PV data - Parameter estimation and sample generation

Martina Kuchlbauer

Tuesday, May 17, 2016

We consider the first column of the data given in PVdata2.csv (to reduce running times, it will work analogously when we take all data into account). Let's generate a matrix where each line represents a day and each column represents one minute of this day:

```
PV1<-PVdata[1:1440,1] #24*60=1440
for (i in 1:30) {
  PV1<-cbind(PV1,PVdata[((i*1440)+1):((i+1)*1440),1])
}
PV1<-t(PV1)
```

1 Normal distribution

1.1 Parameter estimation

1.1.1 Parameter estimation - multivariate (dependent) for 1h intervals

We obtain an estimation for the values of expectation and the covariance matrix under the assumption of a **multivariate** normal distribution for intervals of 1h:

```
PV1h<-matrix(rep(0,744),nrow=31) #hourly values -> take means
for(i in 1:31){
  for (j in 1:24){
    PV1h[i,j]<-mean(PV1[i,((j-1)*60+1):(j*60)])
  }
}

estimates_n_dep<-mlest(PV1h) #under assumption of no independence: hourly means and covariance matrix

estimates_n_dep$muhat #estimate of mean (mu)
```

```
##  [1] -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09
##  [7]  2.000e+00  4.244e+02  1.086e+03  1.641e+03  2.026e+03  2.262e+03
## [13]  2.253e+03  2.212e+03  1.874e+03  1.358e+03  7.384e+02  5.380e+01
## [19] -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09
```

```
estimates_n_dep$sigmahat #estimate of covariance matrix (sigma)
```

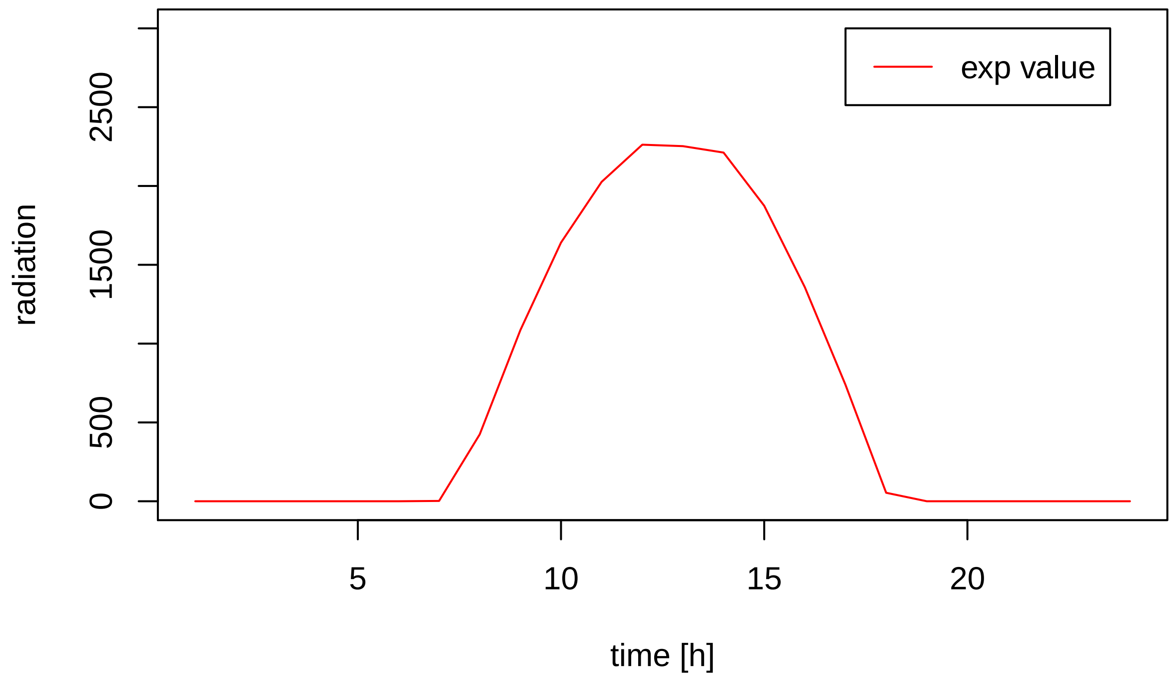
```
##           [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
##  [1,] 0.0001377 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
##  [2,] 0.0000000 0.0001377 0.0000000 0.0000000 0.0000000 0.0000000
##  [3,] 0.0000000 0.0000000 0.0001377 0.0000000 0.0000000 0.0000000
##  [4,] 0.0000000 0.0000000 0.0000000 0.0001377 0.0000000 0.0000000
##  [5,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0001377 0.0000000
```

```
##  [6,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0001377
##  [7,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
##  [8,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
##  [9,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [10,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [11,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [12,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [13,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [14,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [15,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [16,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [17,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [18,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [19,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [20,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [21,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [22,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [23,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [24,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
##            [,7]      [,8]      [,9]     [,10]     [,11]     [,12]
##  [1,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [2,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [3,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [4,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [5,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [6,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [7,] 1.665e+00 1.016e+02 2.306e+02 1.970e+02 2.243e+02 1.545e+02
##  [8,] 1.016e+02 2.489e+04 6.212e+04 8.897e+04 1.071e+05 1.055e+05
##  [9,] 2.306e+02 6.212e+04 1.577e+05 2.257e+05 2.721e+05 2.694e+05
## [10,] 1.970e+02 8.897e+04 2.257e+05 3.531e+05 4.296e+05 4.420e+05
## [11,] 2.243e+02 1.071e+05 2.721e+05 4.296e+05 5.281e+05 5.468e+05
## [12,] 1.545e+02 1.055e+05 2.694e+05 4.420e+05 5.468e+05 6.088e+05
## [13,] 2.484e+01 1.067e+05 2.743e+05 4.658e+05 5.786e+05 6.461e+05
## [14,] 8.870e+01 7.870e+04 1.998e+05 3.410e+05 4.244e+05 4.734e+05
## [15,] 1.495e+02 7.840e+04 1.982e+05 3.194e+05 3.968e+05 4.150e+05
## [16,] 1.230e+02 6.866e+04 1.739e+05 2.673e+05 3.268e+05 3.206e+05
## [17,] 7.585e+01 3.769e+04 9.666e+04 1.455e+05 1.762e+05 1.779e+05
## [18,] 7.215e+00 3.623e+03 9.375e+03 1.327e+04 1.610e+04 1.738e+04
## [19,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [20,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [21,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [22,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [23,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [24,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
##           [,13]     [,14]     [,15]     [,16]     [,17]     [,18]
##  [1,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [2,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [3,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [4,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [5,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [6,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [7,] 2.484e+01 8.870e+01 1.495e+02 1.230e+02 7.585e+01 7.215e+00
##  [8,] 1.067e+05 7.870e+04 7.840e+04 6.866e+04 3.769e+04 3.623e+03
##  [9,] 2.743e+05 1.998e+05 1.982e+05 1.739e+05 9.666e+04 9.375e+03
```

```
## [10,] 4.658e+05 3.410e+05 3.194e+05 2.673e+05 1.455e+05 1.327e+04
## [11,] 5.786e+05 4.244e+05 3.968e+05 3.268e+05 1.762e+05 1.610e+04
## [12,] 6.461e+05 4.734e+05 4.150e+05 3.206e+05 1.779e+05 1.738e+04
## [13,] 7.022e+05 5.119e+05 4.461e+05 3.473e+05 1.895e+05 1.825e+04
## [14,] 5.119e+05 4.757e+05 4.145e+05 3.089e+05 1.692e+05 1.656e+04
## [15,] 4.461e+05 4.145e+05 3.856e+05 3.048e+05 1.636e+05 1.587e+04
## [16,] 3.473e+05 3.089e+05 3.048e+05 2.677e+05 1.435e+05 1.422e+04
## [17,] 1.895e+05 1.692e+05 1.636e+05 1.435e+05 8.194e+04 8.822e+03
## [18,] 1.825e+04 1.656e+04 1.587e+04 1.422e+04 8.822e+03 1.369e+03
## [19,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [20,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [21,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [22,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [23,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [24,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
##           [,19]     [,20]     [,21]     [,22]     [,23]     [,24]
##  [1,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [2,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [3,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [4,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [5,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [6,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [7,] 3.082e-06 3.082e-06 3.082e-06 3.082e-06 3.082e-06 3.082e-06
##  [8,] 2.109e-03 2.109e-03 2.109e-03 2.109e-03 2.109e-03 2.109e-03
##  [9,] 5.373e-03 5.373e-03 5.373e-03 5.373e-03 5.373e-03 5.373e-03
## [10,] 8.743e-03 8.743e-03 8.743e-03 8.743e-03 8.743e-03 8.743e-03
## [11,] 1.079e-02 1.079e-02 1.079e-02 1.079e-02 1.079e-02 1.079e-02
## [12,] 1.162e-02 1.162e-02 1.162e-02 1.162e-02 1.162e-02 1.162e-02
## [13,] 1.243e-02 1.243e-02 1.243e-02 1.243e-02 1.243e-02 1.243e-02
## [14,] 9.736e-03 9.736e-03 9.736e-03 9.736e-03 9.736e-03 9.736e-03
## [15,] 8.794e-03 8.794e-03 8.794e-03 8.794e-03 8.794e-03 8.794e-03
## [16,] 6.991e-03 6.991e-03 6.991e-03 6.991e-03 6.991e-03 6.991e-03
## [17,] 3.812e-03 3.812e-03 3.812e-03 3.812e-03 3.812e-03 3.812e-03
## [18,] 3.659e-04 3.659e-04 3.659e-04 3.659e-04 3.659e-04 3.659e-04
## [19,] 1.377e-04 2.304e-10 2.304e-10 2.304e-10 2.304e-10 2.304e-10
## [20,] 2.304e-10 1.377e-04 2.304e-10 2.304e-10 2.304e-10 2.304e-10
## [21,] 2.304e-10 2.304e-10 1.377e-04 2.304e-10 2.304e-10 2.304e-10
## [22,] 2.304e-10 2.304e-10 2.304e-10 1.377e-04 2.304e-10 2.304e-10
## [23,] 2.304e-10 2.304e-10 2.304e-10 2.304e-10 1.377e-04 2.304e-10
## [24,] 2.304e-10 2.304e-10 2.304e-10 2.304e-10 2.304e-10 1.377e-04
```

Let’s visualize the expected value we estimated:

```r
plot(estimates_n_dep$muhat,xlab="time [h]", ylab="radiation", type="l", col="red", ylim=c(0,3000))
legend(17,3000, c("exp value"), col=c("red"), lty=c(1))
```



1.1.2 Parameter estimation - independent for 15min intervals

Using the package above it is not possible to analyse a multivariate normal distribution with more than 50 variables, hence we continue the analysis with the assumption of **independently** distributed variables for every 15 minutes.

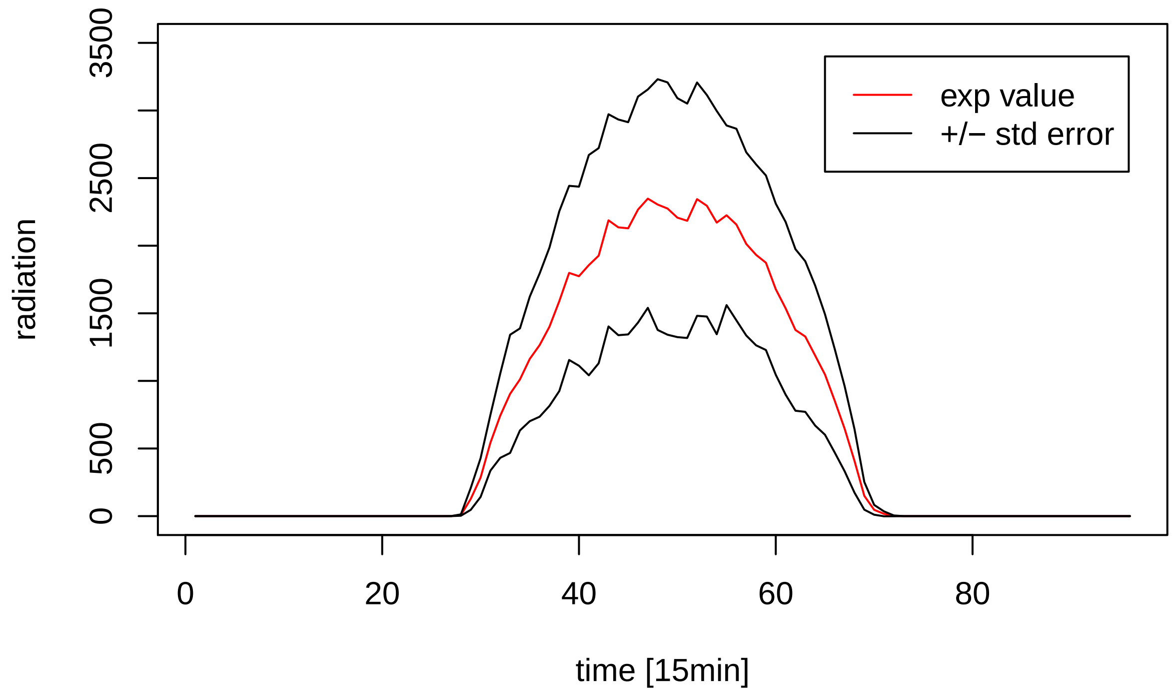
```
PV1quh<-matrix(rep(0,(744*4)),nrow=31) #quarter hourly values -> take means
for(i in 1:31){
  for (j in 1:(24*4)){
    PV1quh[i,j]<-mean(PV1[i,((j-1)*15+1):(j*15)])
  }
}

estimates_n_ind<-matrix(rep(0,2*96),nrow=2) #under assumption of independence
for (i in 1:(24*4)){
  estimates_n_ind[1,i]<-fitdistr(PV1quh[,i],"normal")$estimate[1] #estimate of mean (mu)
  estimates_n_ind[2,i]<-fitdistr(PV1quh[,i],"normal")$estimate[2] #estimate of std error (sigma)
  }
estimates_n_ind
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## [1,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [2,]    0    0    0    0    0    0    0    0    0     0     0     0     0
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24]
```

```
## [1,]     0     0     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0     0     0
##      [,25] [,26]  [,27] [,28]  [,29] [,30] [,31] [,32] [,33]  [,34]  [,35]
## [1,]     0     0 0.1239 7.877 127.27 284.8 542.7 742.8 904.3 1011.0 1163.0
## [2,]     0     0 0.2215 4.954  80.92 143.2 206.3 311.8 437.1  377.3  460.8
##       [,36]  [,37]  [,38]  [,39]  [,40]  [,41]  [,42]  [,43]  [,44]  [,45]
## [1,] 1264.7 1400.7 1589.7 1798.8 1774.3 1856.2 1926.0 2187.5 2135.7 2128.6
## [2,]  529.6  585.5  664.9  643.9  662.3  814.7  795.6  784.6  797.5  784.7
##       [,46]  [,47]  [,48]  [,49]  [,50]  [,51]  [,52]  [,53]  [,54]  [,55]
## [1,] 2267.2 2348.1 2304.1 2274.7 2207.5 2184.2 2344.3 2295.1 2170.8 2224.9
## [2,]  835.8  807.5  927.3  933.1  883.6  866.8  862.9  819.1  825.8  664.1
##       [,56]  [,57]  [,58]  [,59]  [,60]  [,61]  [,62]  [,63]  [,64]  [,65]
## [1,] 2156.4 2013.1 1932.2 1873.9 1678.1 1537.3 1376.8 1328.1 1188.2 1047.5
## [2,]  708.6  677.5  669.1  645.3  632.7  638.8  597.6  556.8  518.2  445.6
##      [,66] [,67] [,68] [,69] [,70] [,71] [,72] [,73] [,74] [,75] [,76]
## [1,] 851.5 646.1 408.6 149.9 46.56 16.86 1.836     0     0     0     0
## [2,] 382.4 314.4 234.9 102.4 36.25 18.04 2.952     0     0     0     0
##      [,77] [,78] [,79] [,80] [,81] [,82] [,83] [,84] [,85] [,86] [,87]
## [1,]     0     0     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0     0     0
##      [,88] [,89] [,90] [,91] [,92] [,93] [,94] [,95] [,96]
## [1,]     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0
```

Let's visualize the expected value and standard errors we estimated:

```r
plot(estimates_n_ind[1,],xlab="time [15min]", ylab="radiation", type="l", col="red", ylim=c(0,3500))
lines(estimates_n_ind[1,]+estimates_n_ind[2,],type="l")
lines(estimates_n_ind[1,]-estimates_n_ind[2,],type="l")
legend(65,3400, c("exp value", "+/- std error"), col=c("red","black"), lty=c(1,1))
```



1.2 Sample generation

1.2.1 Sample generation - dependent for 1h intervals

We generate a sample of size N of a **multivariate** normal distribution with the parameters estimated above:

```
N<-1000
Nsample<-mvrnorm(n=N, estimates_n_dep$muhat, estimates_n_dep$sigmahat)
```

To validate this sample generation, we estimate its distribution and standard error and compare them with the parameters we used:

```
test<-mlest(Nsample)
diffmu<-estimates_n_dep$muhat-test$muhat
diffsigma<-estimates_n_dep$sigmahat-test$sigmahat
max(diffmu)
```

```
## [1] 3.072
```

```
max(diffsigma)
```

```
## [1] 0.2024
```

These values show us that a sample size of $N = 1000$ is probably not enough.

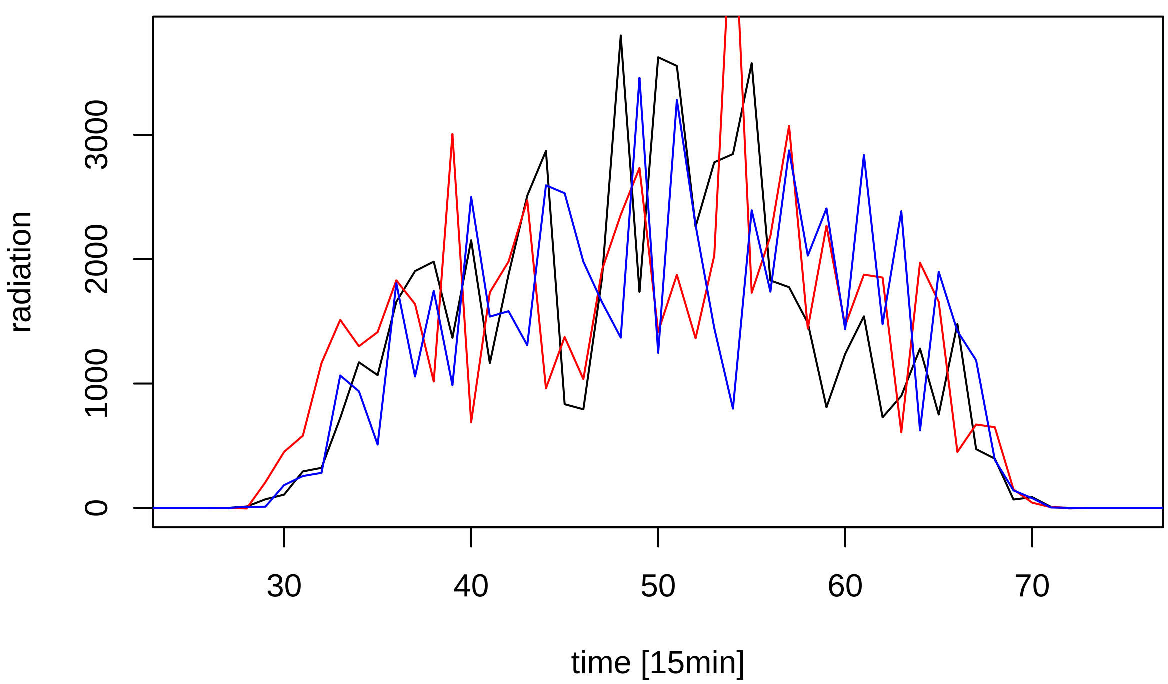
1.2.2 Sample generation - independent for 15min intervals

We generate a sample of N **independently** identically distributed random variables of the normal distribution with the parameters estimated above:

```
N<-10000
N_ind_sample<-matrix(rep(0,24*4*N), ncol=24*4) # 1 column for 1 time interval, 1 row for 1 realization
for(i in 1:N){
N_ind_sample[i,]<-rnorm(24*4,estimates_n_ind[1,], estimates_n_ind[2,])
}
```

To visualize, the first three realizations that were generated, look like this:

```
plot(N_ind_sample[1,], type="l", xlim=c(25,75), ylab="radiation", xlab="time [15min]")
lines(N_ind_sample[2,], type="l", col="red")
lines(N_ind_sample[3,], type="l", col="blue")
```



2 Weibull distribution

2.1 Parameter estimation

2.1.1 Parameter estimation - independent for 15min intervals

We assume **independently** distributed values for every 15 minutes and estimate a and b called the *shape parameter* and the *scale parameter*.

```
estimates_w_ind<-matrix(rep(0,2*96),nrow=2) #under assumption of independence
for (i in 1:(24*4)){
  estimates_w_ind[1,i]<-fitdistr(PV1quh[,i],"normal")$estimate[1] #estimate of shape paramter
  estimates_w_ind[2,i]<-fitdistr(PV1quh[,i],"normal")$estimate[2] #estimate of scale parameter
  }
estimates_w_ind
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## [1,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [2,]    0    0    0    0    0    0    0    0    0     0     0     0     0
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24]
## [1,]     0     0     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0     0     0
##      [,25] [,26]  [,27] [,28]  [,29] [,30] [,31] [,32] [,33]  [,34]  [,35]
## [1,]     0     0 0.1239 7.877 127.27 284.8 542.7 742.8 904.3 1011.0 1163.0
## [2,]     0     0 0.2215 4.954  80.92 143.2 206.3 311.8 437.1  377.3  460.8
##       [,36]  [,37]  [,38]  [,39]  [,40]  [,41]  [,42]  [,43]  [,44]  [,45]
## [1,] 1264.7 1400.7 1589.7 1798.8 1774.3 1856.2 1926.0 2187.5 2135.7 2128.6
## [2,]  529.6  585.5  664.9  643.9  662.3  814.7  795.6  784.6  797.5  784.7
##       [,46]  [,47]  [,48]  [,49]  [,50]  [,51]  [,52]  [,53]  [,54]  [,55]
## [1,] 2267.2 2348.1 2304.1 2274.7 2207.5 2184.2 2344.3 2295.1 2170.8 2224.9
## [2,]  835.8  807.5  927.3  933.1  883.6  866.8  862.9  819.1  825.8  664.1
##       [,56]  [,57]  [,58]  [,59]  [,60]  [,61]  [,62]  [,63]  [,64]  [,65]
## [1,] 2156.4 2013.1 1932.2 1873.9 1678.1 1537.3 1376.8 1328.1 1188.2 1047.5
## [2,]  708.6  677.5  669.1  645.3  632.7  638.8  597.6  556.8  518.2  445.6
##      [,66] [,67] [,68] [,69] [,70] [,71] [,72] [,73] [,74] [,75] [,76]
## [1,] 851.5 646.1 408.6 149.9 46.56 16.86 1.836     0     0     0     0
## [2,] 382.4 314.4 234.9 102.4 36.25 18.04 2.952     0     0     0     0
##      [,77] [,78] [,79] [,80] [,81] [,82] [,83] [,84] [,85] [,86] [,87]
## [1,]     0     0     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0     0     0
##      [,88] [,89] [,90] [,91] [,92] [,93] [,94] [,95] [,96]
## [1,]     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0
```