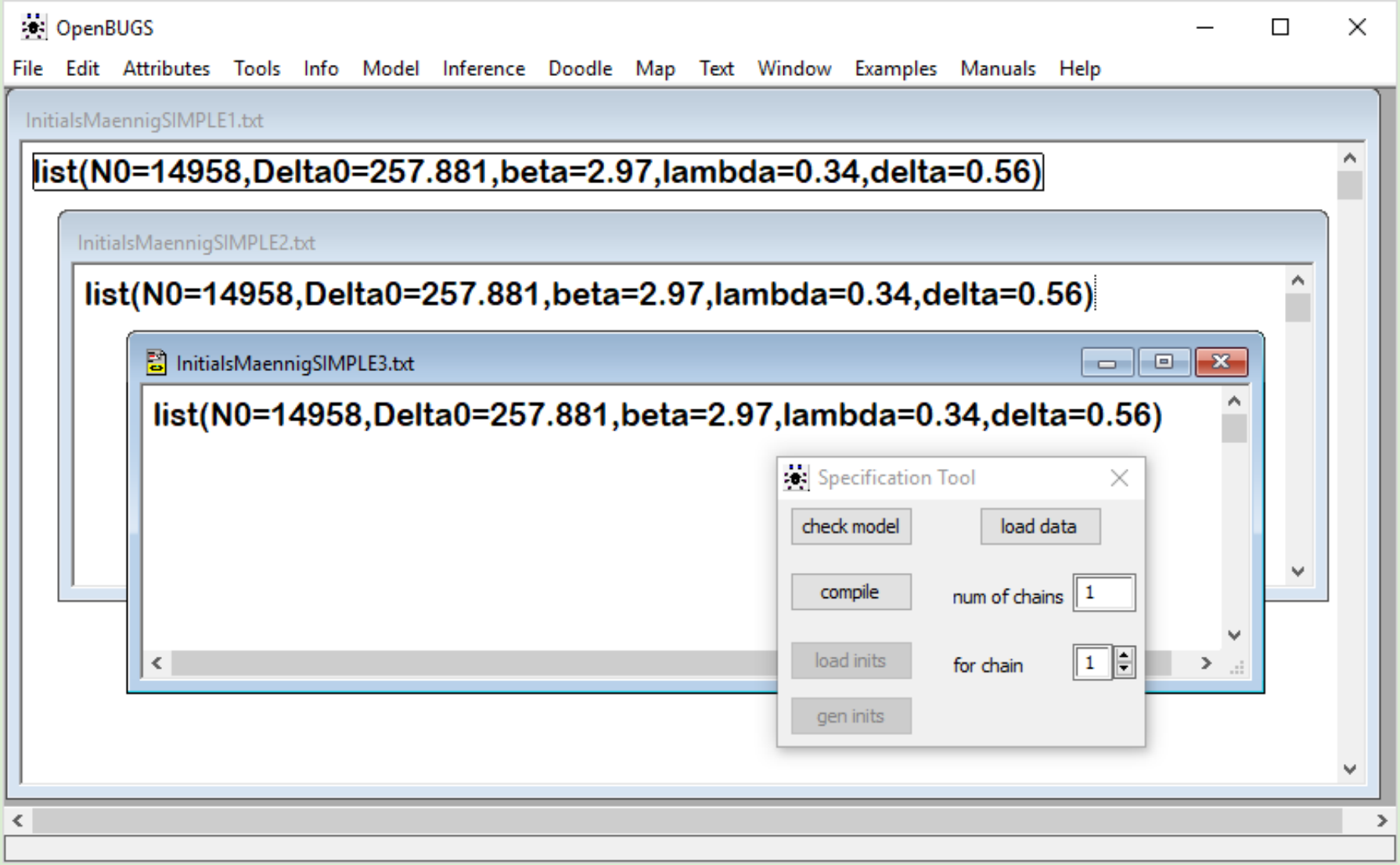
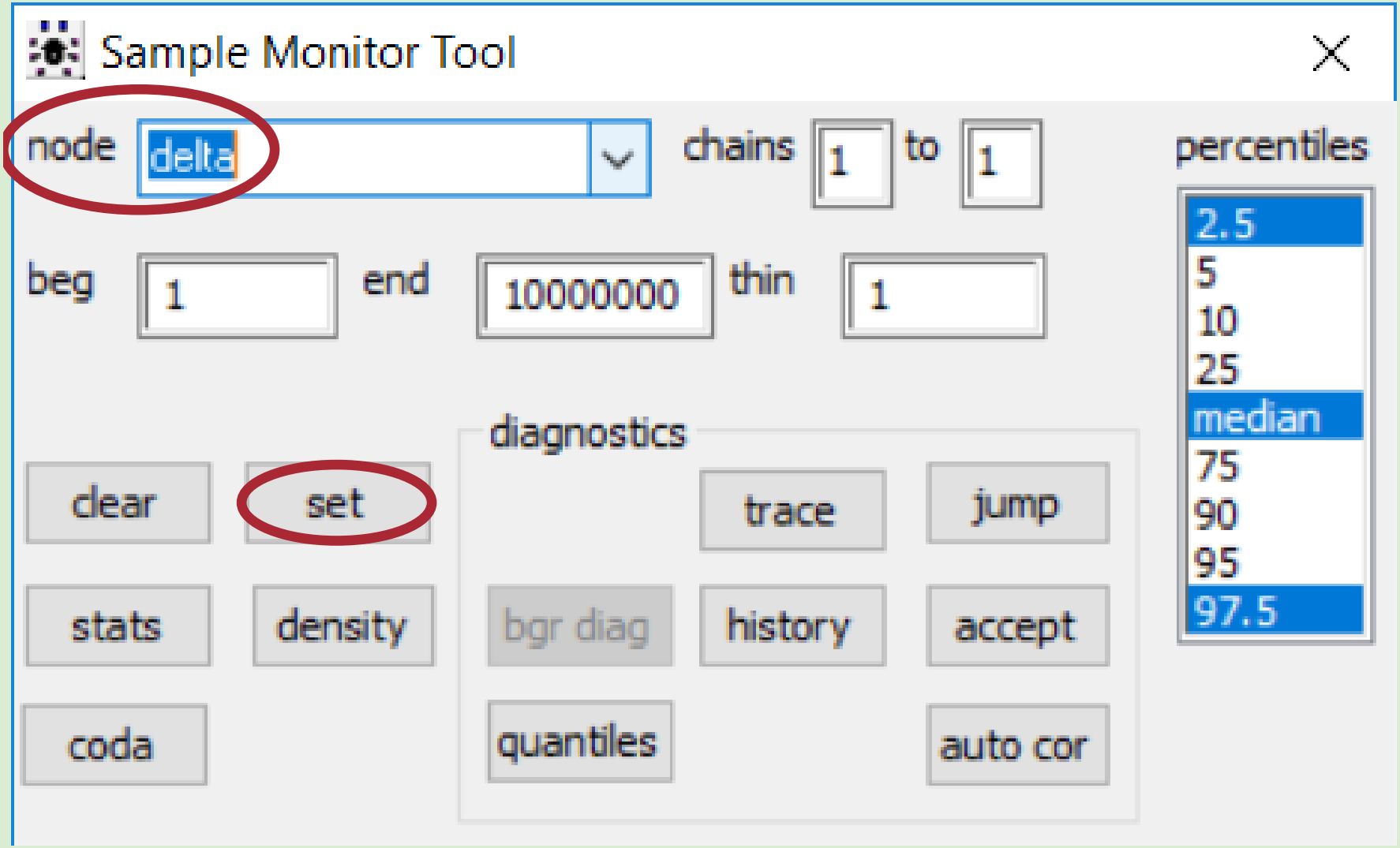


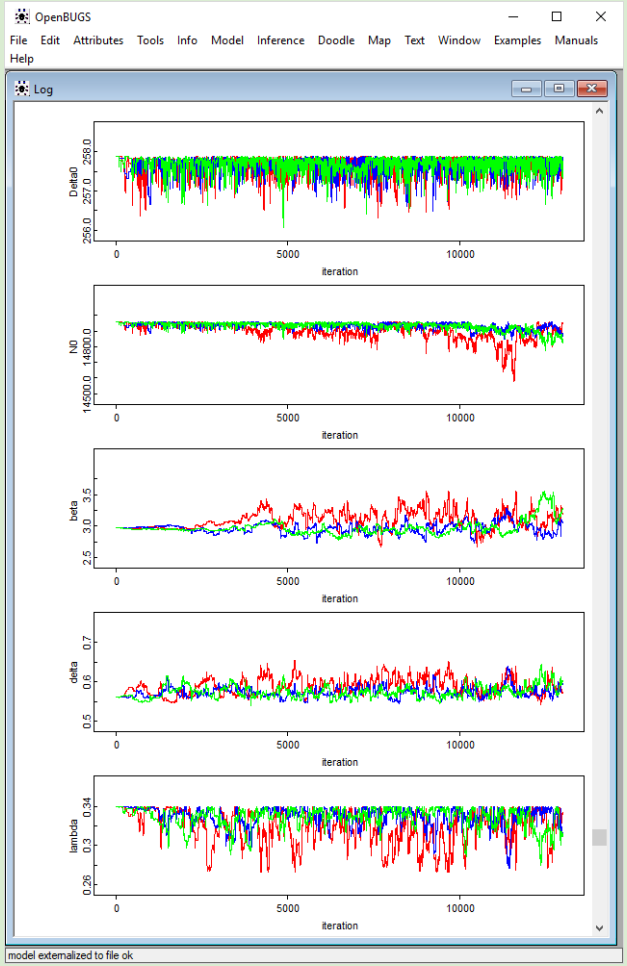
Illustration of how to load the initial values for the simulation.

The Monitor Tool



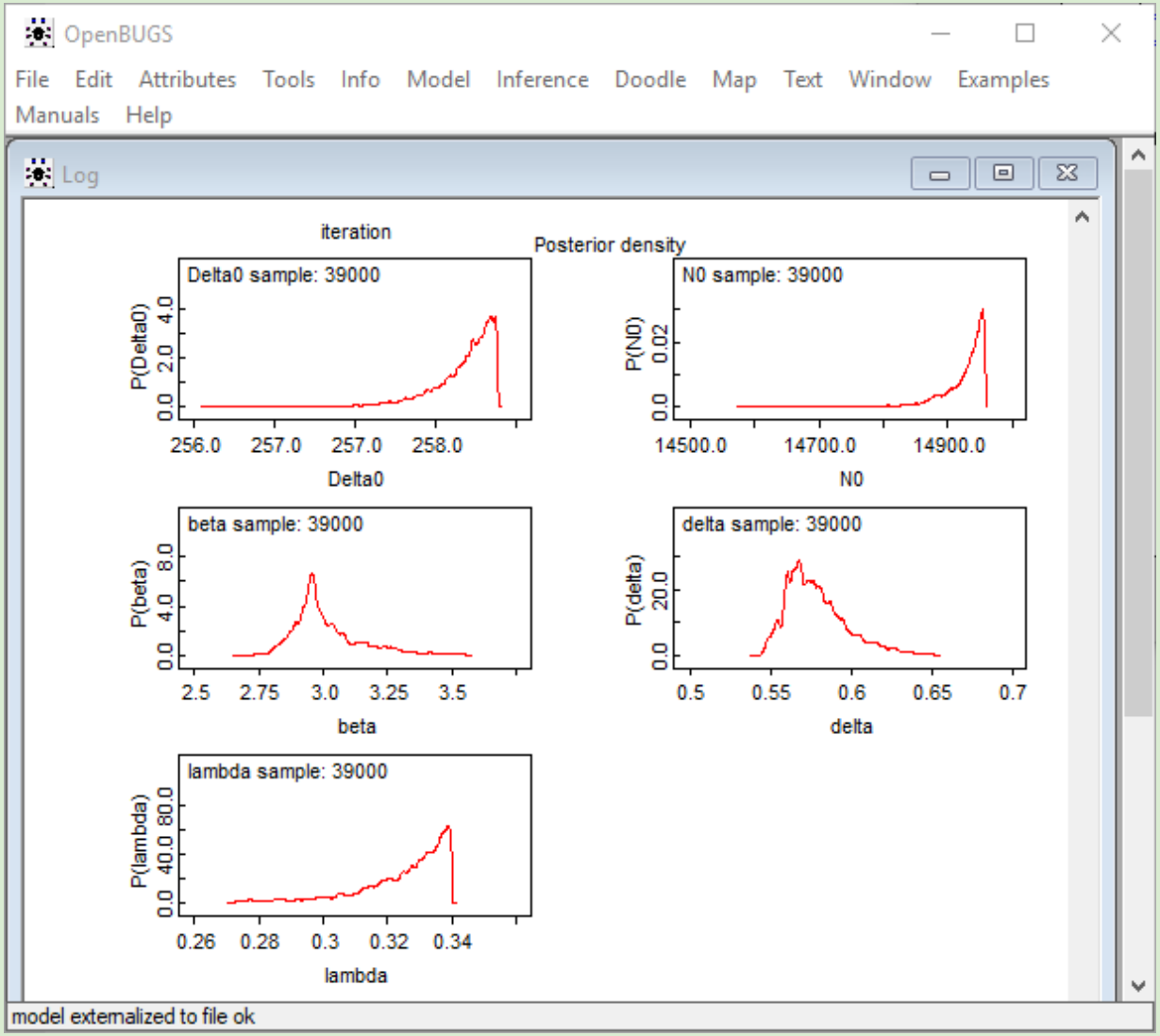
This is the Sample Monitor Tool.

Convergence Information of the Gibs Sampler for the Maennig Data



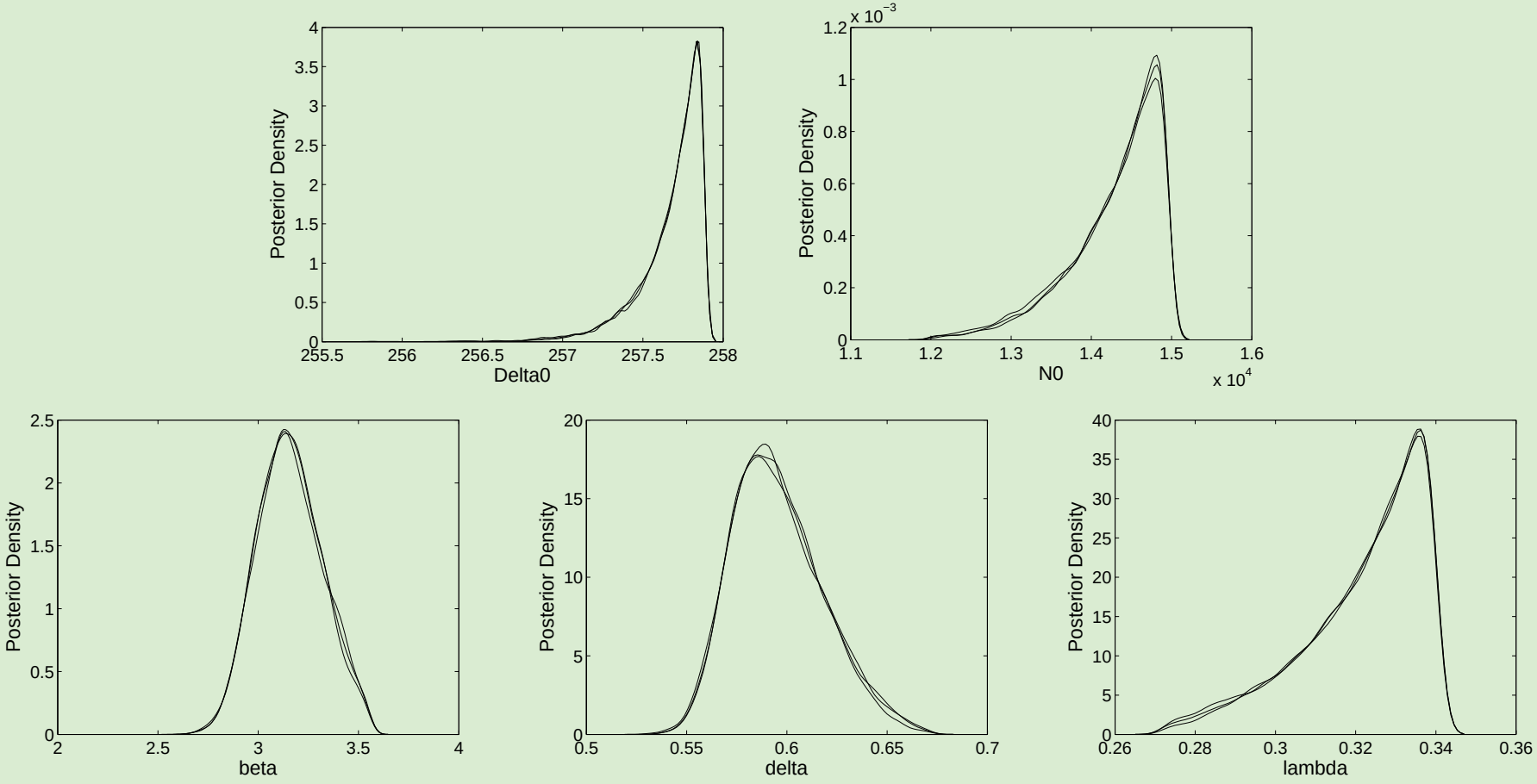
Convergence information of the Gibs sampler for the Maennig data.

Parameter Posterior Densities for the Maennig Data



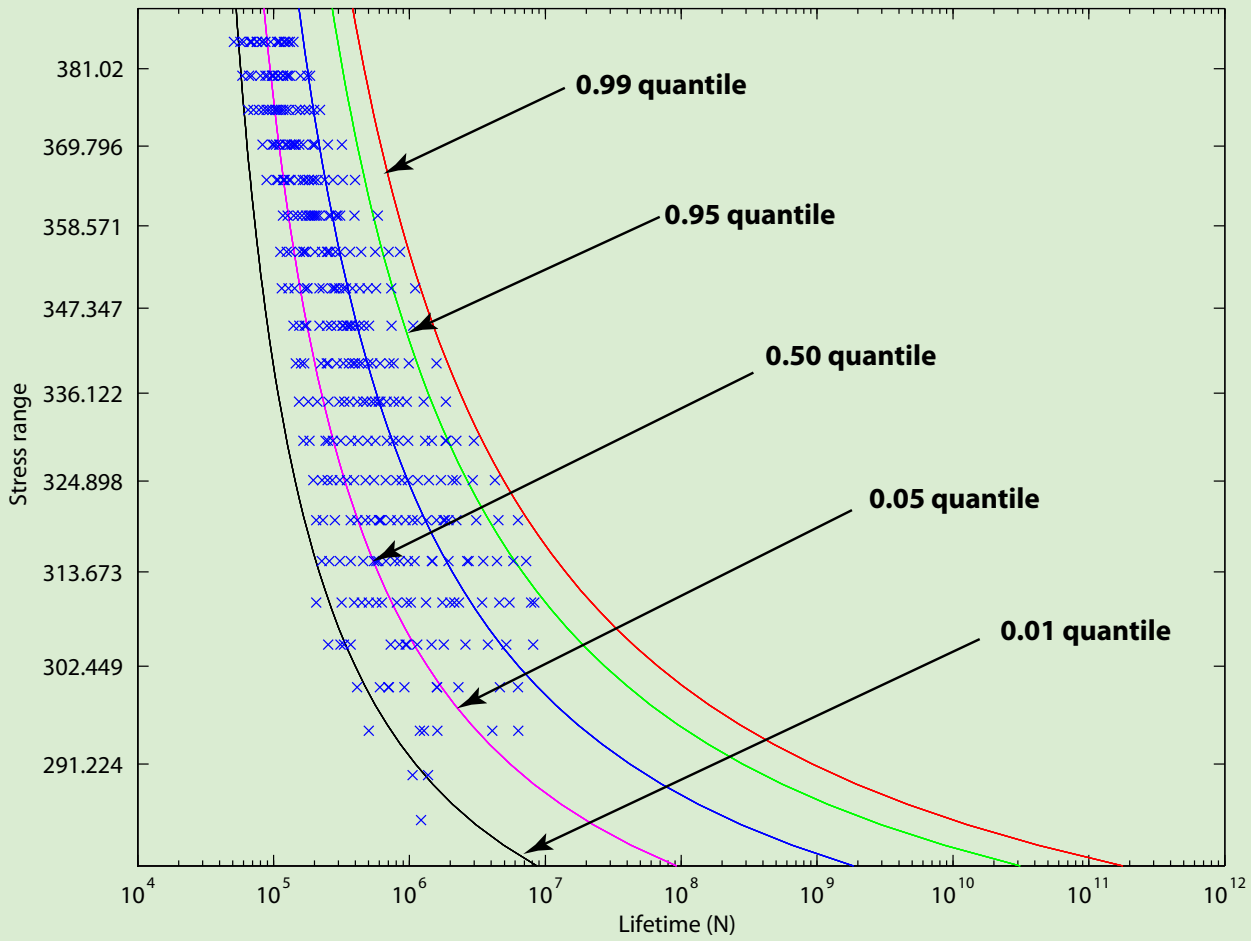
Parameter posterior densities for the Maennig data.

Parameter Posterior Densities for the Maennig Data



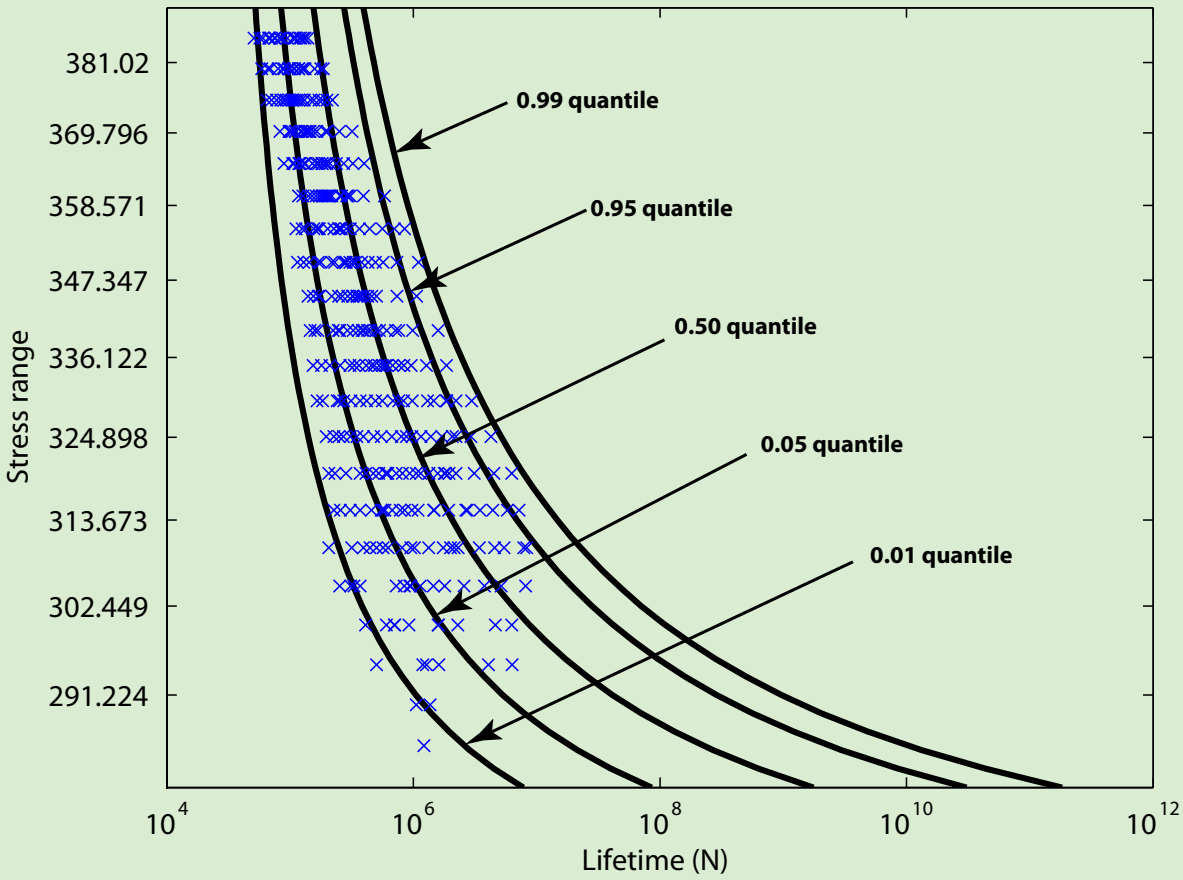
Parameter posterior densities for the Maennig data.

Initial Percentiles Using Maximum Likelihood



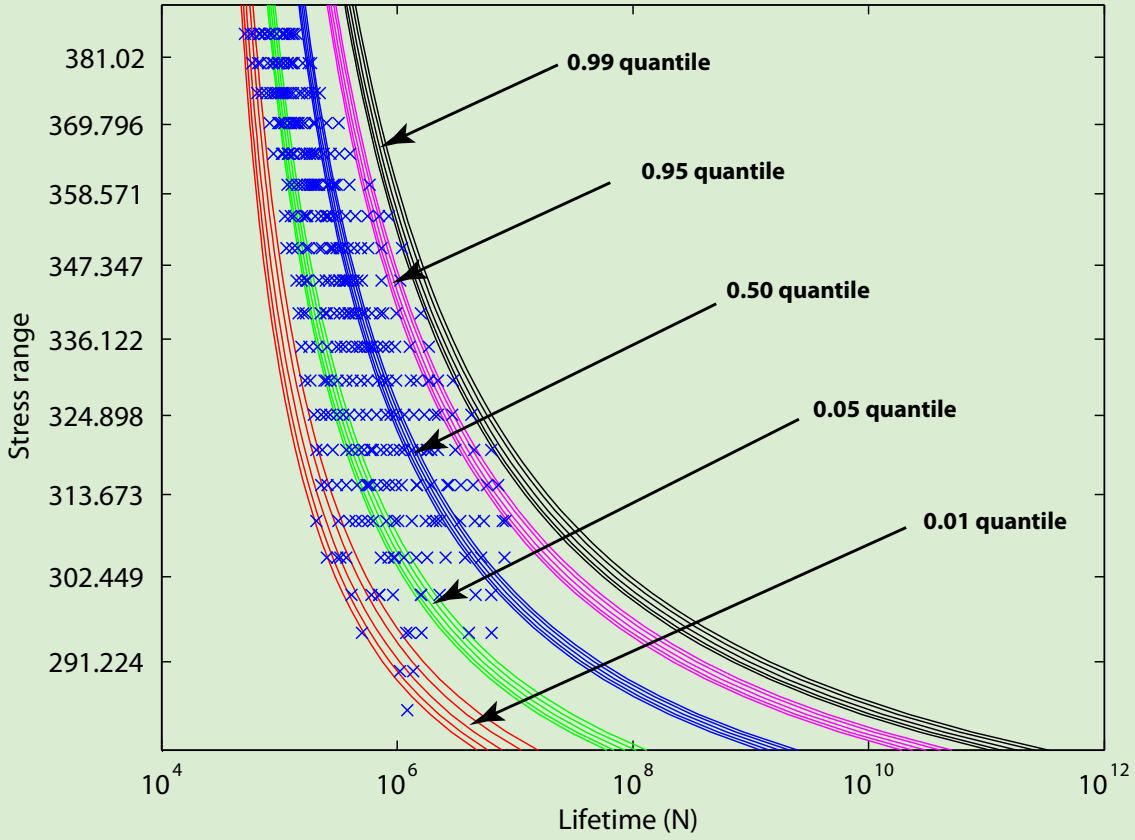
These are the initial percentiles using classical methods based on maximum likelihood.

Median Percentiles Using the Bayesian Method and the Openbugs Samples



These are the median percentiles using the Bayesian method and the OpenBUGS samples.

The Percentile Percentiles Using the Bayesian Method



These are the percentile percentiles $0.01, 0.1, 0.5, 0.9$ and 0.99 using the Bayesian method and the OpenBUGS samples.

The Fatigue Problem Script

SCRIPT.txt

```
modelDisplay('log')

# Check model syntax
modelCheck('D:/DOC/Enrique/Articulos/Castillo_Canteli/OpenBUGS/Matlab/Commands.t

# Load data
modelData('D:/DOC/Enrique/Articulos/Castillo_Canteli/OpenBUGS/Matlab/Data.txt')
# Compile with one chain
modelCompile(1)

# Load initial values for first chain
modelInits('D:/DOC/Enrique/Articulos/Castillo_Canteli/OpenBUGS/Matlab/Initials.txt')

# Start with 1000 update burn-in
modelUpdate(1000)

# Set nodes of interest
samplesSet('N0')
samplesSet('Delta0')
samplesSet('beta')
samplesSet('lambda')
samplesSet('delta')

# Follow by a further 20,000 updates
modelUpdate(20000)
```

One example of Script to execute OpenBUGS very fast without using menus and windows.

The Fatigue Problem Script

SCRIPT.txt

```
# Look at sample statistics
samplesStats('*')

# Look at sample Coda
samplesCoda('N0','D:/DOC/Enrique/Articulos/Castillo_Canteli/OpenBUGS/Matlab/N0')
samplesCoda('Delta0','D:/DOC/Enrique/Articulos/Castillo_Canteli
/OpenBUGS/Matlab/Delta0')
samplesCoda('lambda','D:/DOC/Enrique/Articulos/Castillo_Canteli
/OpenBUGS/Matlab/lambda')
samplesCoda('delta','D:/DOC/Enrique/Articulos/Castillo_Canteli/OpenBUGS/Matlab/delta')
samplesCoda('beta','D:/DOC/Enrique/Articulos/Castillo_Canteli/OpenBUGS/Matlab/beta')

# Look at sample quantiles
samplesQuantiles('*')

# Look at sample densities
samplesDensity('*')

# save model state
modelSaveState('D:/DOC/Enrique/Articulos/Castillo_Canteli/OpenB
UGS/Matlab/StateModel')

# node values info
infoNodeValues('*')
```

One example of Script to execute OpenBUGS very fast without using menus and windows.

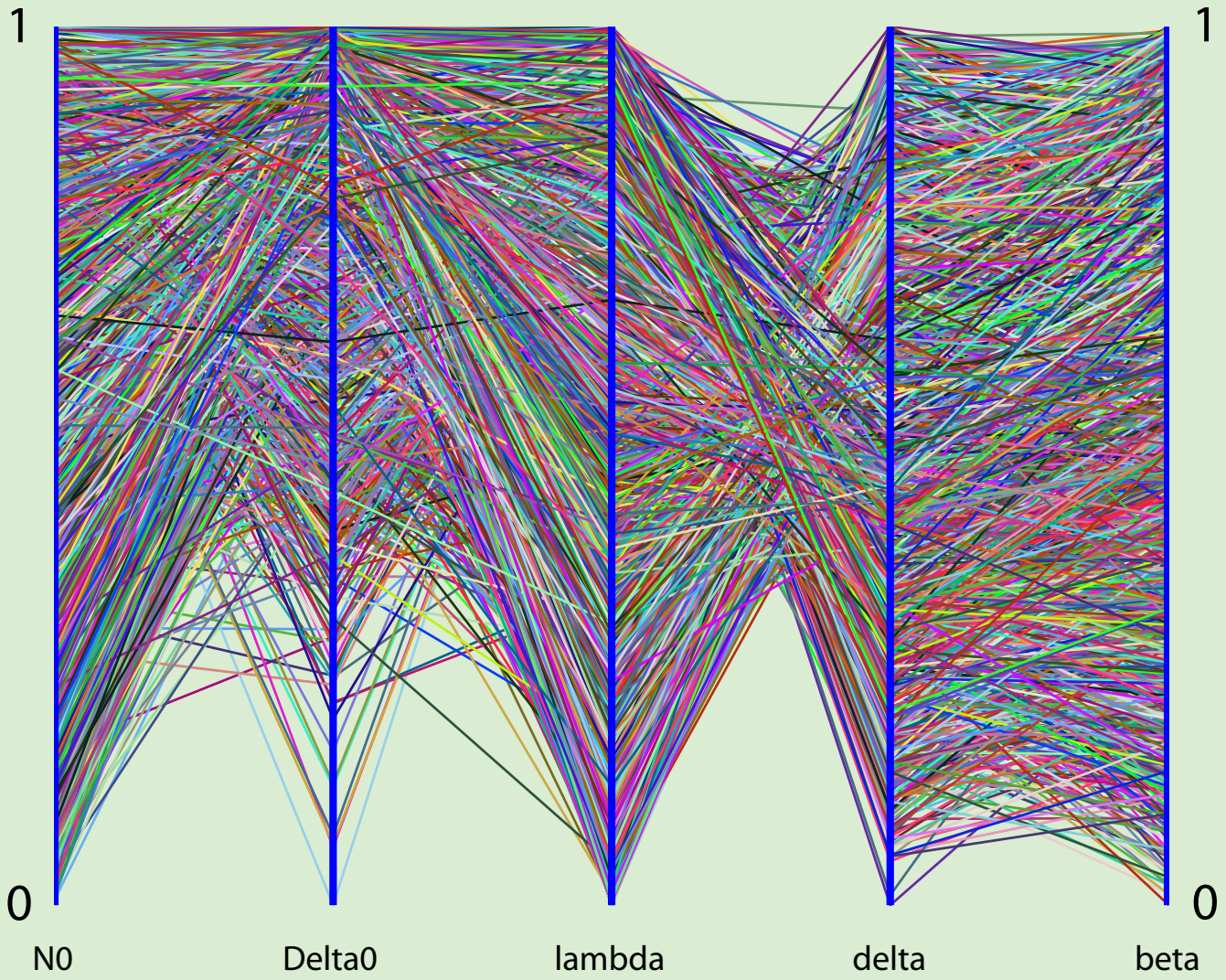
The Fatigue Problem Script

SCRIPT.txt

```
# SummarySet
SummarySet('*')

# SummaryStats
SummaryStats('*')

# SummaryMean
SummaryMean('*')

# node methods info
infoNodeMethods('*')

# node types info
infoNodeTypes('*')

# memory info
infoMemory()

# save model log
modelSaveLog('D:/DOC/Enrique/Articulos/Castillo_Canteli/OpenBUG
S/Matlab/LogModel.odc')

# Quit model
modelQuit('Yes')
```

One example of Script to execute OpenBUGS very fast without using menus and windows.

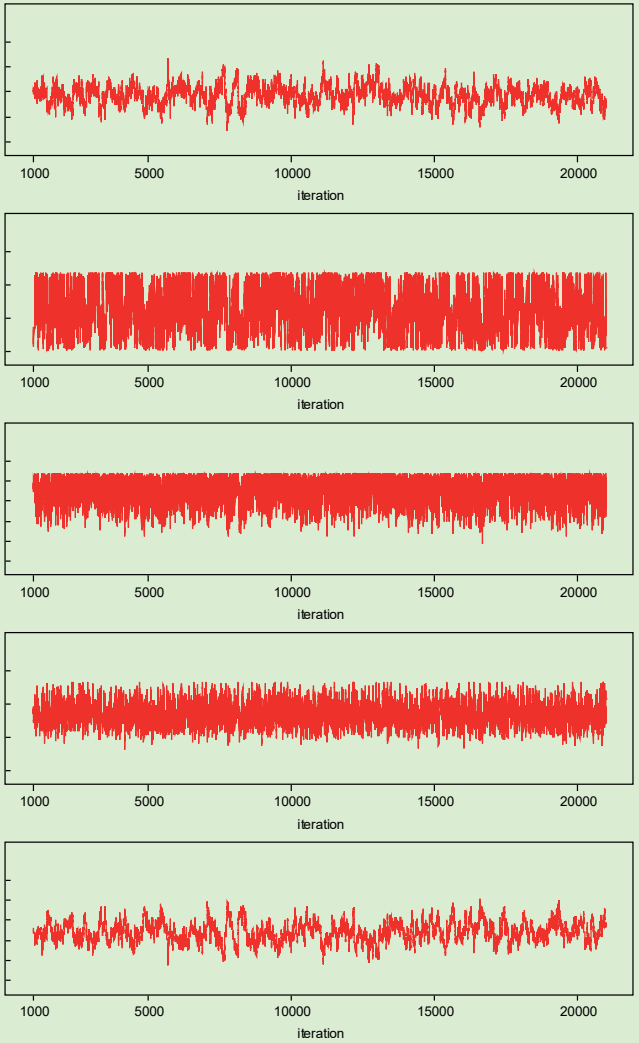
Parameter dependencies



0-1 normalized values of the sample

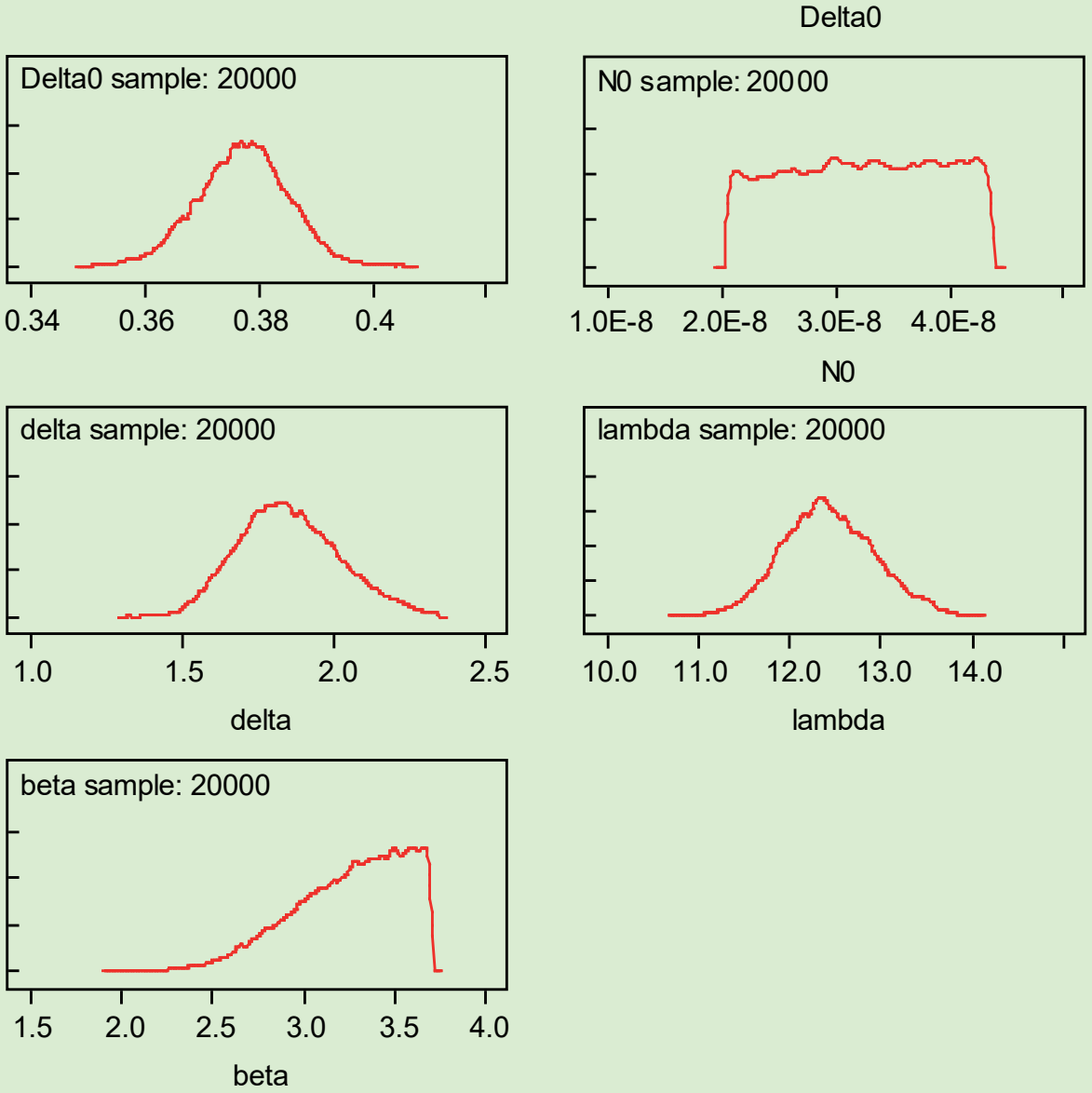
The Holmen data

The Monitor Tool

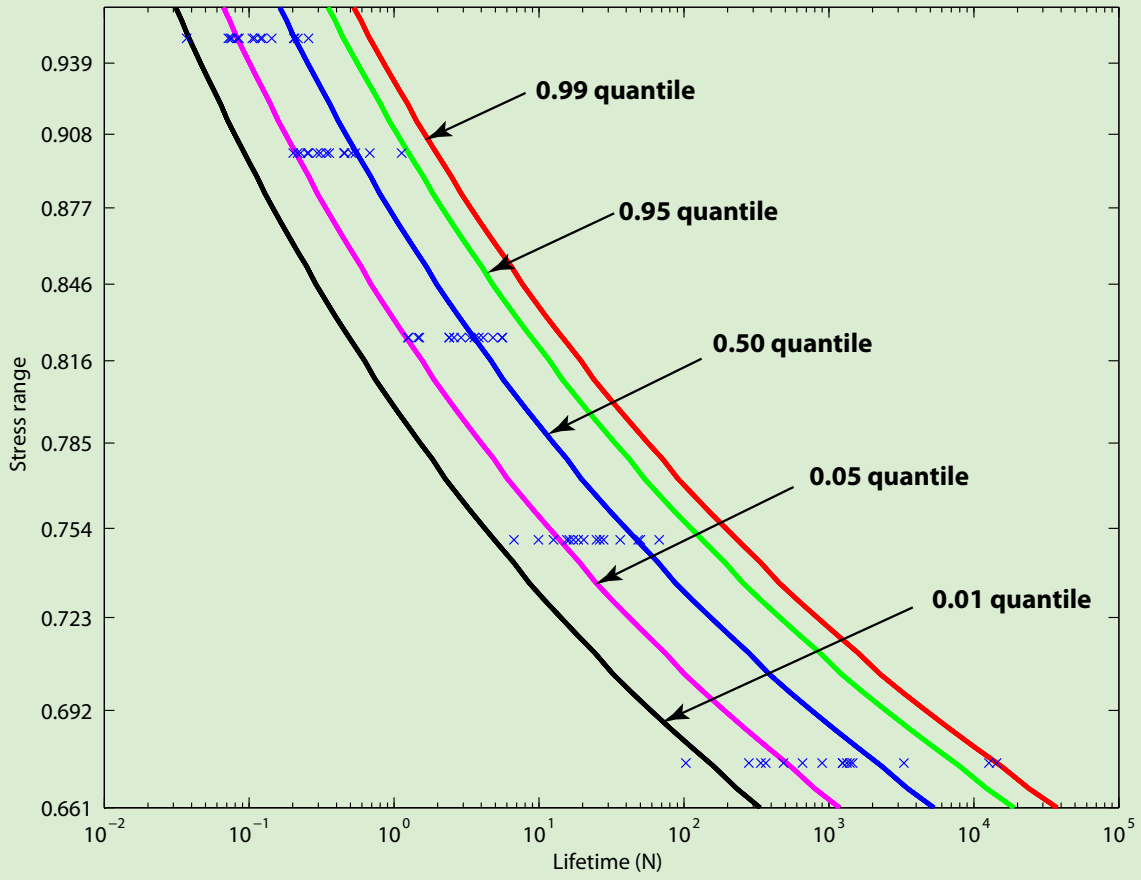


Convergence information of the Gibs sampler for the Holmen data.

The Parameter Posterior Densities for fhe Holmen Data



Initial Percentiles Using Maximum Likelihood



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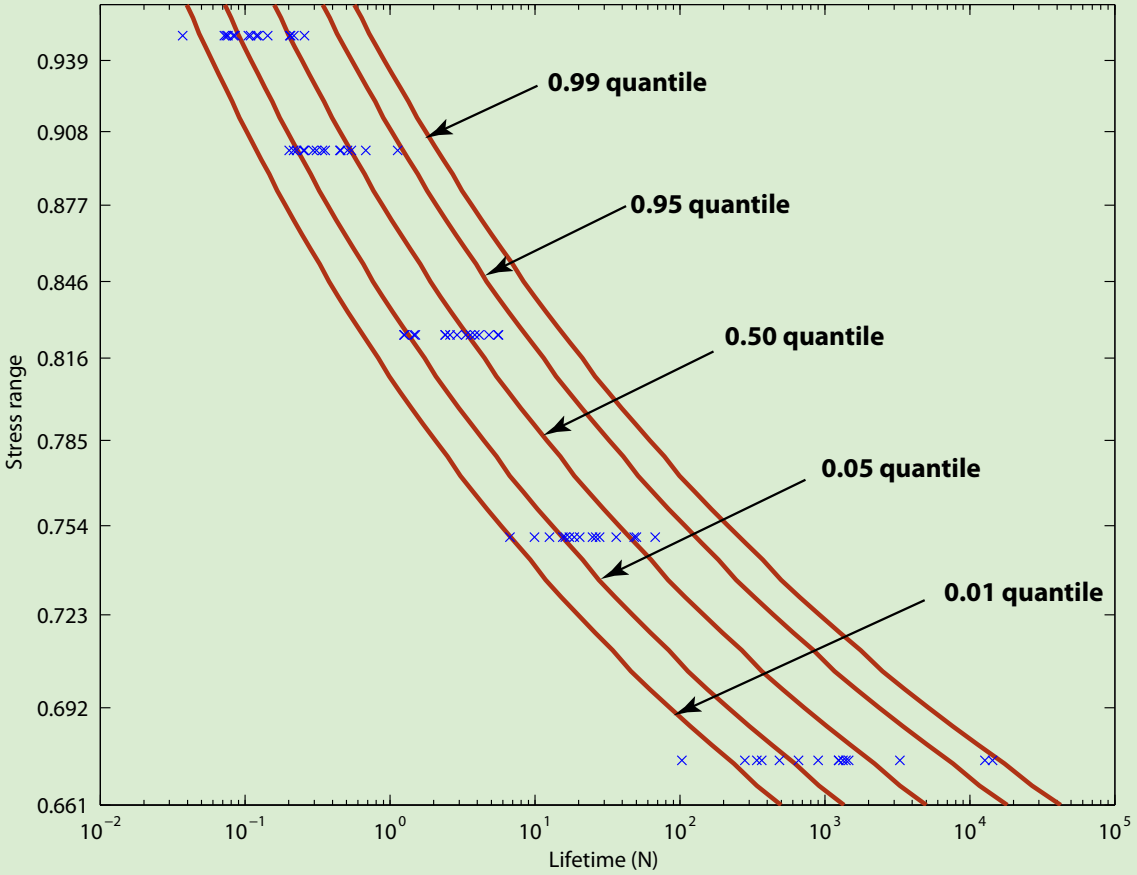
Median percentiles using the Bayesian method and the OpenBUGS samples



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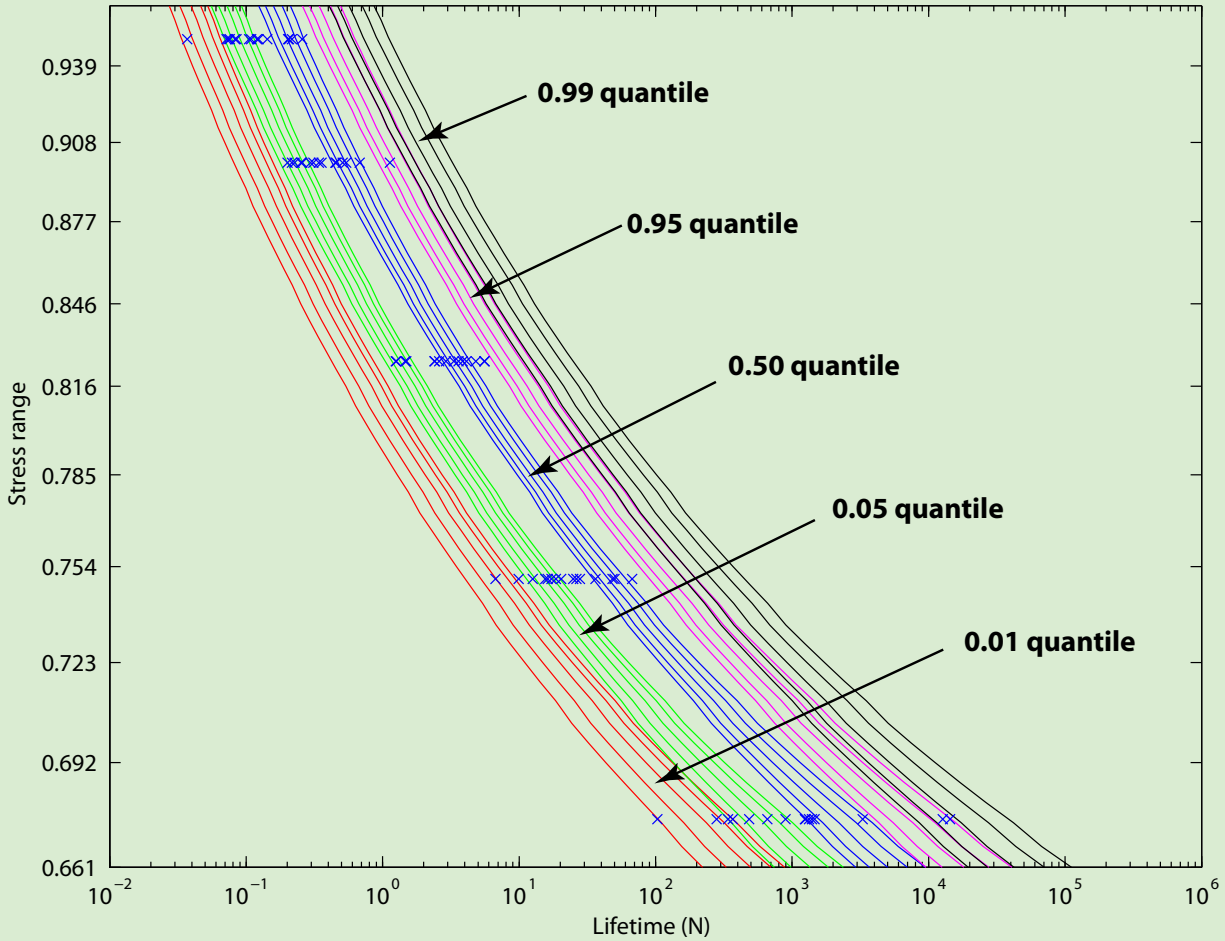
The Percentile Percentiles Using The Bayesian Method and The Openbugs Samples



These are the percentile percentiles $0.01, 0.1, 0.5, 0.9$ and 0.99 using the Bayesian method and the OpenBUGS samples.

The Manuals, Examples and Help Menus

The Manuals, Examples and Help Menus

At this stage of the course, **the reader should dedicate some time to play with the OpenBUGS Manuals**, which are accesible by means of the “Manuals” menu. There you can consult how to use the different menus and **how to generate mixed documents** including text, the command, data and initial files, the plots resulting from the OpenBUGS software, and any plots generated by the user using other software tools.

It is very important to take a look to the “Examples” menu, where very interesting examples of applications are included. **The user should run several of these examples and try to understand what the different models do**. Note that we are in an age at which the self learning component plays a central role. More that asking questions to other people we must be able to answer them by ourselves. This material provides a nice help in this direction.

Finally, the “Help” menu includes two options: **“Distributions”** and **“Functions”**. **The first provides a list of all implemented distribution families** that we can use directly in our models, and **the second lists all defined functions**, that we will need in our model building process.