557_Project_2BS

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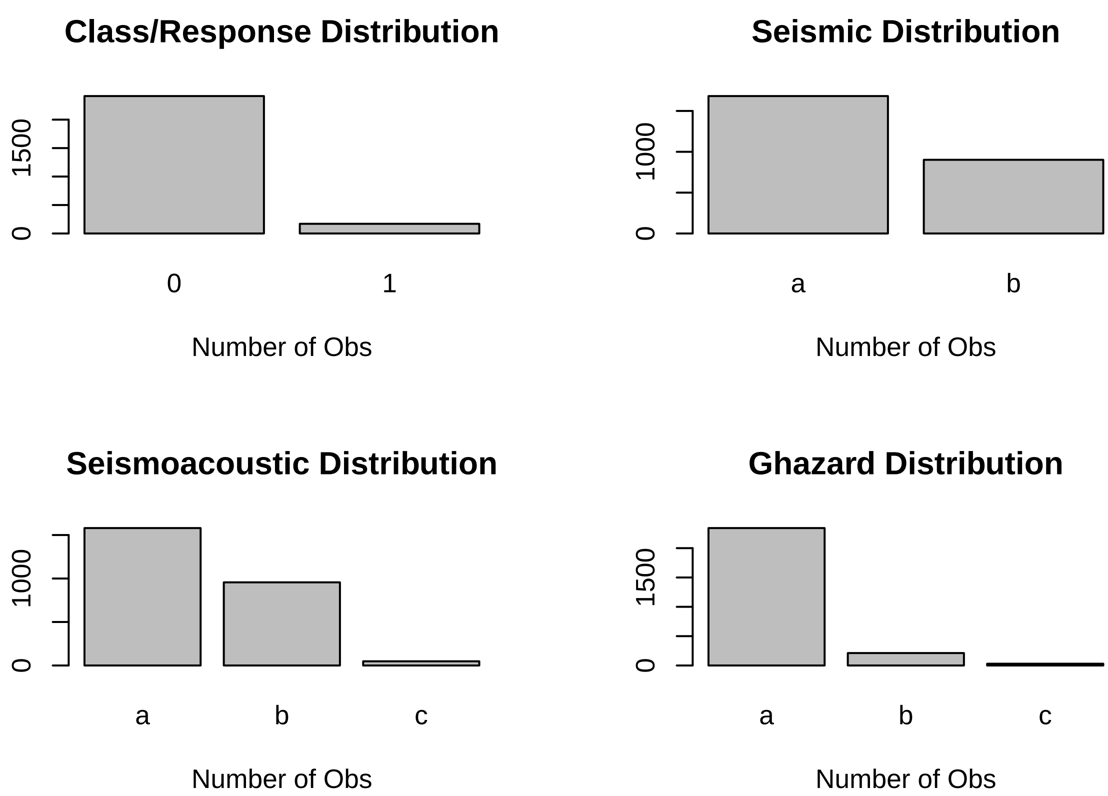
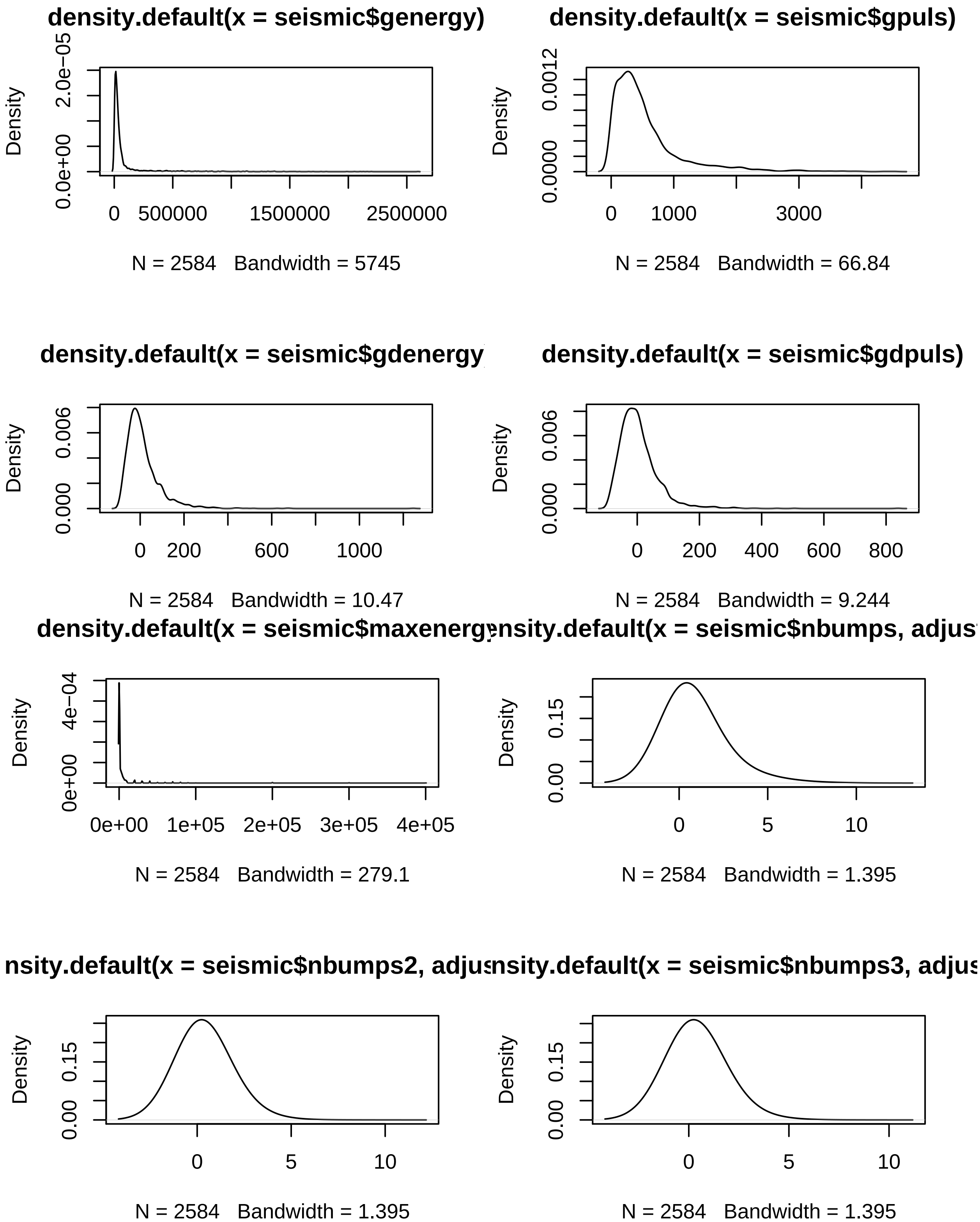
No Command Lines Ever. Whoa

```
## function (..., recursive = FALSE)  .Primitive("c")
```

What the Factor Variables look like

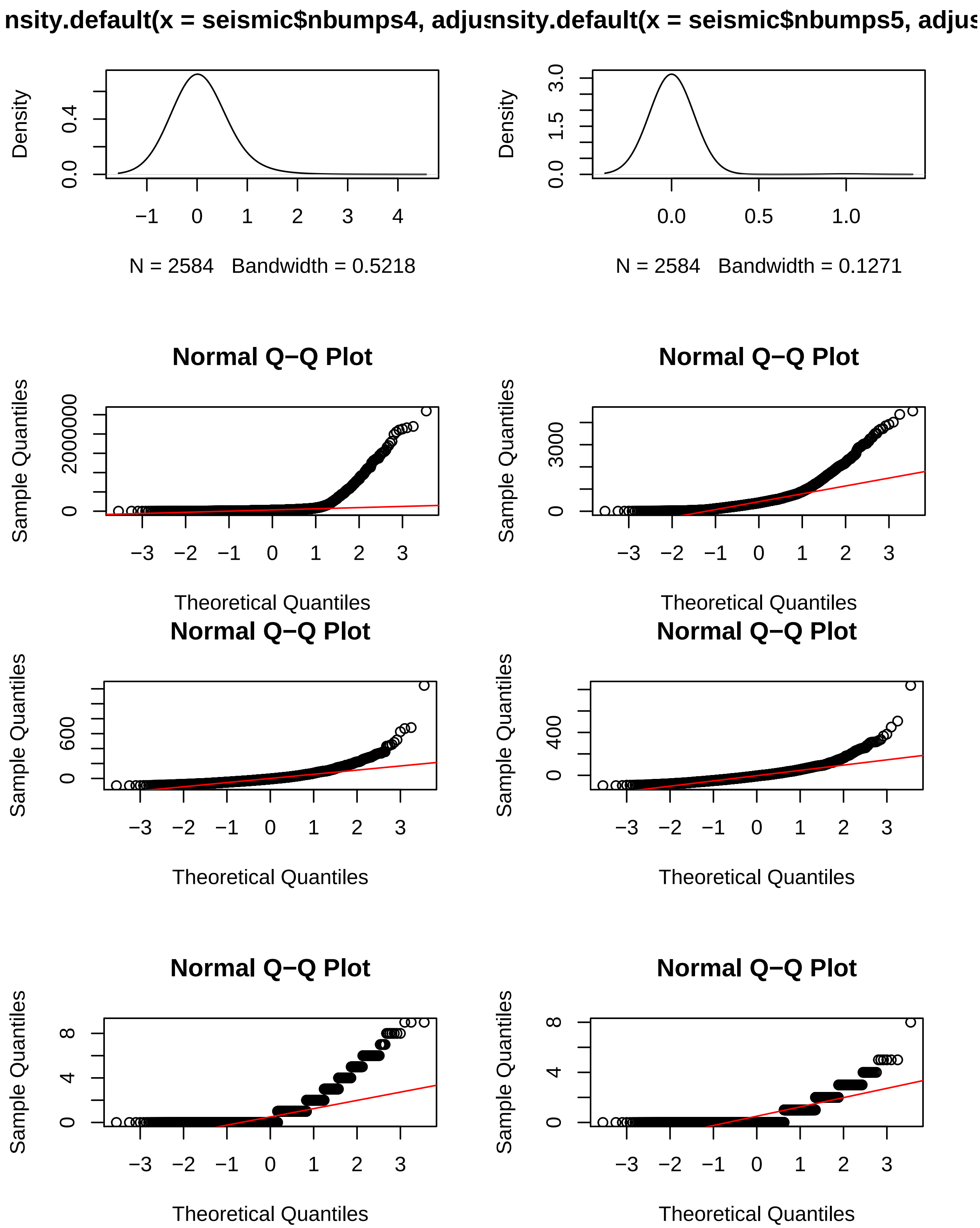


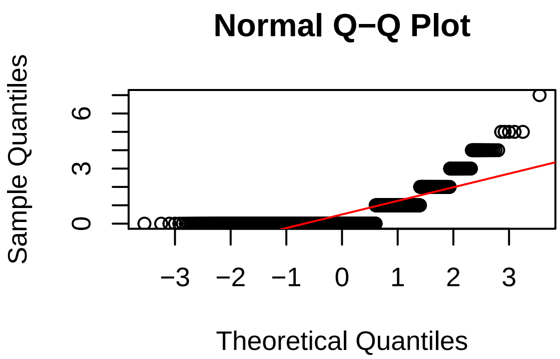
What the Continuous Variables look like

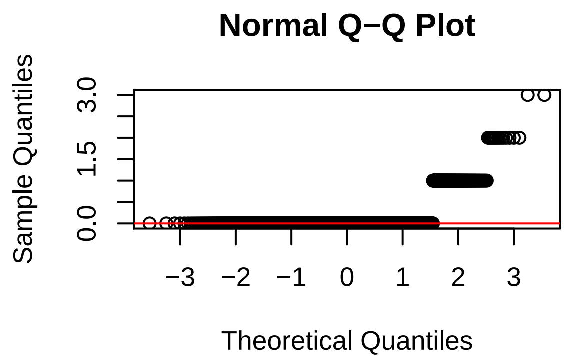


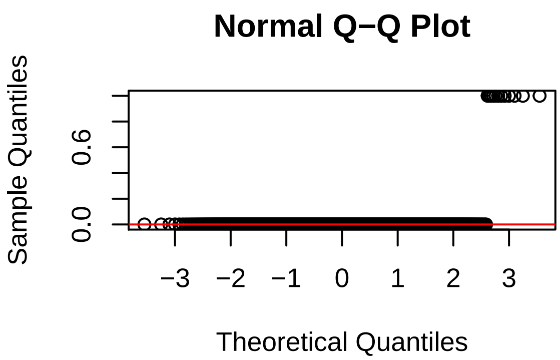

```
Call:
```

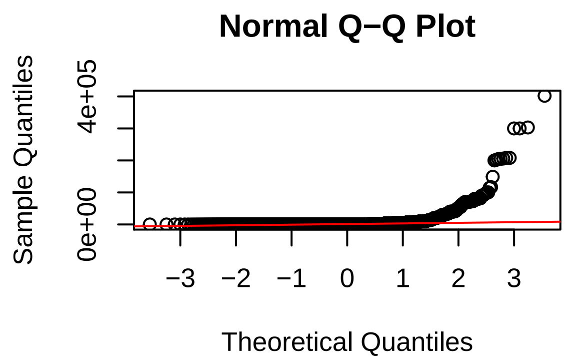
```
lm(formula = class ~ ., data = seismic)

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
```

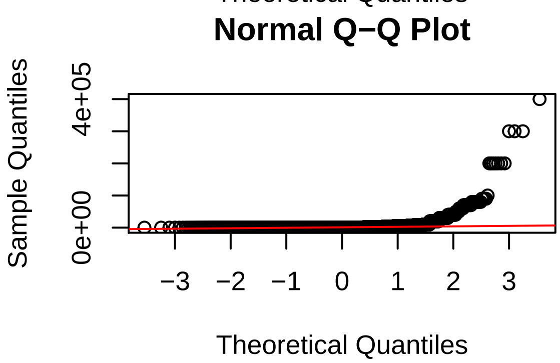

nsity.default(x = seismic$nbumps4, adju
nsity.default(x = seismic$nbumps5, adjus
Density
N = 2584   Bandwidth = 0.5218
N = 2584   Bandwidth = 0.1271
Normal Q−Q Plot
Sample Quantiles
Theoretical Quantiles

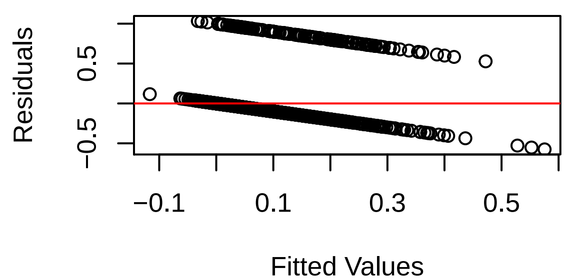

Normal Q−Q Plot
Sample Quantiles
Theoretical Quantiles
0
3
6
−3
−2
−1
0
1
2
3

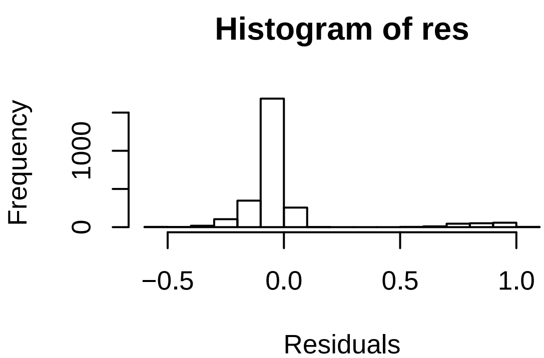

Normal Q−Q Plot
Sample Quantiles
Theoretical Quantiles
0.0
1.5
3.0
−3
−2
−1
0
1
2
3


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


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


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


Residuals
Fitted Values
−0.5
0.5
−0.1
0.1
0.3
0.5

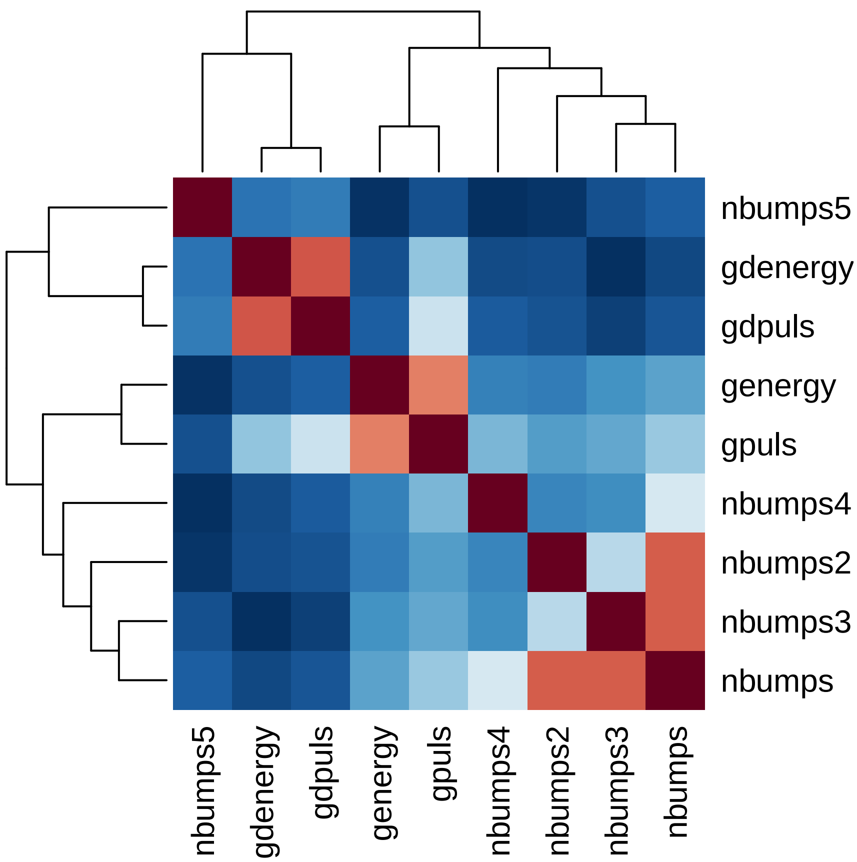

Histogram of res
Frequency
Residuals
0
1000
−0.5
0.0
0.5
1.0

Lots of multicollinearity to worry about during variable selection

```r
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
```

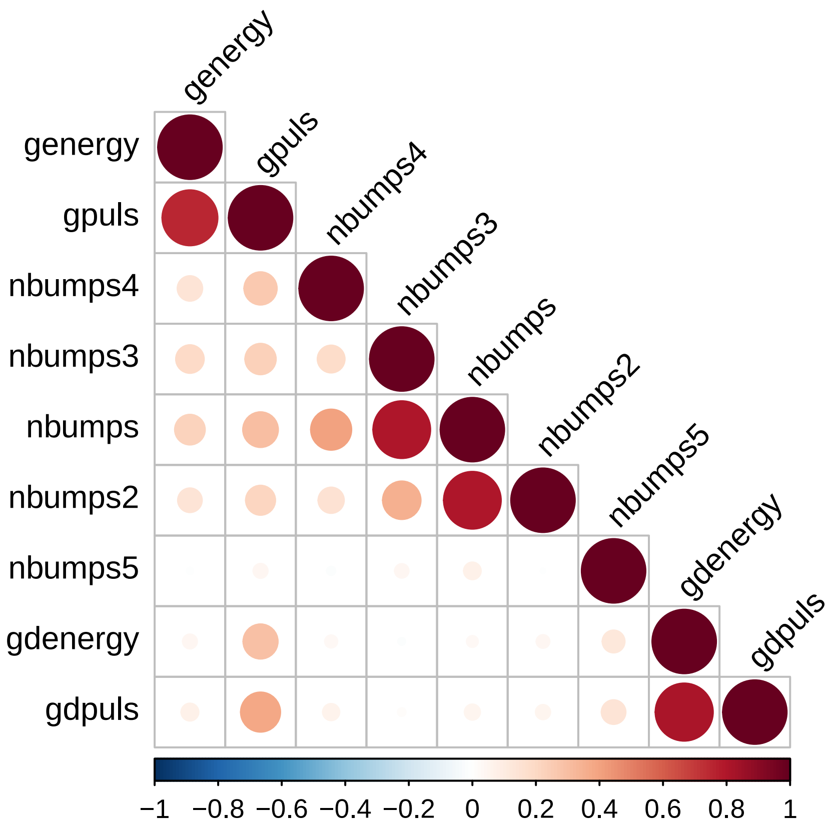
Correlation of the Variables




```
$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

```r
##-------------------------------------
## 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
```

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

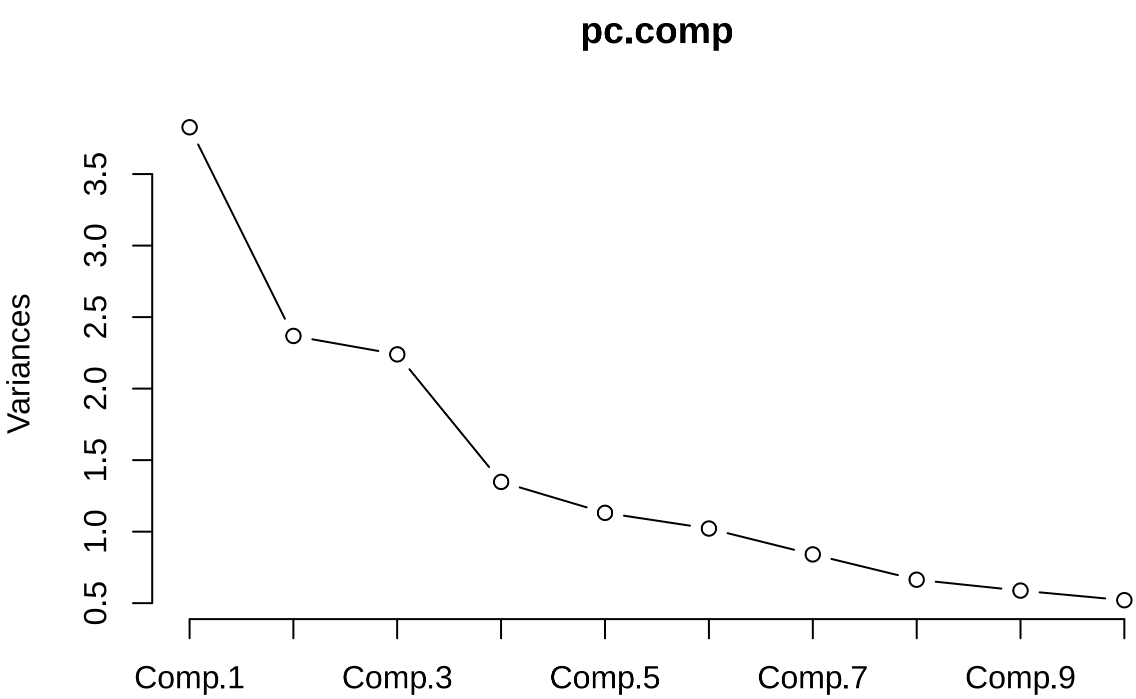
```
[1] 1938   16
```

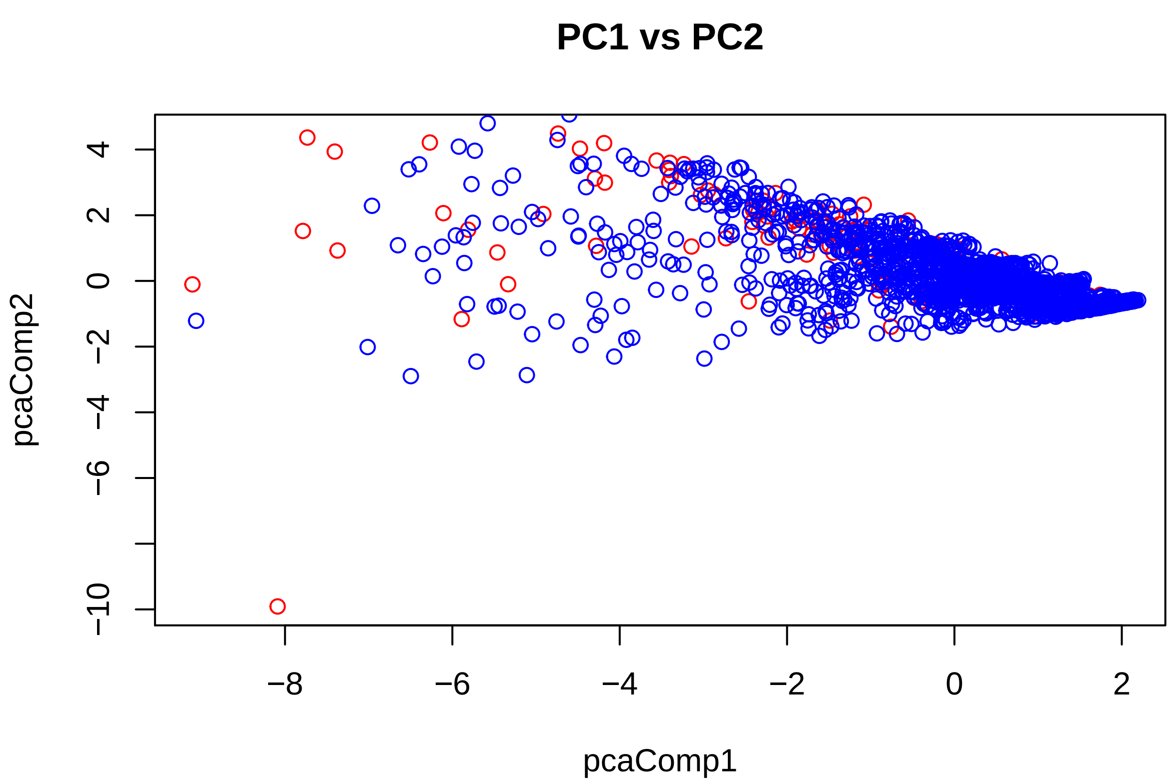
```r
dim(seismic.test)
```

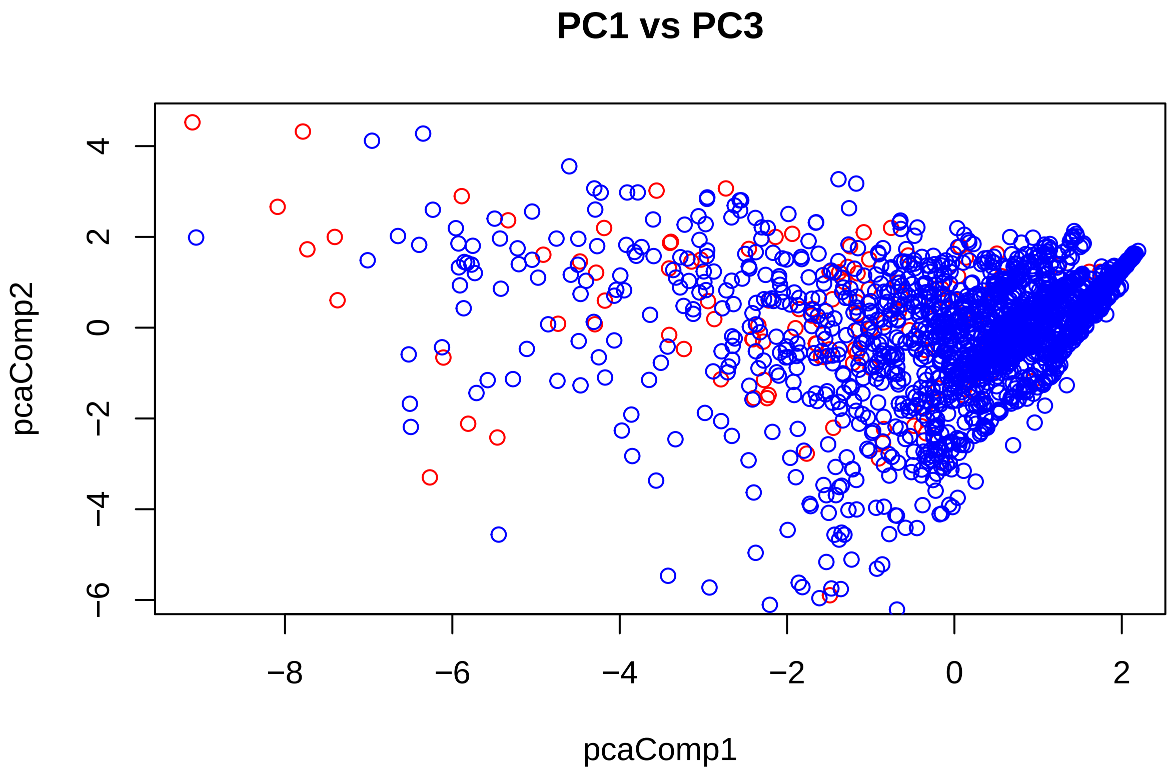
```
[1] 646  16
```

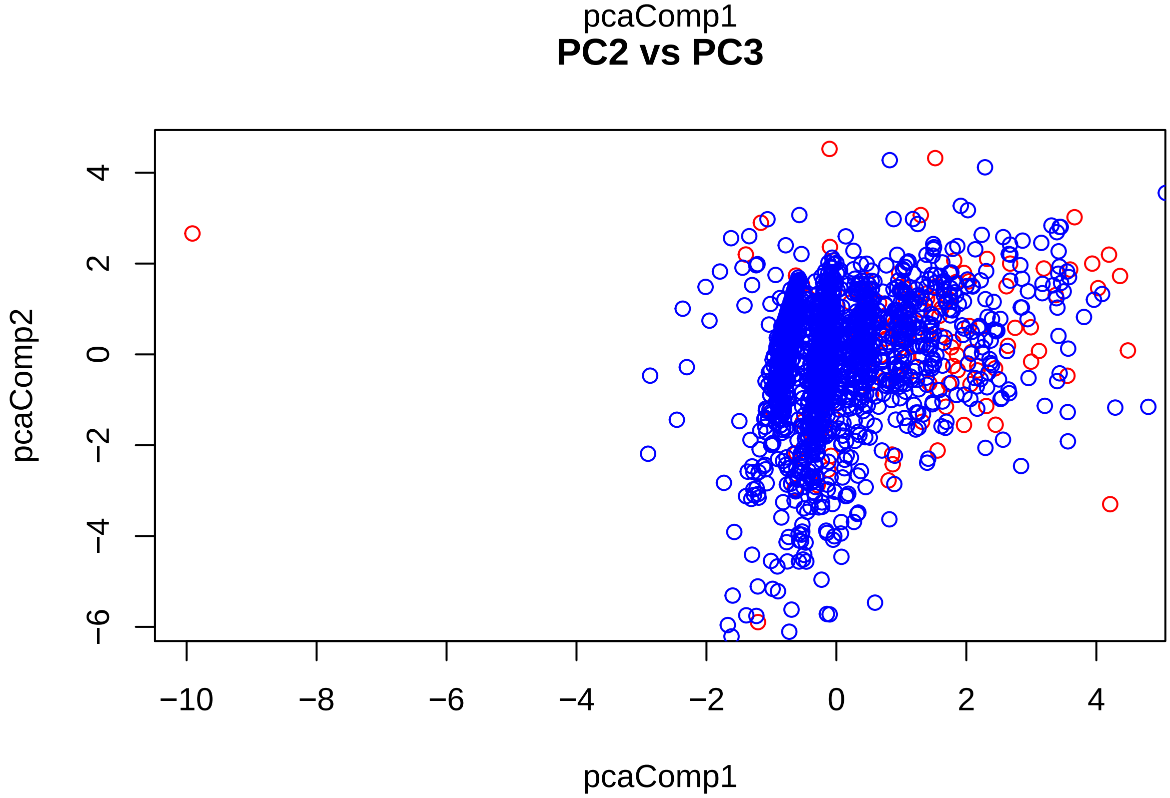
```r
#View(seismic.train)
#View(seismic.test)
```

Linear regression of an indicator matrix





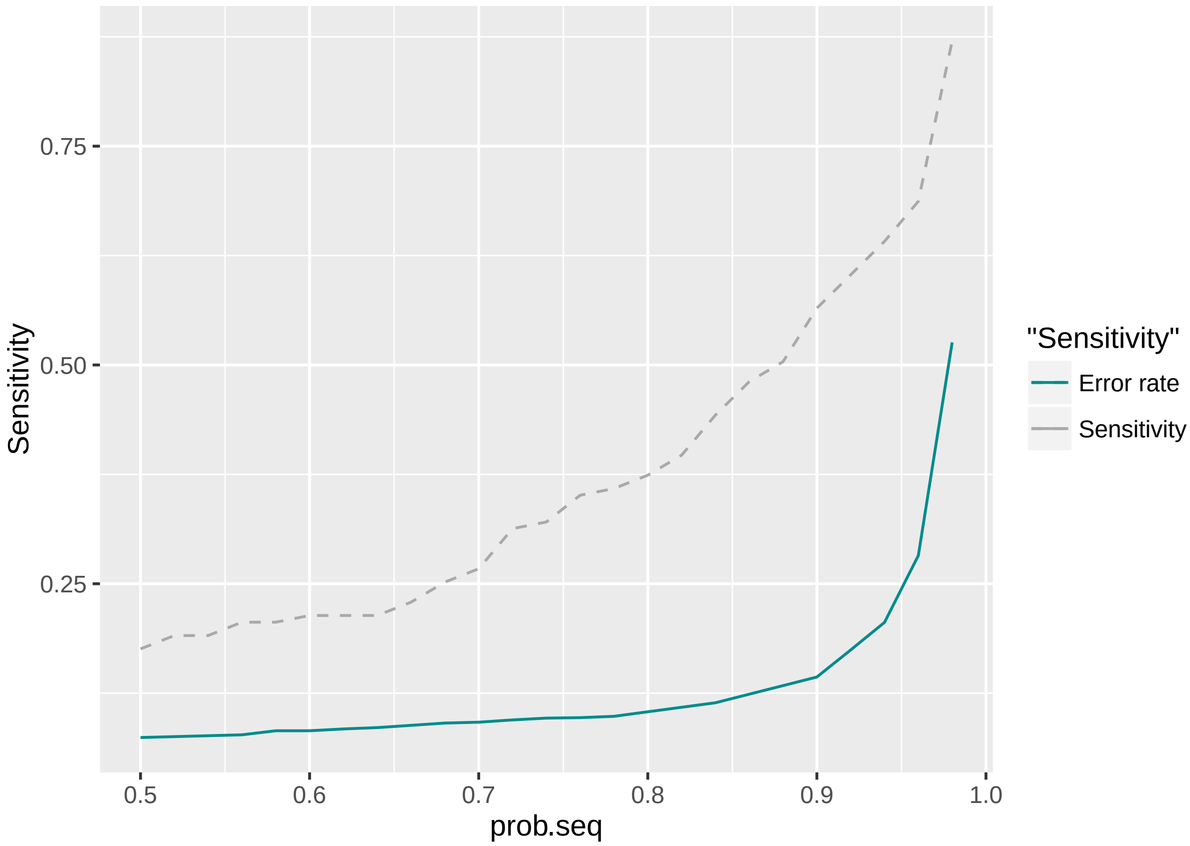




lda.class	0	1
0	1771	108
1	36	23

```
[1] 0.1755725
```

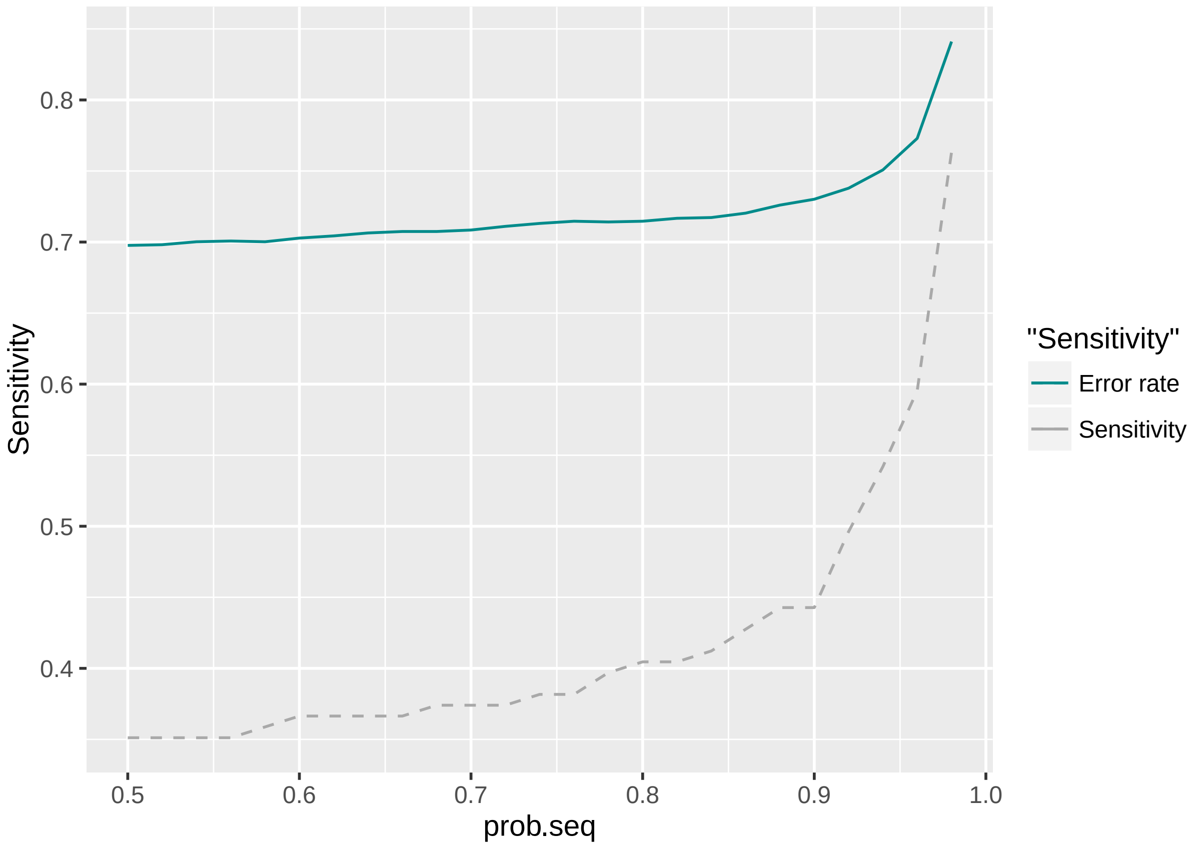
```
[1] 0.9800775
```




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

```
[1] 0.1282051
```

```
[1] 0.9736409
```



Logistic Regression on the Training and Test Sets

```
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
```

The predictors that are significant in our logistic model are seismic, shift and gpuls. The predictors nbumps6, nbumps7 and nbumps89 were removed as they did not provide any data.

```
[1] 0.9329205
```

```
glm.pred    0    1
       0 1802  125
       1    5    6
```

```
[1] 0.04580153
```

```
[1] 0.997233
```

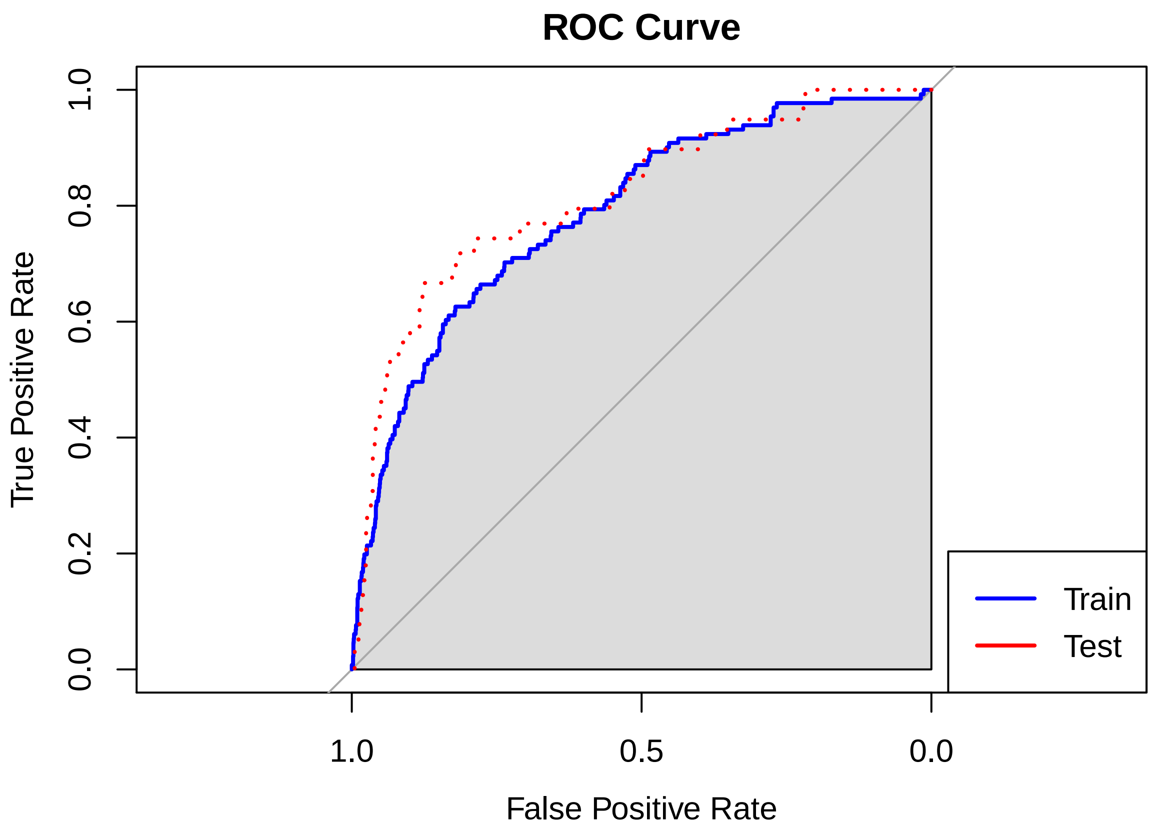
The diagonal elements of the confusion matrix indicate correct predictions, while the off-diagonals represent incorrect predictions. Hence our model on the training data set correctly predicted that the seismic activity would be of no harzard on 1786 observations and that it would be of hazard on 0 observations, for a total of $1786 + 0 = 1786$ correct predictions. The mean() function can be used to compute the fraction of hazards for which the prediction was correct. In this case, logistic regression correctly predicted the class of hazard 92 percent of the time. The bad part about this 92 percent of the time is that it did not get any of our actual real hazards observations correct!!!

```
## [1] 0.9349845
```

```
##
## glm.pred   0   1
##        0 602  37
##        1   5   2
```

```
## [1] 0.05128205
```

```
## [1] 0.9917628
```



The diagonal elements of the confusion matrix indicate correct predictions, while the off-diagonals represent incorrect predictions. Hence our model on the testing data set correctly predicted that the seismic activity would be of no harzard on 605 observations and that it would be hazardous on 2 observations, for a total of 602 + 2 = 604 correct predictions. The mean() function can be used to compute the fraction of seismic activity for which the prediction was correct. In this case, logistic regression correctly predicted class of hazard 93.5 % of the time. However, again worrisome, is that the model miss 5 observations that were hazardous instances and 37 that were not hazardous.

Recall that the logistic regression model had only 3 predictors that were significant from an avaiable 19. Perhaps by removing the variables that appear not to be helpful in predicting seismic hazard, we can obtain a more effective model. After all, using predictors that have no relationship with the response tends to cause a deterioration in the test error rate (since such predictors cause an increase in variance without a corresponding decrease in bias), and so removing such predictors may in turn yield an improvement [straight from the book]

Random Notes on Roc Curve

This type of graph is called a Receiver Operating Characteristic curve (or ROC curve.) It is a plot of the true positive rate against the false positive rate for the different possible cutpoints of a diagnostic test.

An ROC curve demonstrates several things:

It shows the tradeoff between sensitivity and specificity (any increase in sensitivity will be accompanied by a decrease in specificity). The closer the curve follows the left-hand border and then the top border of the ROC space, the more accurate the test. The closer the curve comes to the 45-degree diagonal of the ROC space, the less accurate the test. The slope of the tangent line at a cutpoint gives the likelihood ratio (LR) for that value of the test. You can check this out on the graph above. Recall that the LR for T4 $<$ 5 is 52. This corresponds to the far left, steep portion of the curve. The LR for T4 $>$ 9 is 0.2. This corresponds to the far right, nearly horizontal portion of the curve. The area under the curve is a measure of text accuracy. This is discussed further in the next section.

The accuracy of the test depends on how well the test separates the group being tested into those with and without the disease in question. Accuracy is measured by the area under the ROC curve. An area of 1 represents a perfect test; an area of .5 represents a worthless test. A rough guide for classifying the accuracy of a diagnostic test is the traditional academic point system:

.90-1 = excellent (A) .80-.90 = good (B) .70-.80 = fair (C) .60-.70 = poor (D) .50-.60 = fail (F)