557_Project_2BS

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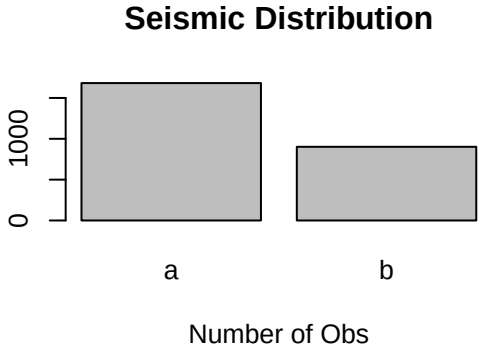
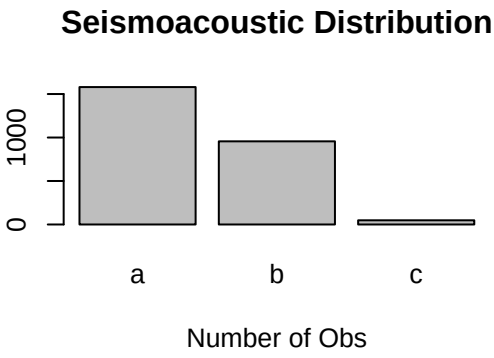
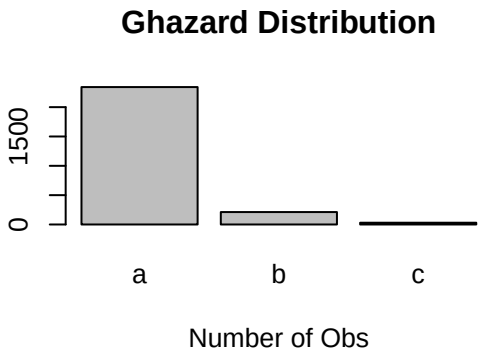
3/15/2017

No Command Lines Ever. Whoa

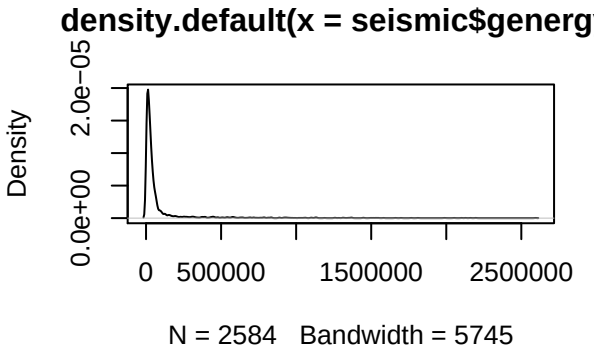
What the Factor Variables look like

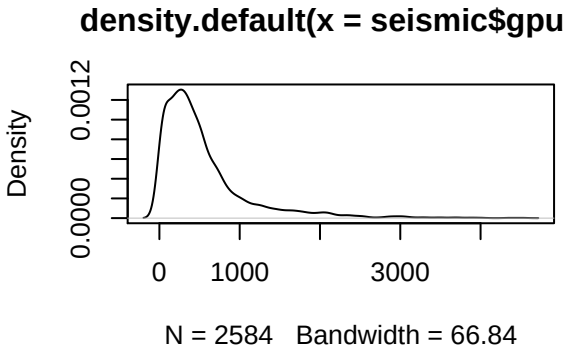


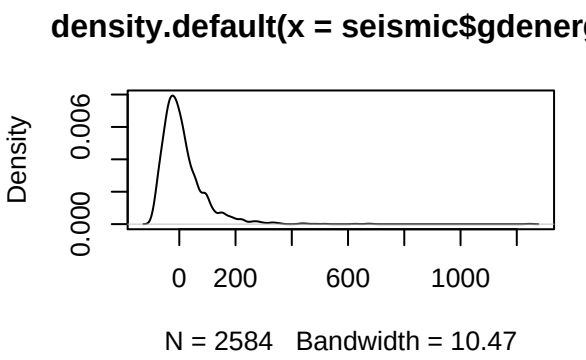


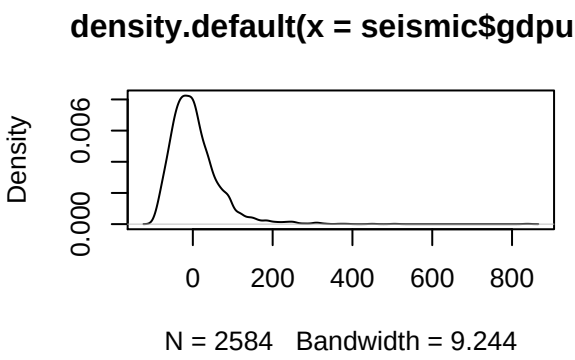


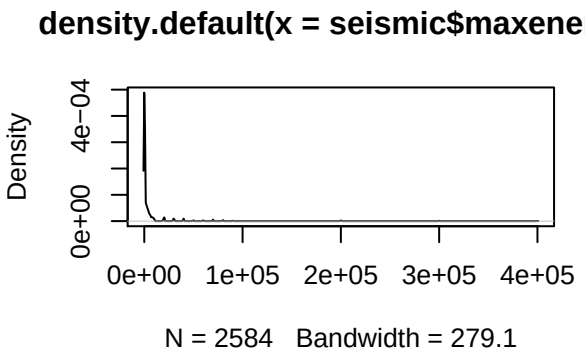
What the Continuous Variables look like

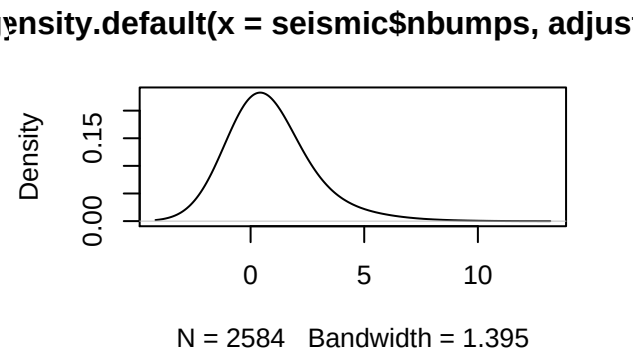


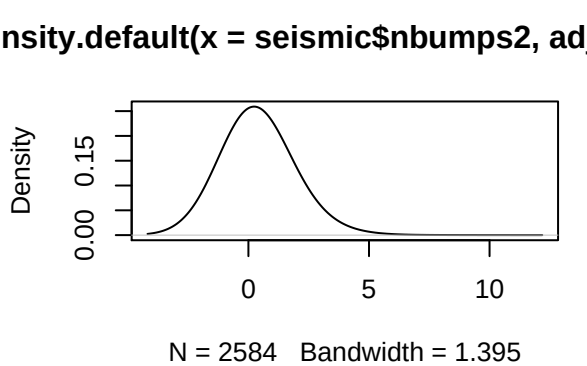


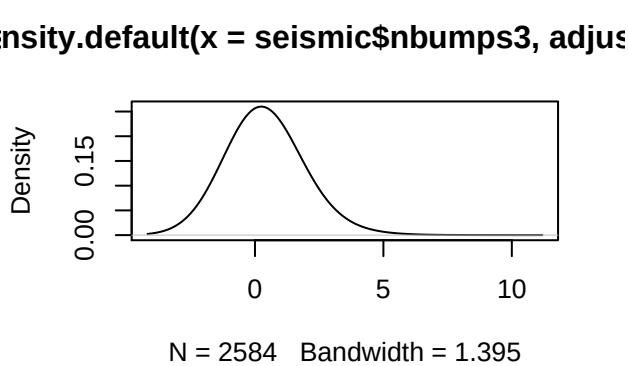






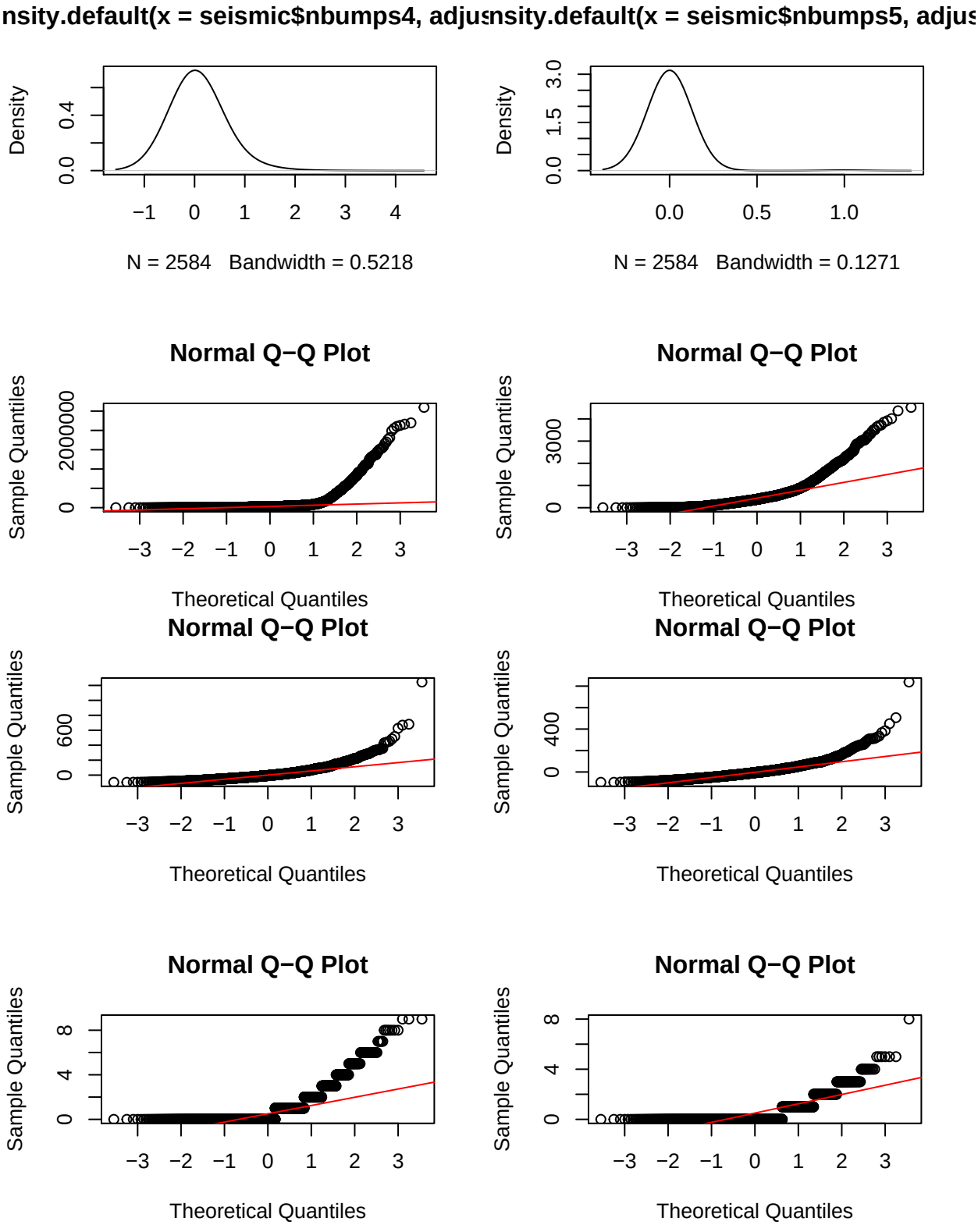


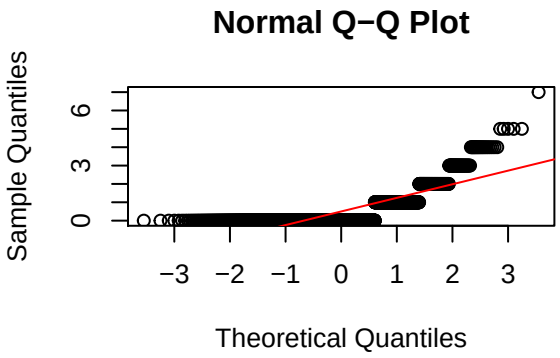


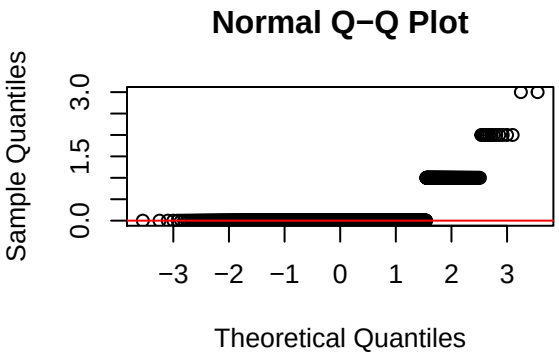


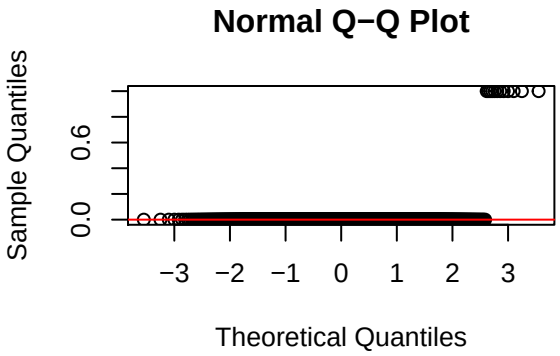

```
Call:
```

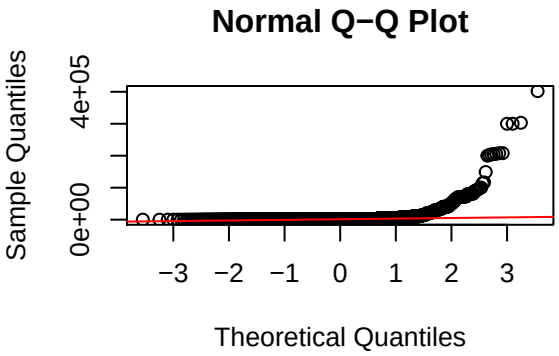
```
lm(formula = class ~ ., data = seismic)

Residuals:
     Min       1Q   Median       3Q      Max
-0.57549 -0.07778 -0.03812 -0.00950  1.03232

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)    -2.393e-02  2.565e-02  -0.933  0.35090
seismic         1.869e-02  1.076e-02   1.737  0.08254 .
seismoacoustic  2.610e-03  1.002e-02   0.260  0.79457
shift           6.190e-04  1.157e-02   0.054  0.95732
genergy        -8.698e-08  3.459e-08  -2.514  0.01199 *
gpuls           1.019e-04  1.670e-05   6.102  1.2e-09 ***
gdenergy       -6.943e-05  1.006e-04  -0.690  0.49009
gdpuls         -1.942e-04  1.368e-04  -1.420  0.15583
ghazard        -1.394e-02  1.608e-02  -0.867  0.38618
nbumps          4.674e-01  1.680e-01   2.783  0.00543 **
nbumps2        -4.282e-01  1.682e-01  -2.546  0.01096 *
nbumps3        -4.260e-01  1.681e-01  -2.535  0.01131 *
nbumps4        -4.622e-01  1.708e-01  -2.706  0.00685 **
nbumps5        -2.963e-01  2.332e-01  -1.270  0.20408
energy          2.536e-07  2.395e-06   0.106  0.91568
maxenergy      -1.054e-06  2.333e-06  -0.452  0.65164
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2371 on 2568 degrees of freedom
Multiple R-squared:  0.09128,   Adjusted R-squared:  0.08597
F-statistic:  17.2 on 15 and 2568 DF,  p-value: < 2.2e-16
```

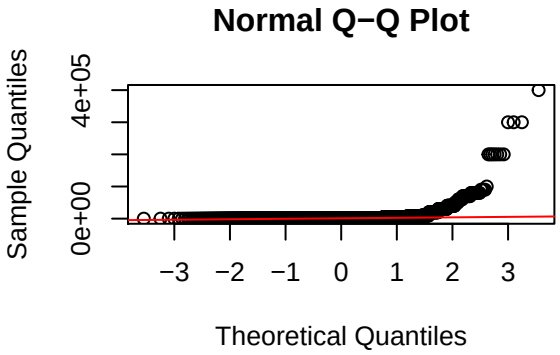

nsity.default(x = seismic$nbumps4, adjus
nsity.default(x = seismic$nbumps5, adjus
Density
N = 2584 Bandwidth = 0.5218
N = 2584 Bandwidth = 0.1271
Normal Q−Q Plot
Sample Quantiles
Theoretical Quantiles

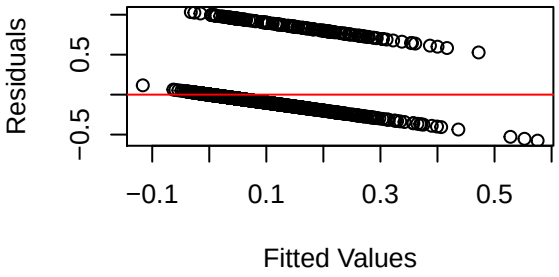

Normal Q−Q Plot
Sample Quantiles
0
3
6
−3
−2
−1
0
1
2
3
Theoretical Quantiles

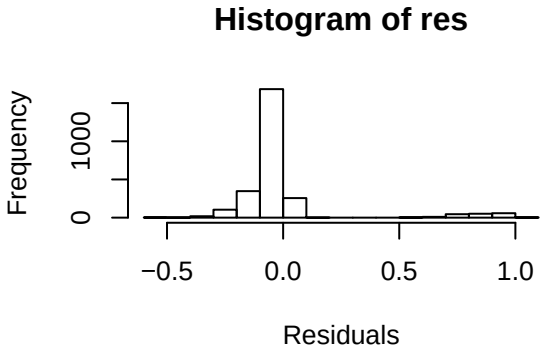

Normal Q−Q Plot
Sample Quantiles
0.0
1.5
3.0
−3
−2
−1
0
1
2
3
Theoretical Quantiles


Normal Q−Q Plot
Sample Quantiles
0.0
0.6
−3
−2
−1
0
1
2
3
Theoretical Quantiles


Normal Q−Q Plot
Sample Quantiles
0e+00
4e+05
−3
−2
−1
0
1
2
3
Theoretical Quantiles


Normal Q−Q Plot
Sample Quantiles
0e+00
4e+05
−3
−2
−1
0
1
2
3
Theoretical Quantiles


Residuals
−0.5
0.5
−0.1
0.1
0.3
0.5
Fitted Values

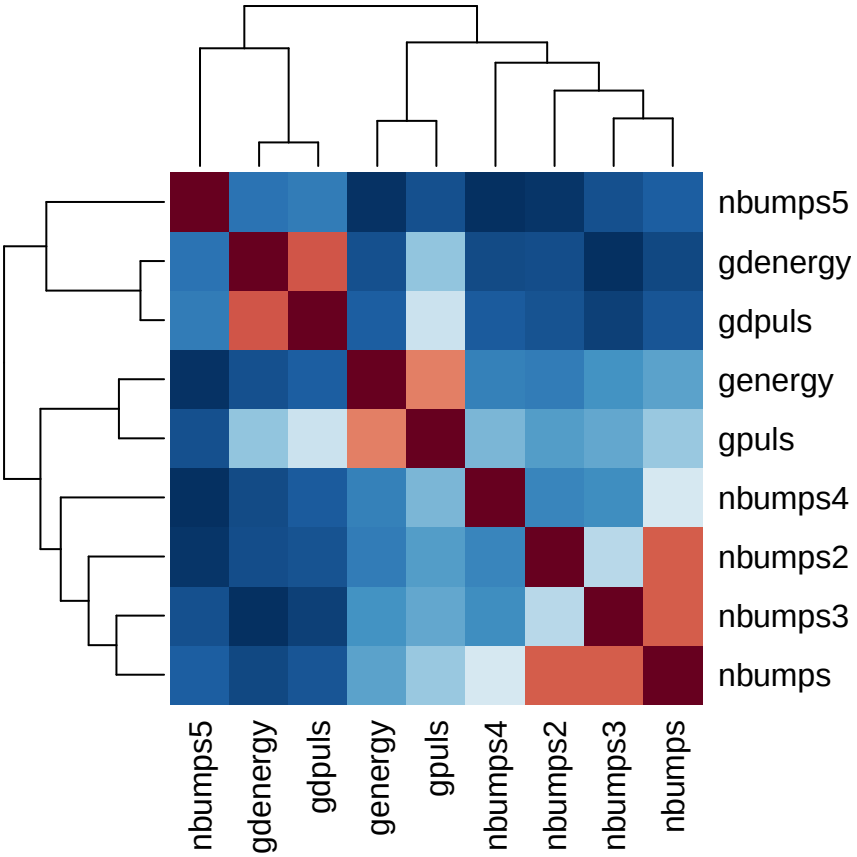

Histogram of res
Frequency
0
1000
−0.5
0.0
0.5
1.0
Residuals

Lots of multicollinearity to worry about during variable selection

```
vif(fit)
```

```
##        seismic seismoacoustic          shift        genergy          gpuls
##       1.209814       1.286183       1.411216       2.889651       4.057018
##       gdenergy          gdpuls        ghazard         nbumps        nbumps2
##       3.000282       3.430524       1.395598    2414.689538     798.964152
##        nbumps3         nbumps4         nbumps5         energy      maxenergy
##     769.131960     104.402690      11.562237     110.283444      93.762895
```

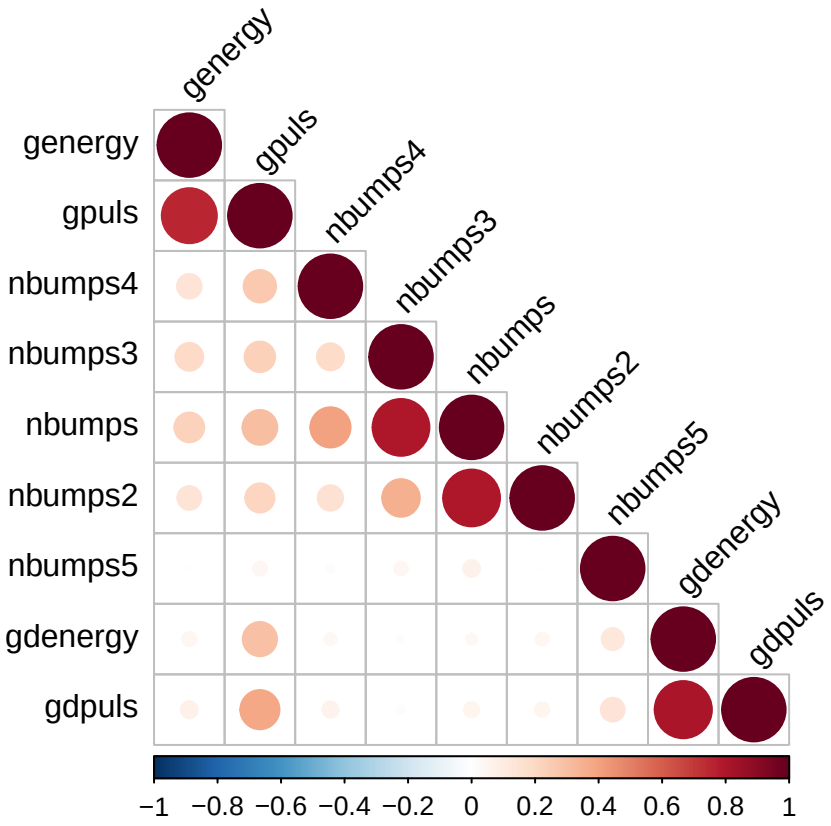
Correlation of the Variables




```
$r
          genergy gpuls nbumps4 nbumps3 nbumps nbumps2 nbumps5 gdenergy
genergy         1
gpuls        0.75      1
nbumps4      0.15   0.26       1
nbumps3      0.19   0.23    0.18       1
nbumps       0.22    0.3     0.4     0.8       1
nbumps2      0.14   0.21    0.16    0.35     0.8       1
nbumps5   -0.0099  0.049  -0.017   0.046    0.07 -0.0053       1
gdenergy    0.049   0.29   0.037  -0.012    0.03   0.041    0.12         1
```

```
gdpuls     0.072  0.38   0.066   0.015  0.058   0.051    0.14     0.81
         gdpuls
genergy
gpuls
nbumps4
nbumps3
nbumps
nbumps2
nbumps5
gdenergy
gdpuls        1

$p
         genergy gpuls nbumps4 nbumps3 nbumps nbumps2 nbumps5 gdenergy
genergy        0
gpuls          0     0
nbumps4  1.4e-14     0       0
nbumps3        0     0       0       0
nbumps         0     0       0       0      0
nbumps2  2.2e-13     0       0       0      0       0
nbumps5     0.62 0.012     0.4   0.018  4e-04    0.79       0
gdenergy   0.014     0   0.061    0.54   0.13   0.036 3.3e-10        0
gdpuls   0.00027     0 0.00076    0.45 0.0032  0.0094 5.9e-13        0
         gdpuls
genergy
gpuls
nbumps4
nbumps3
nbumps
nbumps2
nbumps5
gdenergy
gdpuls        0

$sym
         genergy gpuls nbumps4 nbumps3 nbumps nbumps2 nbumps5 gdenergy
genergy  1
gpuls    ,       1
nbumps4                1
nbumps3                        1
nbumps                 .       ,       1
nbumps2                        .       ,      1
nbumps5                                               1
gdenergy                                                      1
gdpuls           .                                            +
         gdpuls
genergy
gpuls
nbumps4
nbumps3
nbumps
nbumps2
nbumps5
gdenergy
```

```
gdpuls   1
attr(,"legend")
[1] 0 ' ' 0.3 '.' 0.6 ',' 0.8 '+' 0.9 '*' 0.95 'B' 1
```




```
$r
        row   column     cor       p
1   genergy    gpuls  0.7500 0.0e+00
2   genergy  nbumps4  0.1500 1.4e-14
3     gpuls  nbumps4  0.2600 0.0e+00
4   genergy  nbumps3  0.1900 0.0e+00
5     gpuls  nbumps3  0.2300 0.0e+00
6   nbumps4  nbumps3  0.1800 0.0e+00
7   genergy   nbumps  0.2200 0.0e+00
8     gpuls   nbumps  0.3000 0.0e+00
9   nbumps4   nbumps  0.4000 0.0e+00
10  nbumps3   nbumps  0.8000 0.0e+00
11  genergy  nbumps2  0.1400 2.2e-13
12    gpuls  nbumps2  0.2100 0.0e+00
13  nbumps4  nbumps2  0.1600 0.0e+00
14  nbumps3  nbumps2  0.3500 0.0e+00
15   nbumps  nbumps2  0.8000 0.0e+00
16  genergy  nbumps5 -0.0099 6.2e-01
17    gpuls  nbumps5  0.0490 1.2e-02
18  nbumps4  nbumps5 -0.0170 4.0e-01
19  nbumps3  nbumps5  0.0460 1.8e-02
20   nbumps  nbumps5  0.0700 4.0e-04
21  nbumps2  nbumps5 -0.0053 7.9e-01
```

```
22  genergy gdenergy  0.0490 1.4e-02
23    gpuls gdenergy  0.2900 0.0e+00
24  nbumps4 gdenergy  0.0370 6.1e-02
25  nbumps3 gdenergy -0.0120 5.4e-01
26   nbumps gdenergy  0.0300 1.3e-01
27  nbumps2 gdenergy  0.0410 3.6e-02
28  nbumps5 gdenergy  0.1200 3.3e-10
29  genergy   gdpuls  0.0720 2.7e-04
30    gpuls   gdpuls  0.3800 0.0e+00
31  nbumps4   gdpuls  0.0660 7.6e-04
32  nbumps3   gdpuls  0.0150 4.5e-01
33   nbumps   gdpuls  0.0580 3.2e-03
34  nbumps2   gdpuls  0.0510 9.4e-03
35  nbumps5   gdpuls  0.1400 5.9e-13
36 gdenergy   gdpuls  0.8100 0.0e+00

$p
NULL

$sym
NULL
```

Separating into Test and Training Sets

```
##-------------------------------------
## Setting up Test and Training Sets
##-------------------------------------

n <- dim(seismic)[1]
p <- dim(seismic)[2]

set.seed(2016)
test <- sample(n, round(n/4))
train <- (1:n)[-test]
seismic.train <- seismic[train,]
seismic.test <- seismic[test,]

dim(seismic)
```

```
[1] 2584   16
```

```
dim(seismic.train)
```

```
[1] 1938   16
```

```
dim(seismic.test)
```

```
[1] 646  16
```

```
#View(seismic.train)
#View(seismic.test)
```

Linear regression of an indicator matrix

```
##-----------------------------------------
## Fit Linear Regression to Indicator Matrix
##-----------------------------------------

fit.lm <- lm(class~., data=seismic.train)
summary(fit.lm)
```

```
##
## Call:
## lm(formula = class ~ ., data = seismic.train)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.53532 -0.08061 -0.03978 -0.00442  1.03254
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -6.001e-02  2.980e-02  -2.014   0.0442 *
## seismic         3.007e-02  1.269e-02   2.370   0.0179 *
## seismoacoustic  1.309e-02  1.183e-02   1.106   0.2688
## shift           1.359e-02  1.333e-02   1.019   0.3084
## genergy        -3.179e-08  4.150e-08  -0.766   0.4437
## gpuls           8.221e-05  2.004e-05   4.102 4.27e-05 ***
## gdenergy       -3.462e-05  1.170e-04  -0.296   0.7673
## gdpuls         -2.266e-04  1.598e-04  -1.418   0.1564
## ghazard        -1.850e-02  1.931e-02  -0.958   0.3382
## nbumps          1.003e+00  2.397e-01   4.186 2.97e-05 ***
## nbumps2        -9.670e-01  2.398e-01  -4.033 5.73e-05 ***
## nbumps3        -9.681e-01  2.398e-01  -4.037 5.63e-05 ***
## nbumps4        -1.004e+00  2.425e-01  -4.139 3.63e-05 ***
## nbumps5        -7.912e-01  3.091e-01  -2.560   0.0106 *
## energy          2.757e-06  3.419e-06   0.806   0.4201
## maxenergy      -3.511e-06  3.346e-06  -1.050   0.2940
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2394 on 1922 degrees of freedom
## Multiple R-squared:  0.09781,    Adjusted R-squared:  0.09077
## F-statistic: 13.89 on 15 and 1922 DF,  p-value: < 2.2e-16
```

```
fit.probs <- predict(fit.lm, type="response")

# Train Data
fit.pred=rep("0",1938)
fit.pred[fit.probs >.5]="1"
```

```
confusion <- table(fit.pred ,seismic.train$class)
mean(fit.pred==seismic.train$class)
```

```
## [1] 0.9318885
```

```
sensitivity <- confusion[2,2]/sum(confusion[,2])
specificity <- confusion[1,1]/sum(confusion[,1])

## Sensitivity is very bad! Dramatically underpredict 1s
confusion
```

```
##
## fit.pred    0    1
##        0 1805  130
##        1    2    1
```

```
sensitivity
```

```
## [1] 0.007633588
```

```
specificity
```

```
## [1] 0.9988932
```

```
# Test Data
fit.probs <- predict(fit.lm, newdata=seismic.test, type="response")

fit.pred=rep("0",646)
fit.pred[fit.probs >.5]="1"
confusion <- table(fit.pred, seismic.test$class)
mean(fit.pred==seismic.test$class)
```

```
## [1] 0.9380805
```

```
sensitivity <- confusion[2,2]/sum(confusion[,2])
specificity <- confusion[1,1]/sum(confusion[,1])

## Sensitivity is very bad! Dramatically underpredict 1s
confusion
```

```
##
## fit.pred   0   1
##        0 606  39
##        1   1   0
```

```
sensitivity
```

```
## [1] 0
```

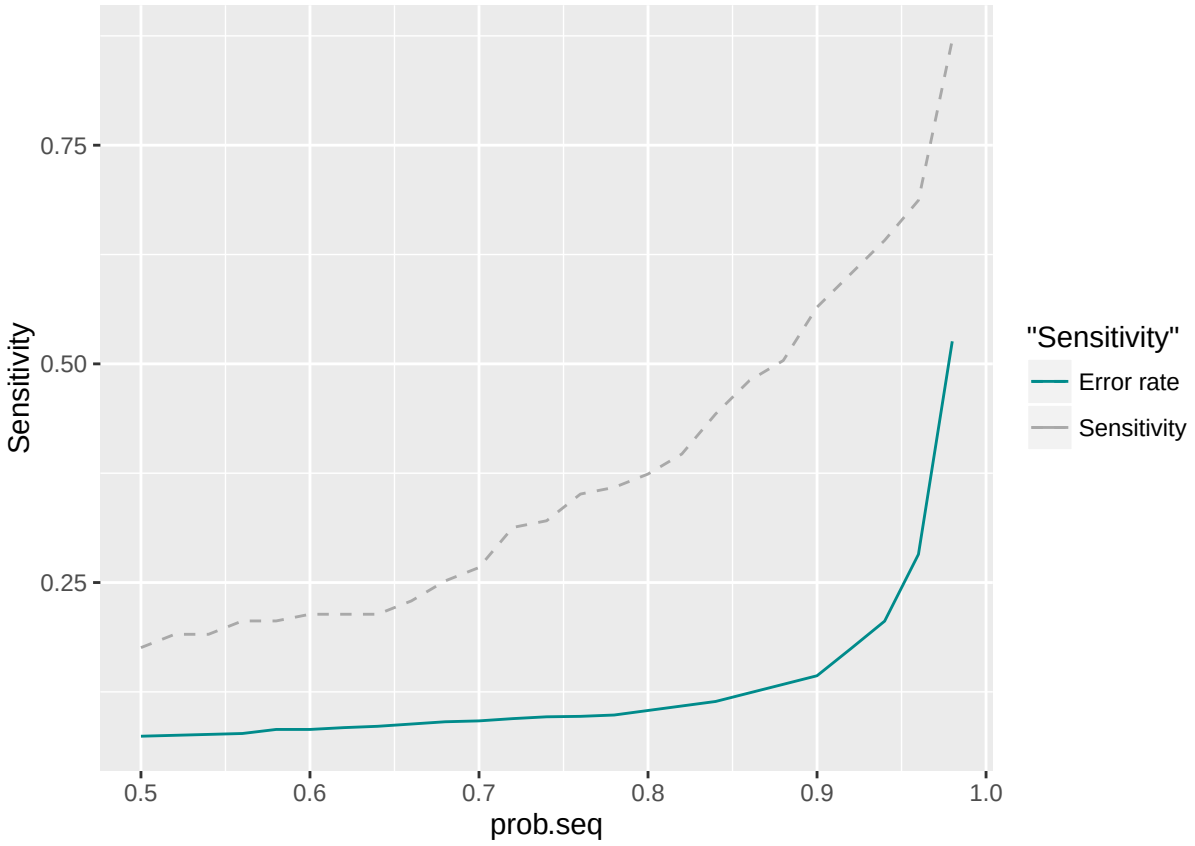
```
specificity
```

```
## [1] 0.9983526
```

```
lda.class    0    1
        0 1771  108
        1   36   23
```

```
[1] 0.1755725
```

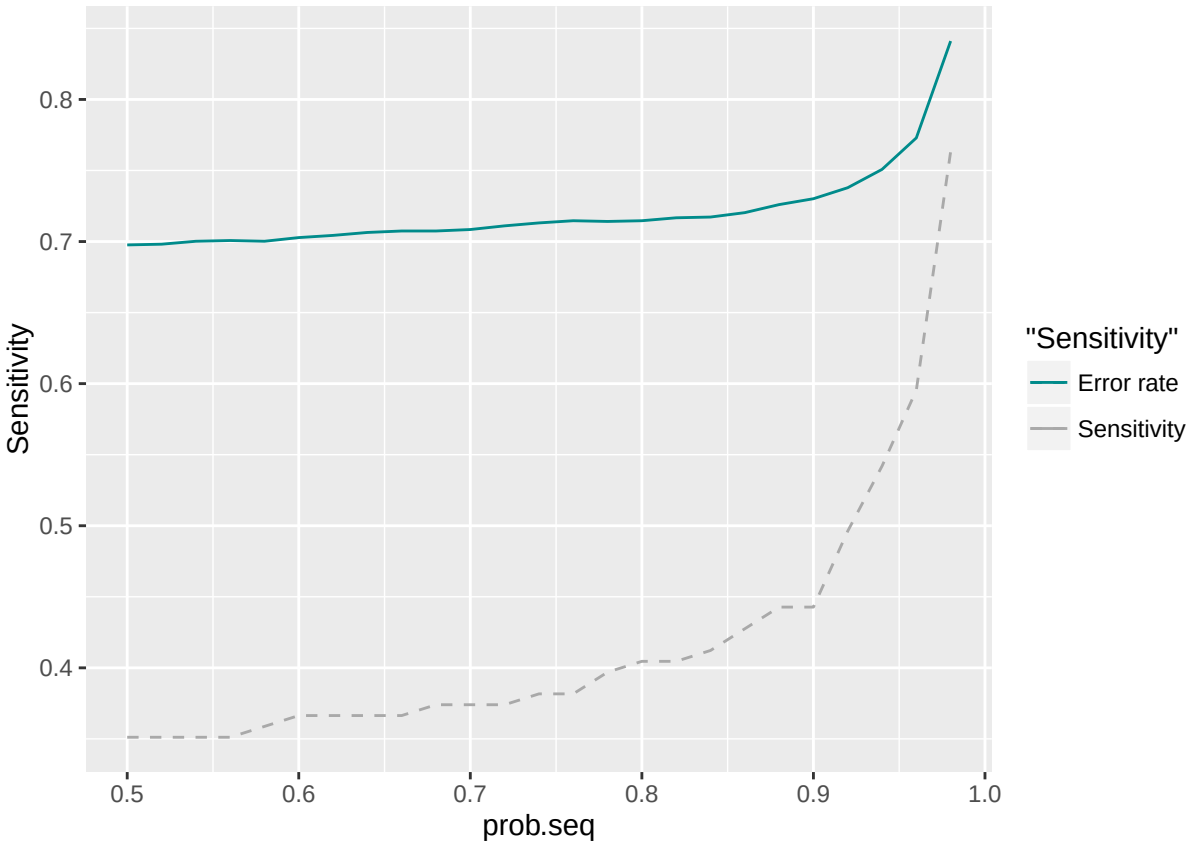
```
[1] 0.9800775
```




```
lda.class   0   1
        0 591  34
        1  16   5
```

```
[1] 0.1282051
```

```
[1] 0.9736409
```

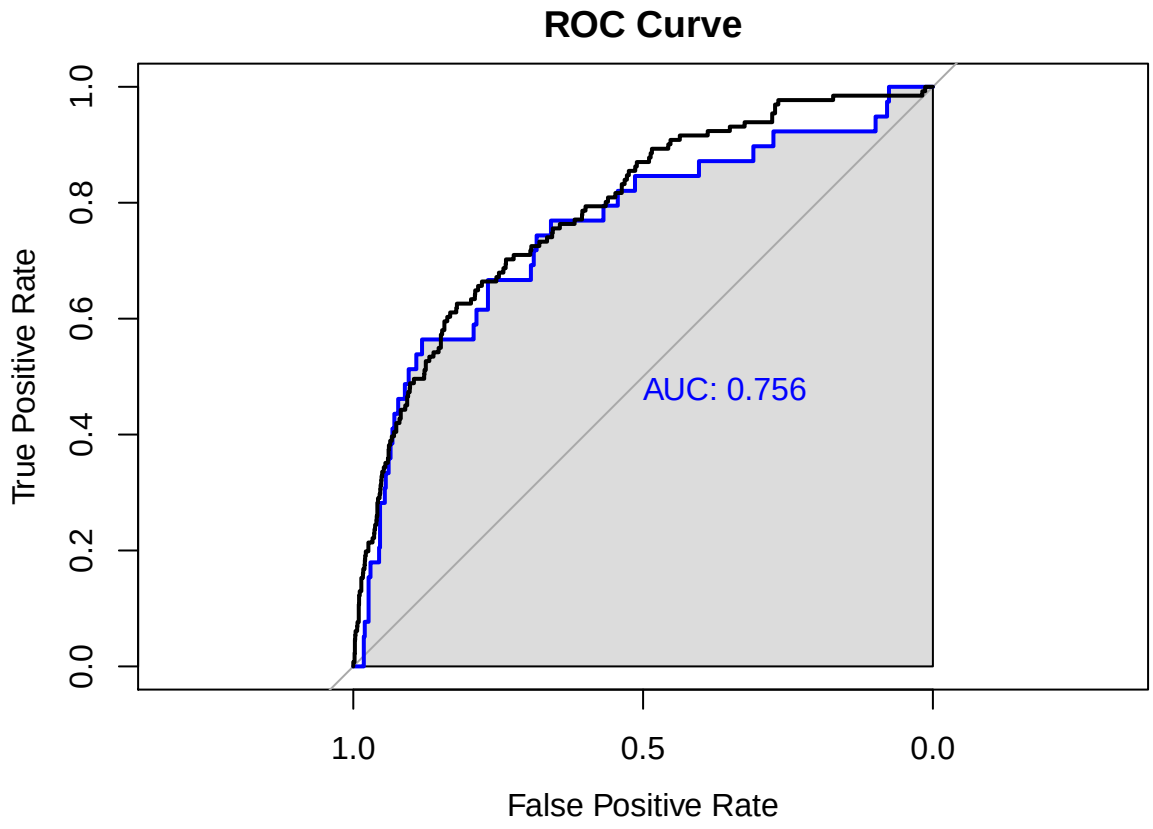


Regularized Discriminant Analysis

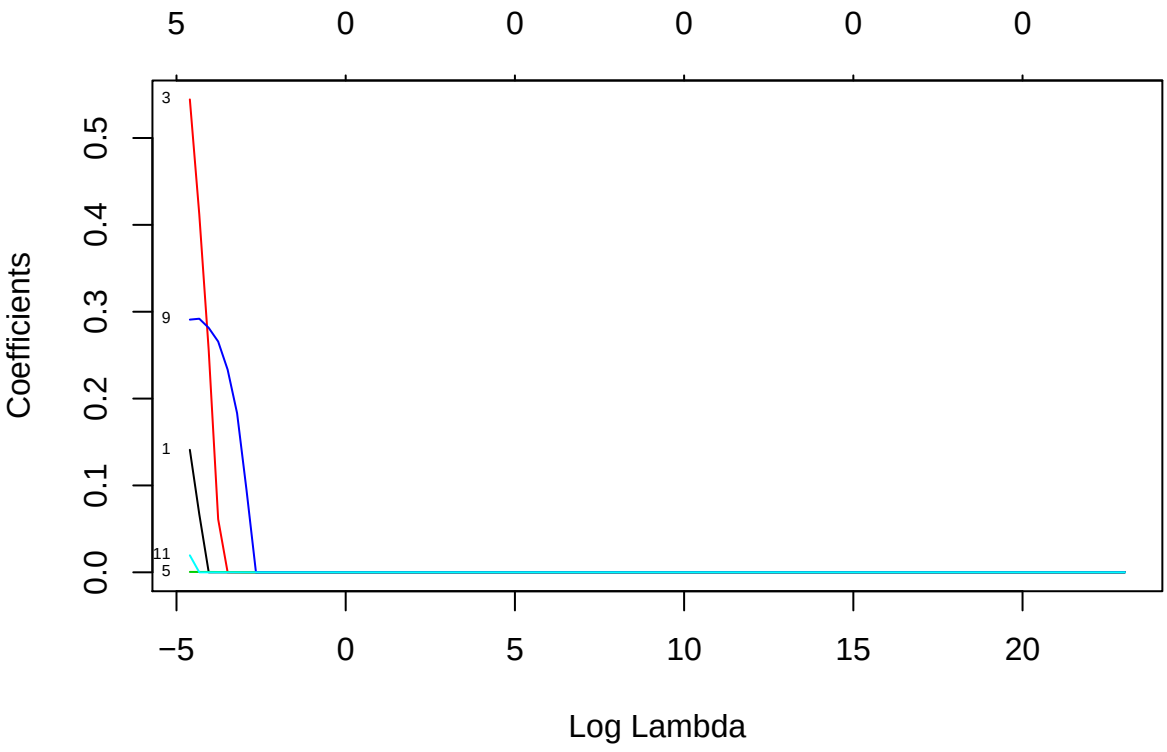
Logistic Regression

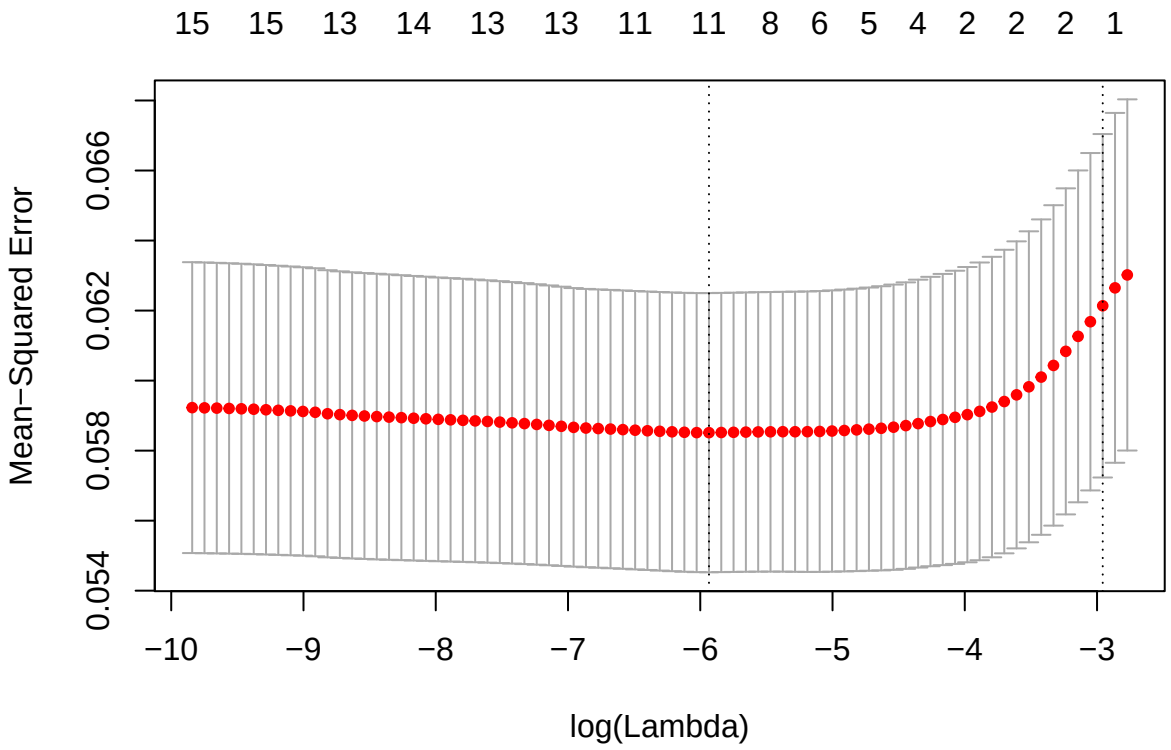
```
Call:
glm(formula = class ~ ., family = binomial, data = seismic.train)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.8471  -0.3860  -0.2851  -0.1566   3.0825

Coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)    -6.343e+00  7.721e-01  -8.215  < 2e-16 ***
seismic         4.808e-01  2.111e-01   2.278 0.022727 *
seismoacoustic  2.159e-01  1.993e-01   1.084 0.278524
shift           1.179e+00  3.573e-01   3.301 0.000965 ***
genergy        -2.471e-07  5.044e-07  -0.490 0.624239
gpuls           7.095e-04  2.474e-04   2.868 0.004136 **
gdenergy       -1.904e-04  2.177e-03  -0.087 0.930292
gdpuls         -2.997e-03  3.093e-03  -0.969 0.332500
ghazard        -2.335e-01  3.509e-01  -0.666 0.505671
nbumps          1.807e+01  5.354e+02   0.034 0.973080
```

```
nbumps2        -1.773e+01  5.354e+02  -0.033 0.973590
nbumps3        -1.771e+01  5.354e+02  -0.033 0.973611
nbumps4        -1.806e+01  5.354e+02  -0.034 0.973097
nbumps5        -1.604e+01  5.354e+02  -0.030 0.976095
energy          1.622e-06  4.033e-05   0.040 0.967929
maxenergy      -7.101e-06  3.969e-05  -0.179 0.858012
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 958.82  on 1937  degrees of freedom
Residual deviance: 813.40  on 1922  degrees of freedom
AIC: 845.4

Number of Fisher Scoring iterations: 12

[1] 0.9329205


glm.pred    0    1
       0 1802  125
       1    5    6

[1] 0.04580153

[1] 0.997233

[1] 0.9349845


glm.pred   0   1
       0 604  39
       1   3   0

[1] 0

[1] 0.9950577
```

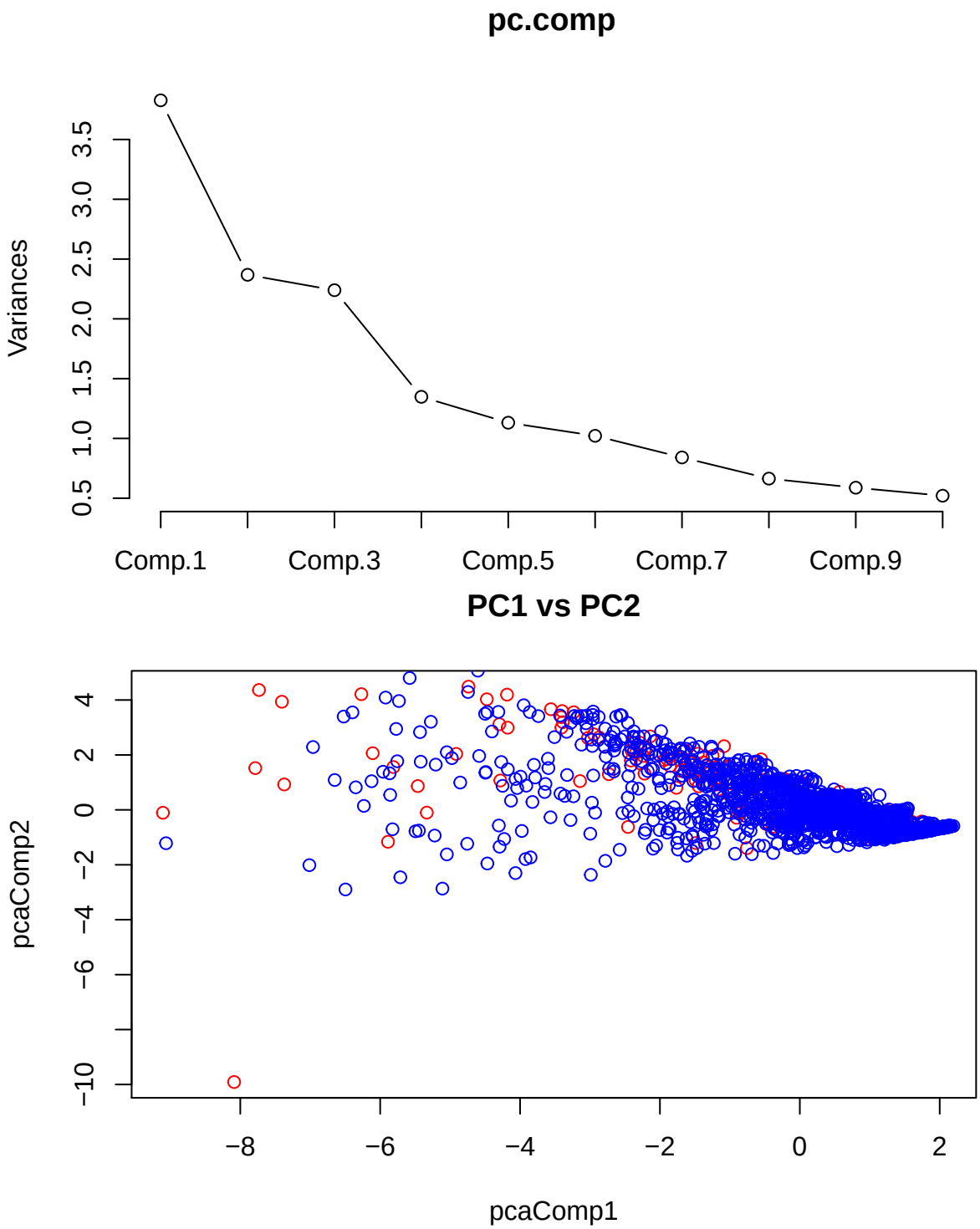


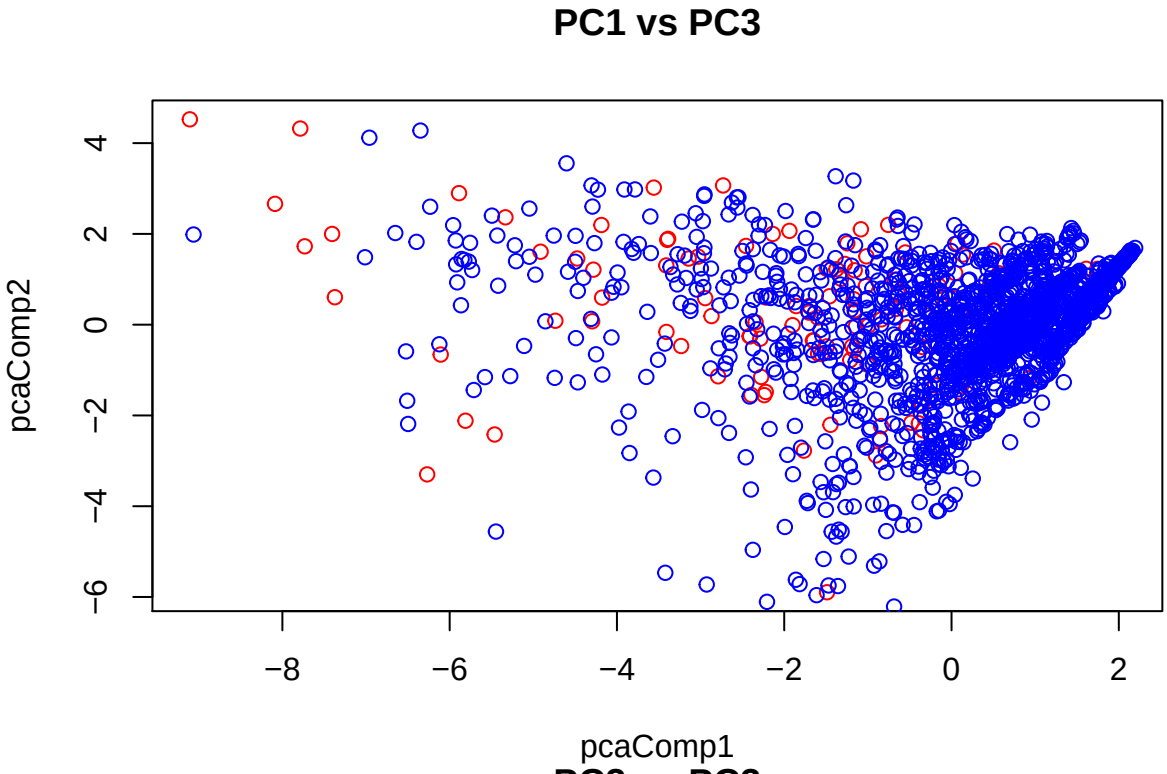
Variable Selection

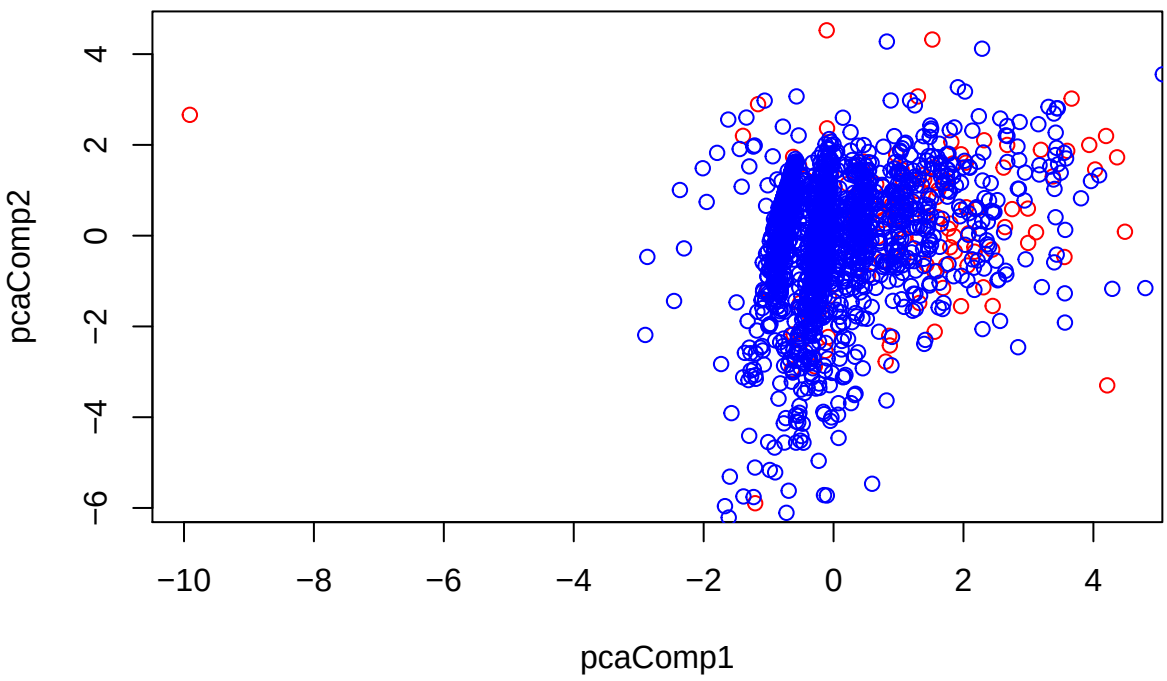





```
[1] 8.670049

  (Intercept)        seismic seismoacoustic          shift        genergy
-8.144581e-03   8.800484e-03   0.000000e+00   7.977504e-03   0.000000e+00
        gpuls       gdenergy         gdpuls       ghazard         nbumps
 4.677101e-05   0.000000e+00   0.000000e+00   0.000000e+00   3.117955e-02
      nbumps2        nbumps3        nbumps4        nbumps5         energy
 0.000000e+00   0.000000e+00   0.000000e+00   0.000000e+00   0.000000e+00
    maxenergy
 0.000000e+00

  (Intercept)       seismic         shift         gpuls        nbumps
-8.144581e-03  8.800484e-03  7.977504e-03  4.677101e-05  3.117955e-02
```

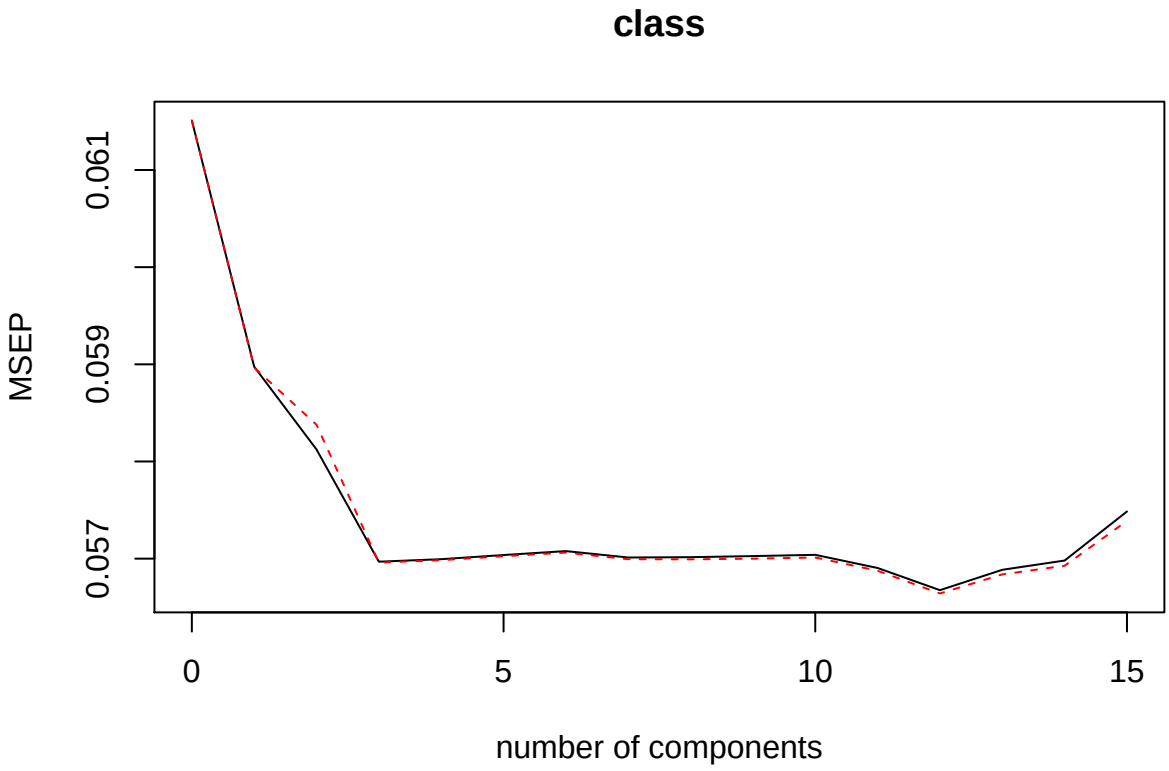

pc.comp
Variances
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Comp.1
Comp.3
Comp.5
Comp.7
Comp.9
PC1 vs PC2
pcaComp2
4
2
0
−2
−4
−6
−10
−8
−6
−4
−2
0
2
pcaComp1

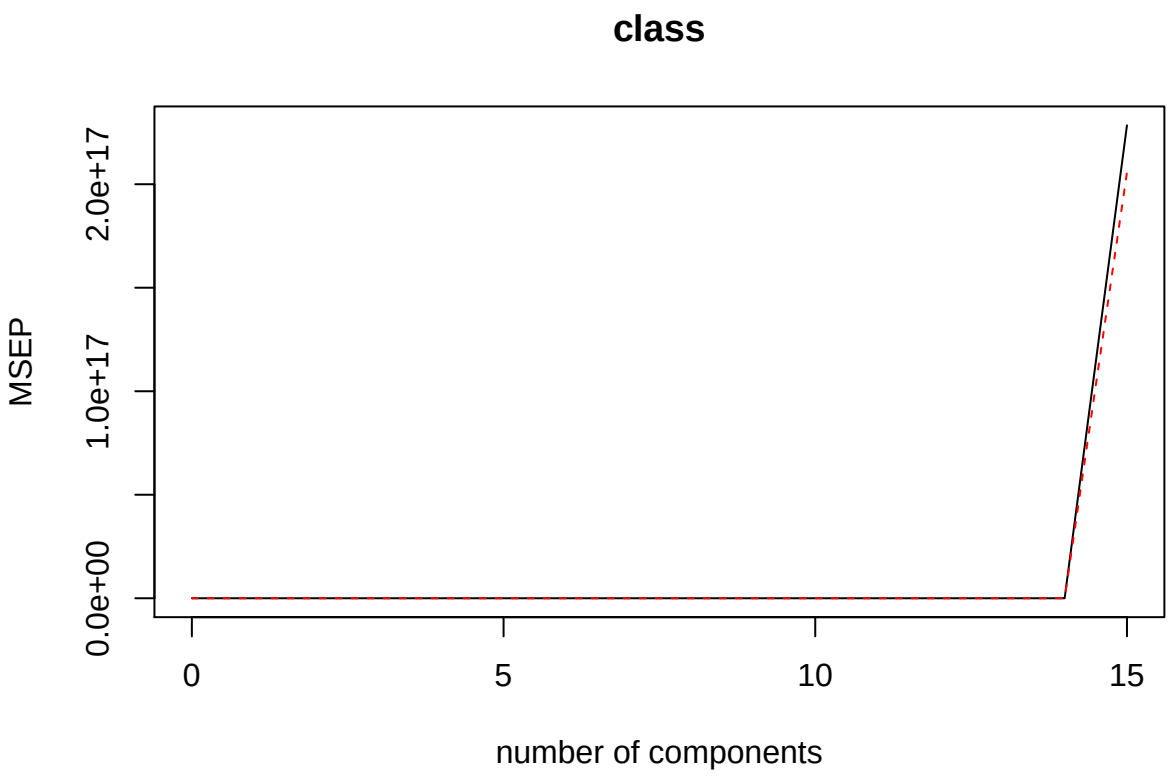





```
Data:   X dimension: 2584 15
    Y dimension: 2584 1
Fit method: svdpc
Number of components considered: 15
```

```
VALIDATION: RMSEP
Cross-validated using 10 random segments.
       (Intercept)  1 comps  2 comps  3 comps  4 comps  5 comps  6 comps
CV           0.248   0.2428   0.2411   0.2387   0.2387   0.2388   0.2389
adjCV        0.248   0.2428   0.2416   0.2387   0.2387   0.2388   0.2389
       7 comps  8 comps  9 comps  10 comps  11 comps  12 comps  13 comps
CV      0.2388   0.2388   0.2388    0.2388    0.2385    0.2381    0.2385
adjCV   0.2387   0.2387   0.2387    0.2388    0.2385    0.2380    0.2384
       14 comps  15 comps
CV       0.2387    0.2398
adjCV    0.2386    0.2396

TRAINING: % variance explained
       1 comps  2 comps  3 comps  4 comps  5 comps  6 comps  7 comps
X       25.306   40.680   55.704   64.926   72.401   79.396   85.185
class    4.225    5.285    7.573    7.577    7.584    7.592    7.792
       8 comps  9 comps  10 comps  11 comps  12 comps  13 comps  14 comps
X       89.627   93.557    97.005    98.398    99.294     99.97    99.998
class    7.917    8.022     8.026     8.289     8.847      8.87     8.872
       15 comps
X       100.000
class     9.128
```






```
[1] 0.05357258
```

Logistic Regression after Variable Selection

```
Call:
glm(formula = class ~ seismic + shift + gpuls + nbumps, family = binomial,
    data = seismic.train)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.6270  -0.3846  -0.2947  -0.1627   2.9781

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -5.9508244  0.6490468  -9.169  < 2e-16 ***
seismic      0.3641160  0.1944250   1.873 0.061098 .
shift        1.1371057  0.3402674   3.342 0.000832 ***
gpuls        0.0004913  0.0001283   3.829 0.000129 ***
nbumps       0.3231048  0.0507286   6.369  1.9e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 958.82  on 1937  degrees of freedom
Residual deviance: 828.98  on 1933  degrees of freedom
```

```
AIC: 838.98

Number of Fisher Scoring iterations: 6

[1] 0.9318885


glm.pred    0    1
       0 1803  128
       1    4    3

[1] 0.02290076

[1] 0.9977864

[1] 0.9380805


glm.pred   0   1
       0 606  39
       1   1   0

[1] 0

[1] 0.9983526
```