557_Project_2BS

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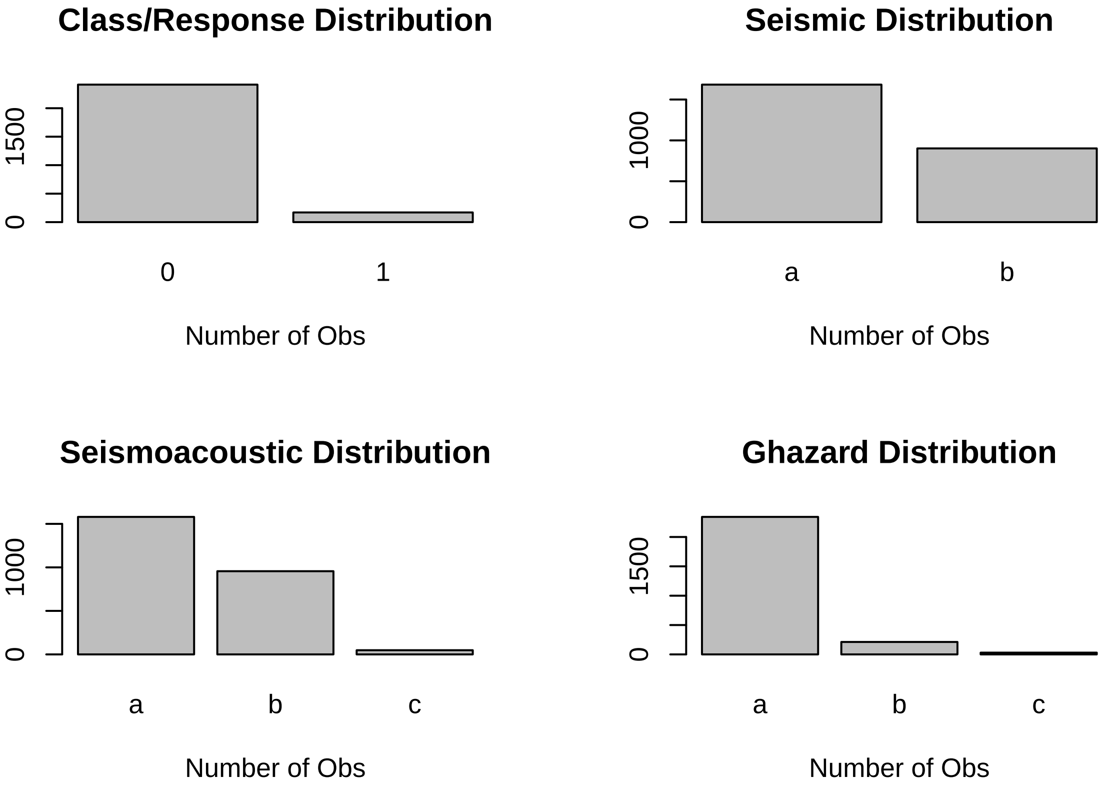
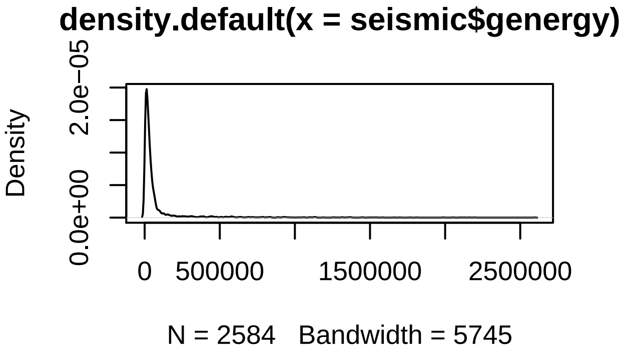
3/15/2017

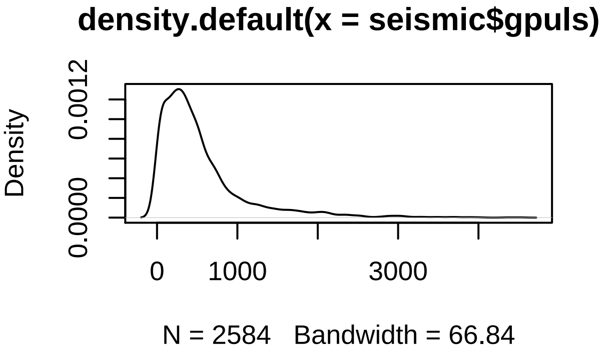
No Command Lines Ever. Whoa

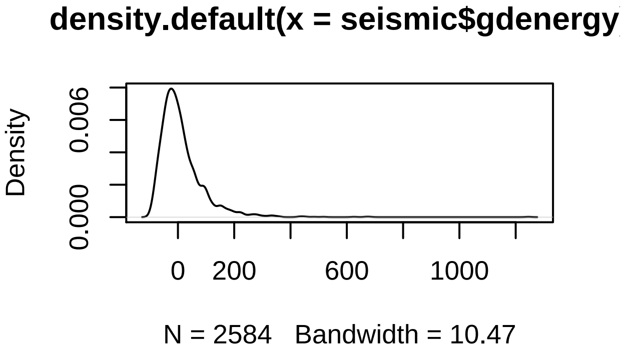
What the Factor Variables look like

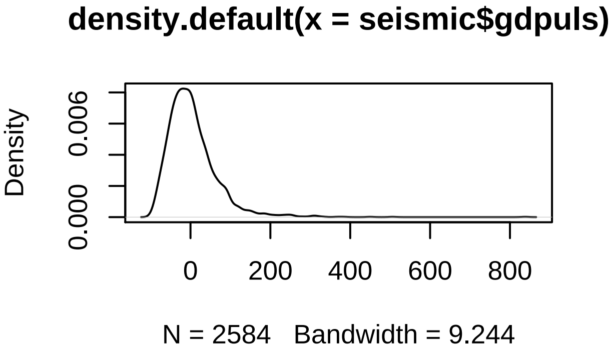


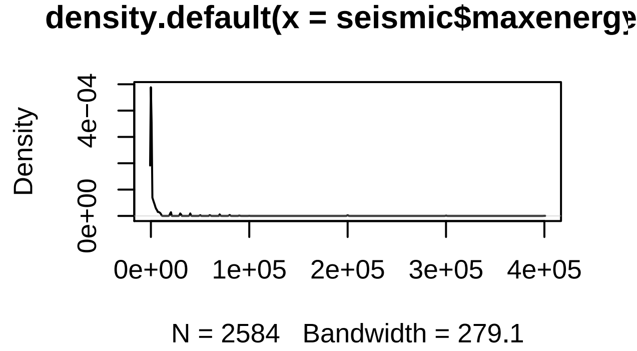
What the Continuous Variables look like

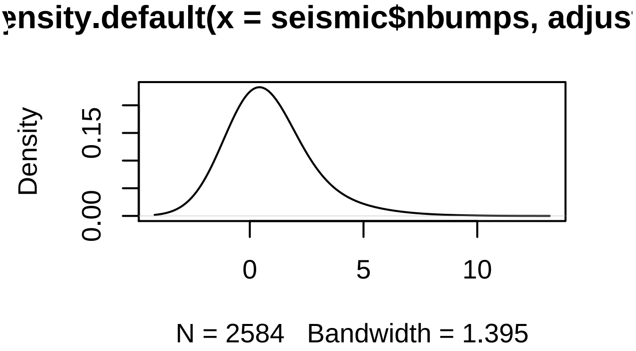


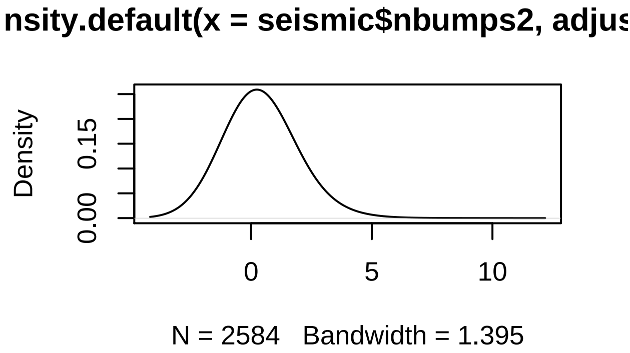


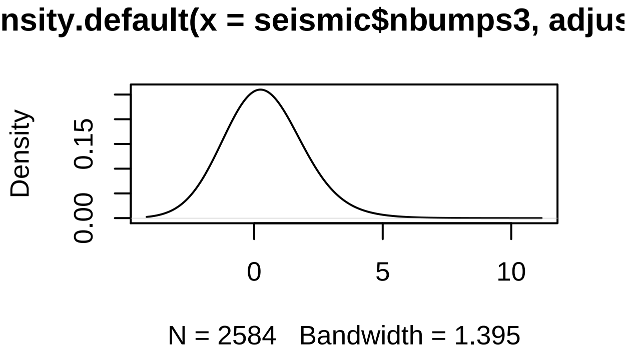






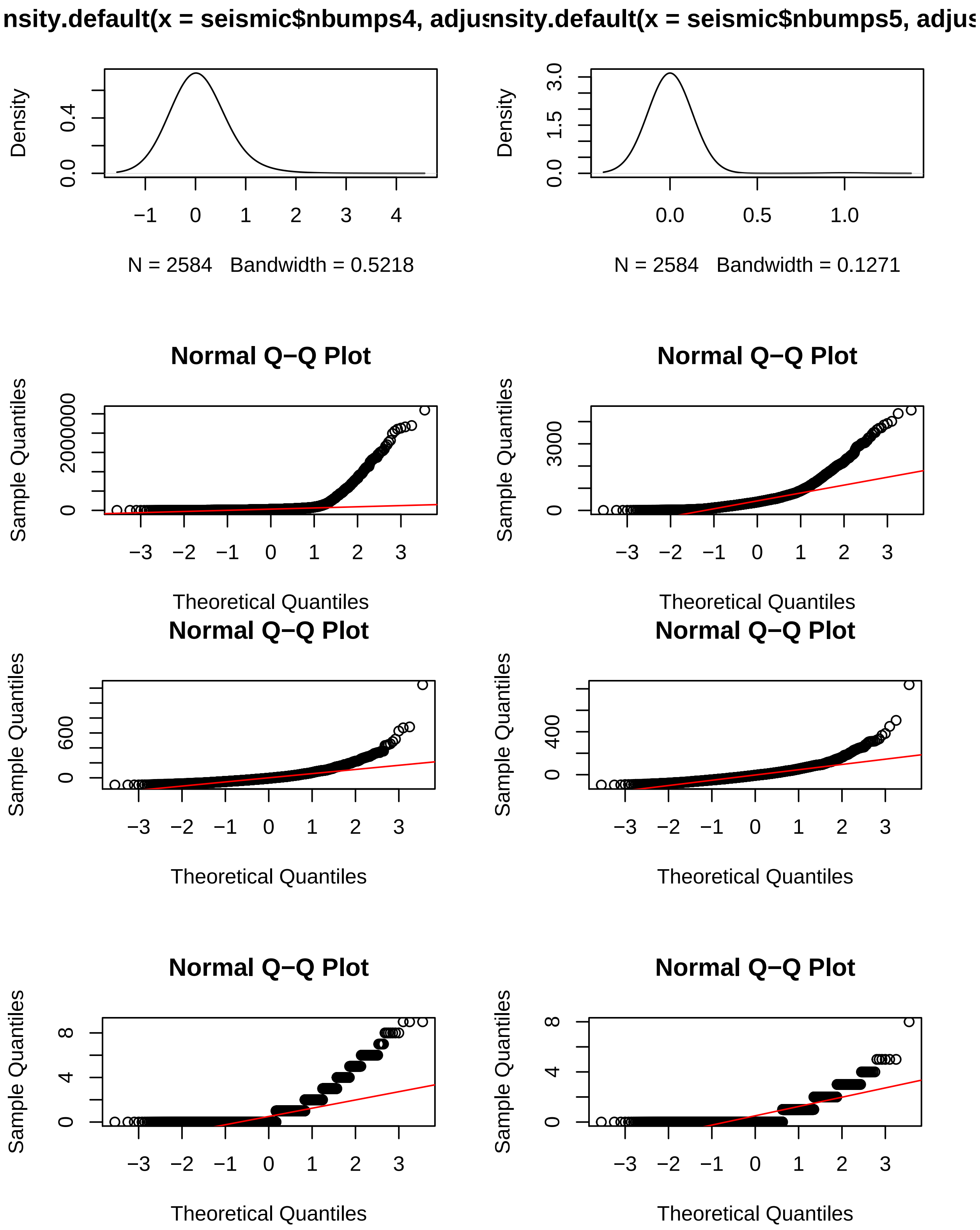


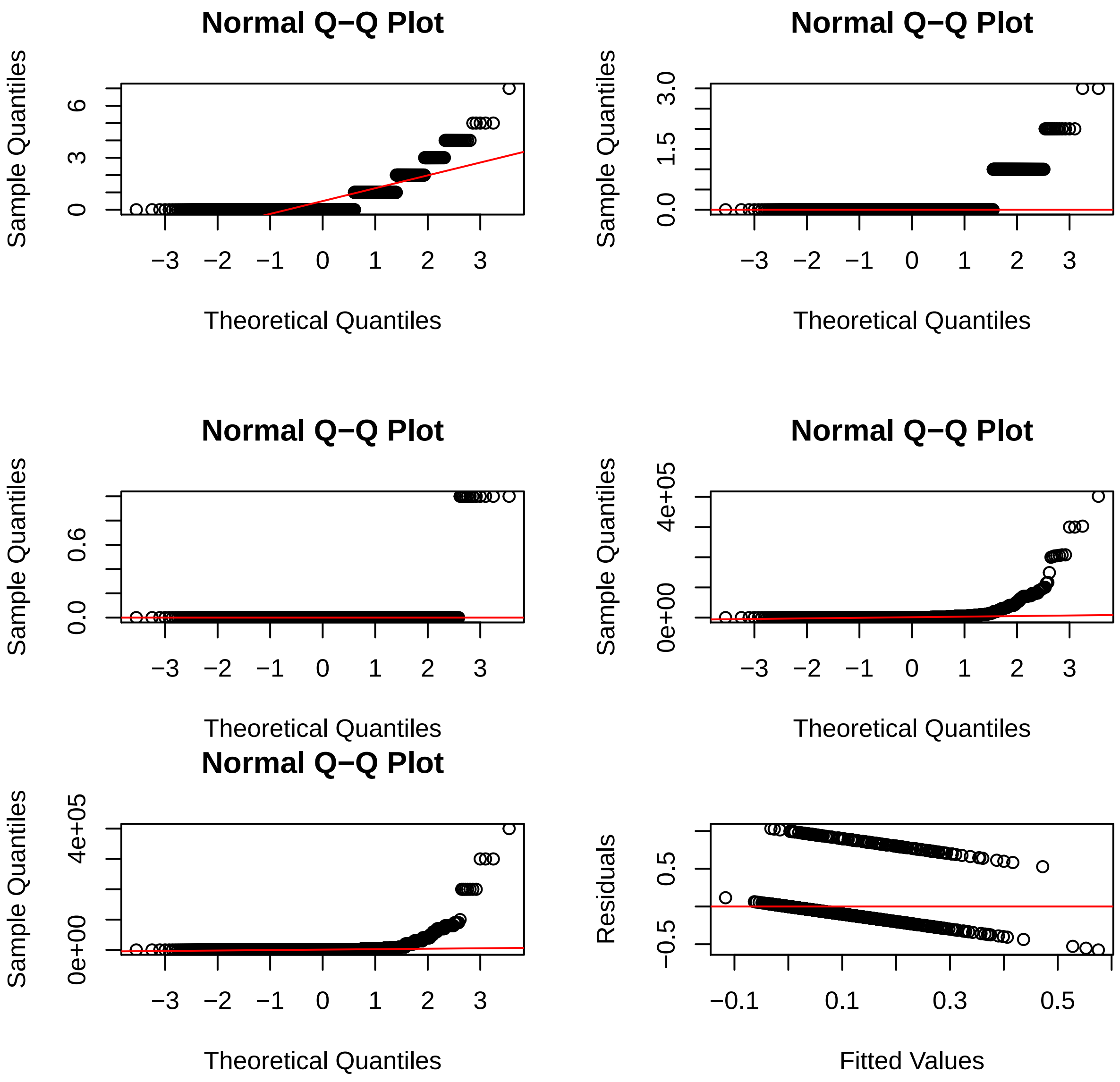


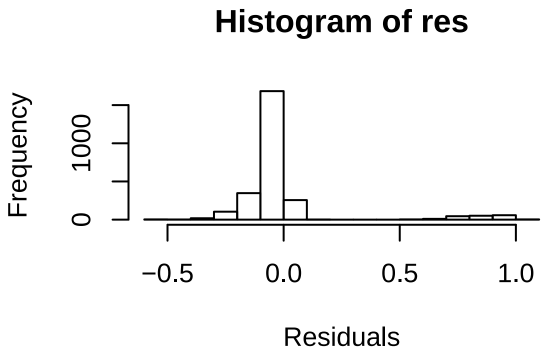


```
Call:
```

```
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
0.0
0.4
−1
0
1
2
3
4
N = 2584   Bandwidth = 0.5218
Density
0.0
1.5
3.0
0.0
0.5
1.0
N = 2584   Bandwidth = 0.1271
Normal Q−Q Plot
Sample Quantiles
0
2000000
−3
−2
−1
0
1
2
3
Theoretical Quantiles
Normal Q−Q Plot
Sample Quantiles
0
3000
−3
−2
−1
0
1
2
3
Theoretical Quantiles
Normal Q−Q Plot
Sample Quantiles
0
600
−3
−2
−1
0
1
2
3
Theoretical Quantiles
Normal Q−Q Plot
Sample Quantiles
0
400
−3
−2
−1
0
1
2
3
Theoretical Quantiles
Normal Q−Q Plot
Sample Quantiles
0
4
8
−3
−2
−1
0
1
2
3
Theoretical Quantiles
Normal Q−Q Plot
Sample Quantiles
0
4
8
−3
−2
−1
0
1
2
3
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

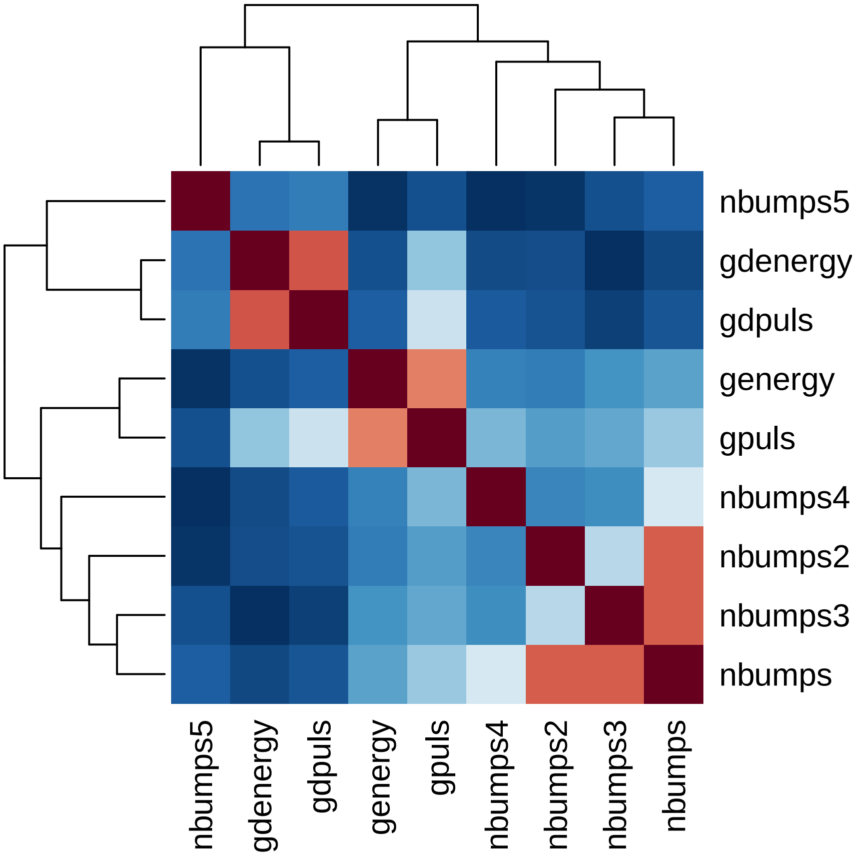

Histogram of res
Frequency
0
1000
−0.5
0.0
0.5
1.0
Residuals

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
```

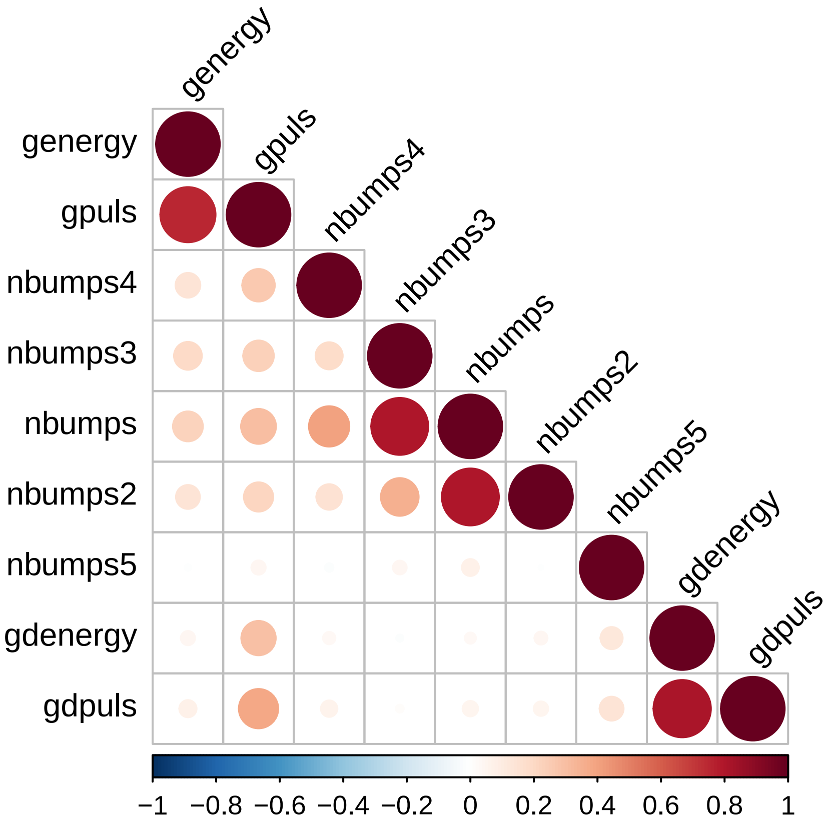
Correlation of the Variables



```
$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

```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
```

```
#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"
```

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

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

```r
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
```

```r
sensitivity
```

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

```r
specificity
```

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

```r
# 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
```

```r
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
```

```r
sensitivity
```

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

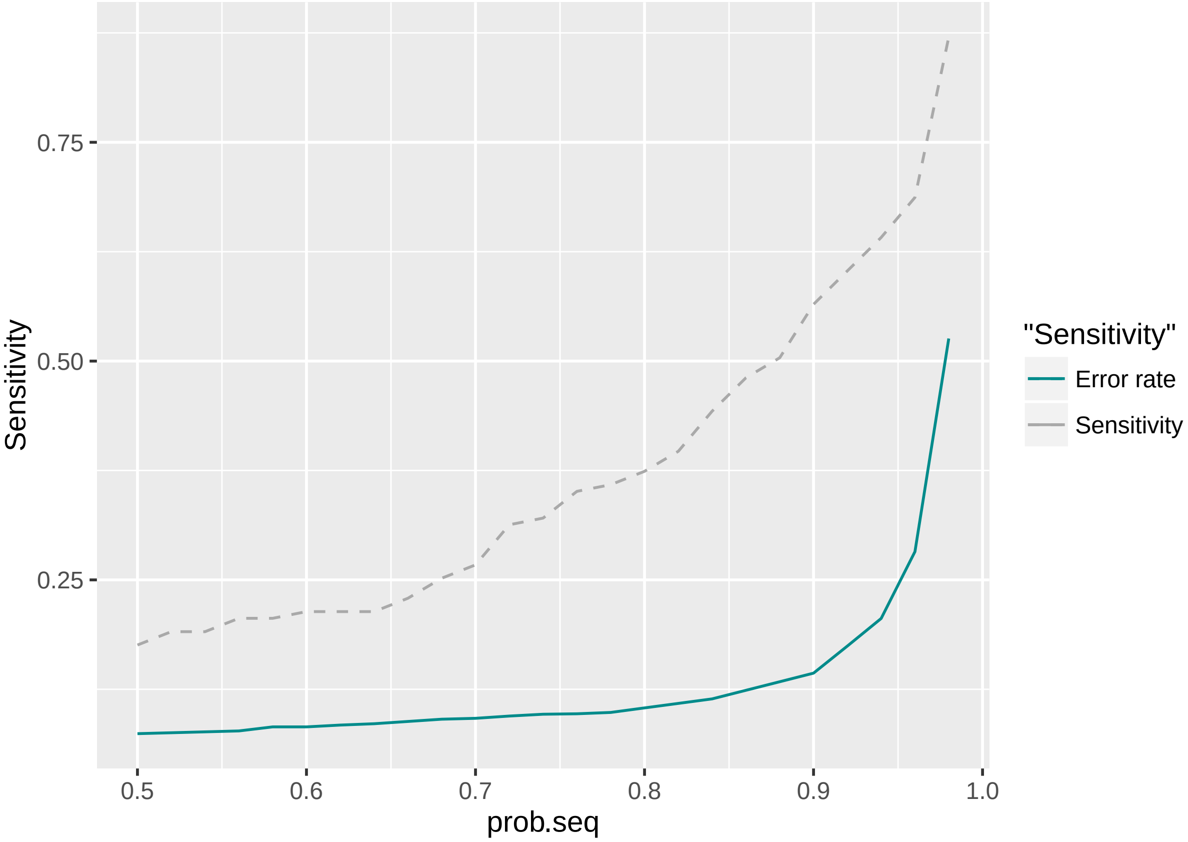
```
specificity
```

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

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

```
[1] 0.1755725
```

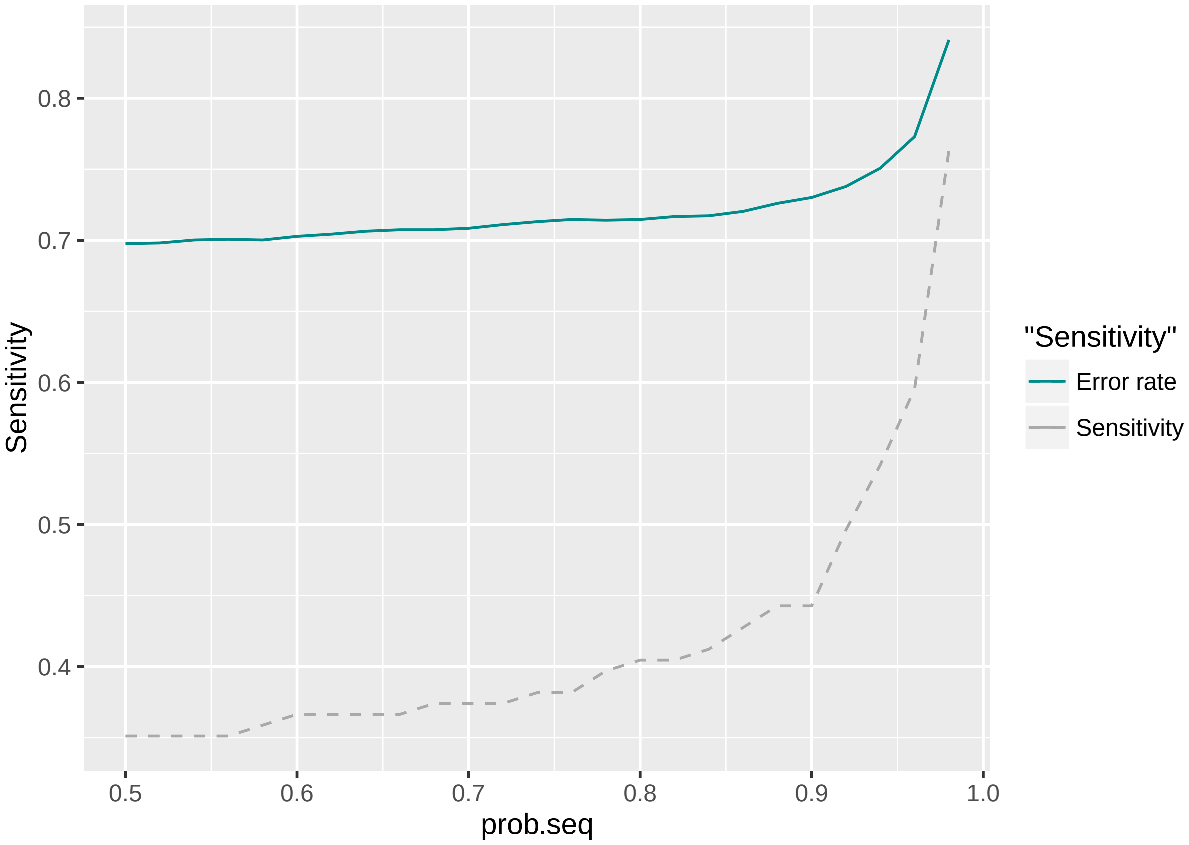
```
[1] 0.9800775
```



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

```
[1] 0.1282051
```

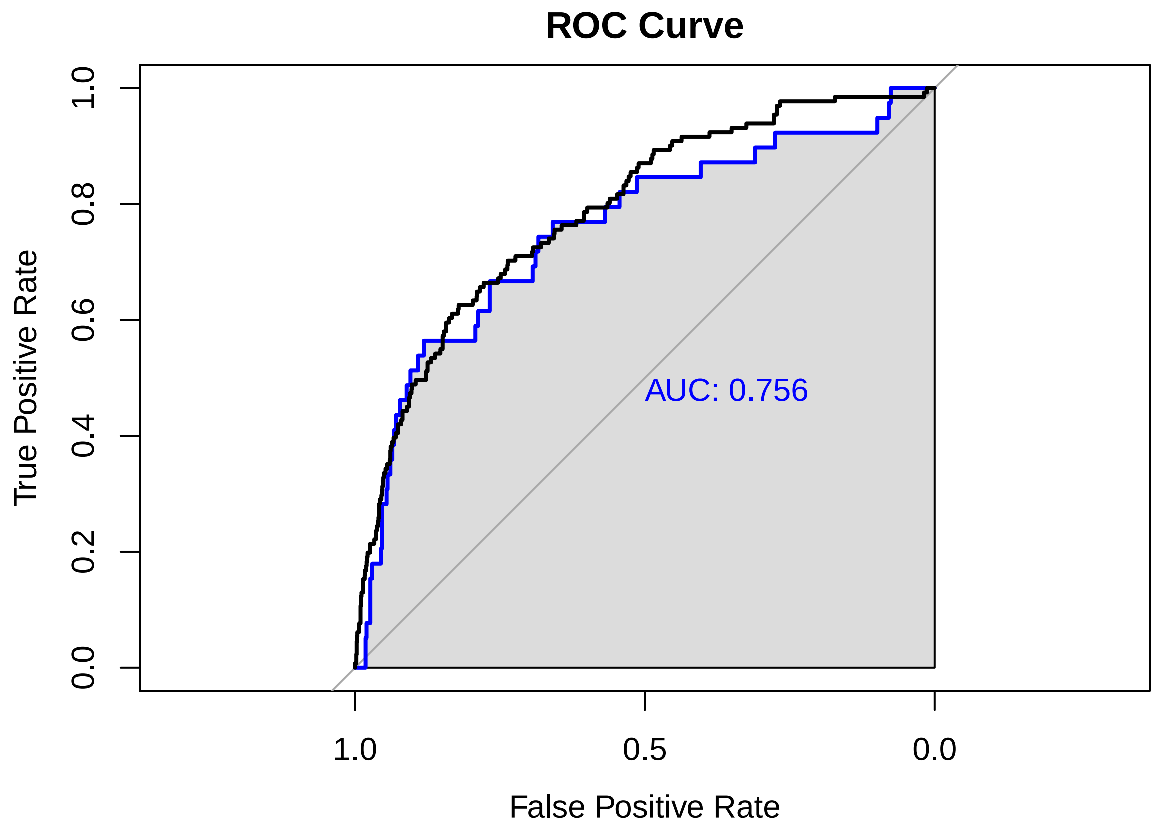
```
[1] 0.9736409
```

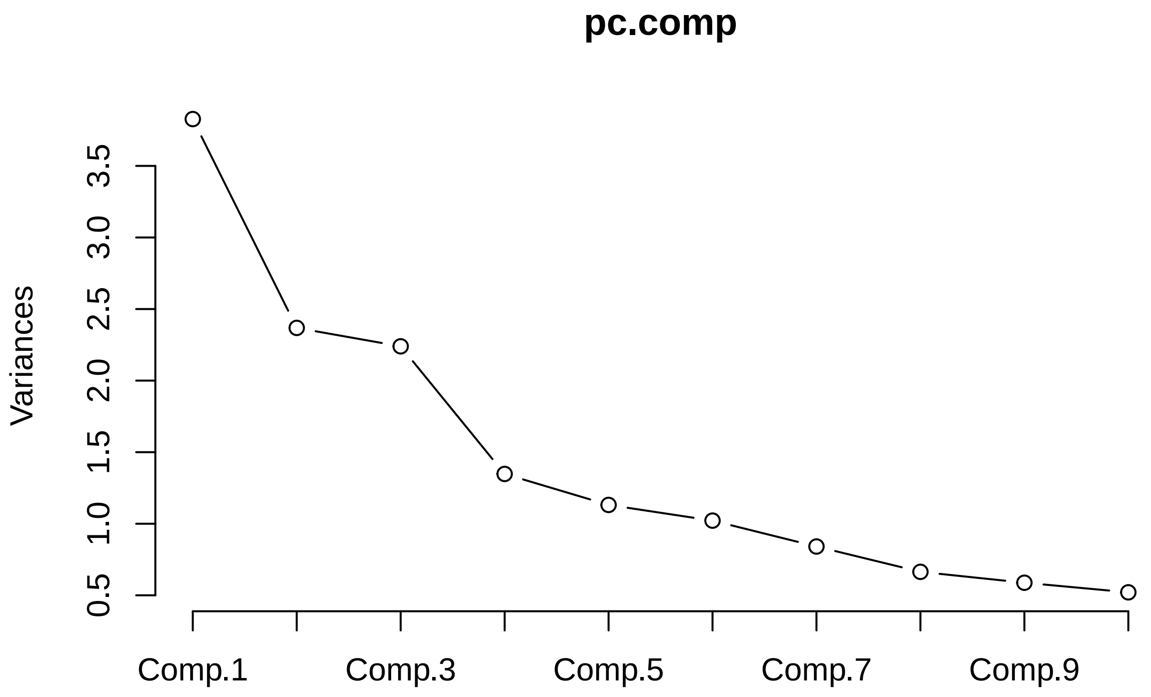


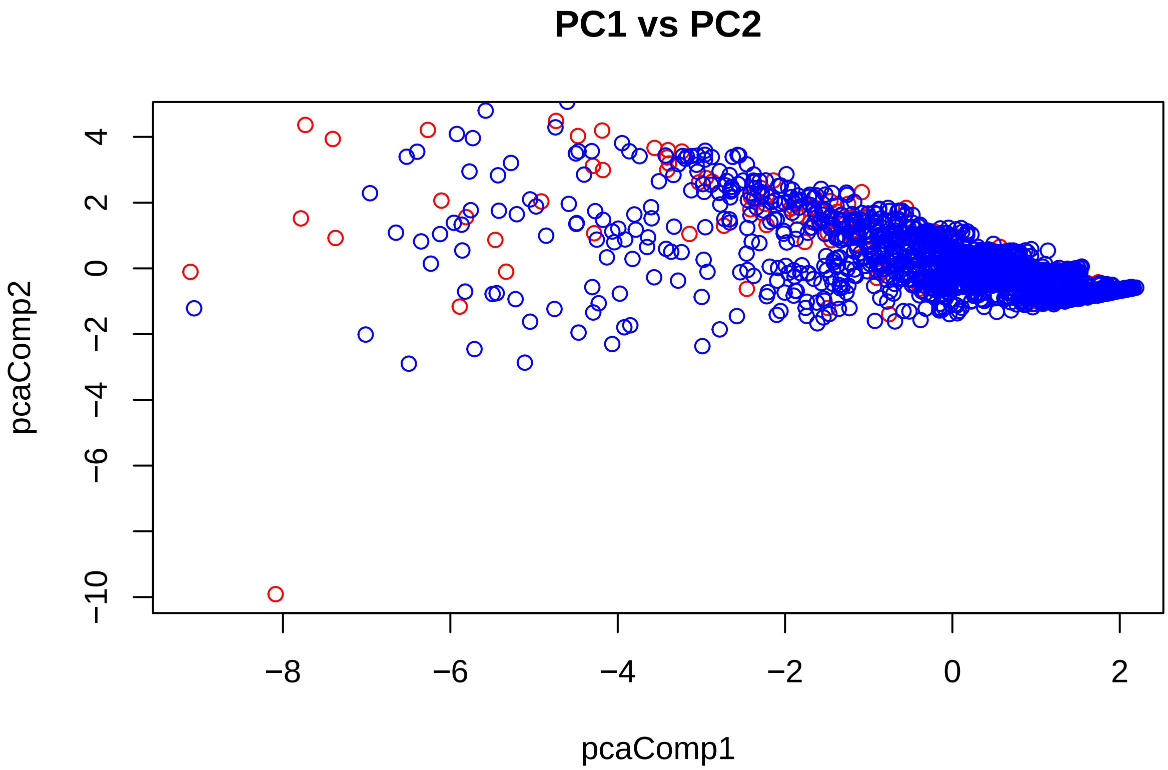
Logistic Regression on the Training and Test Sets

```
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
```

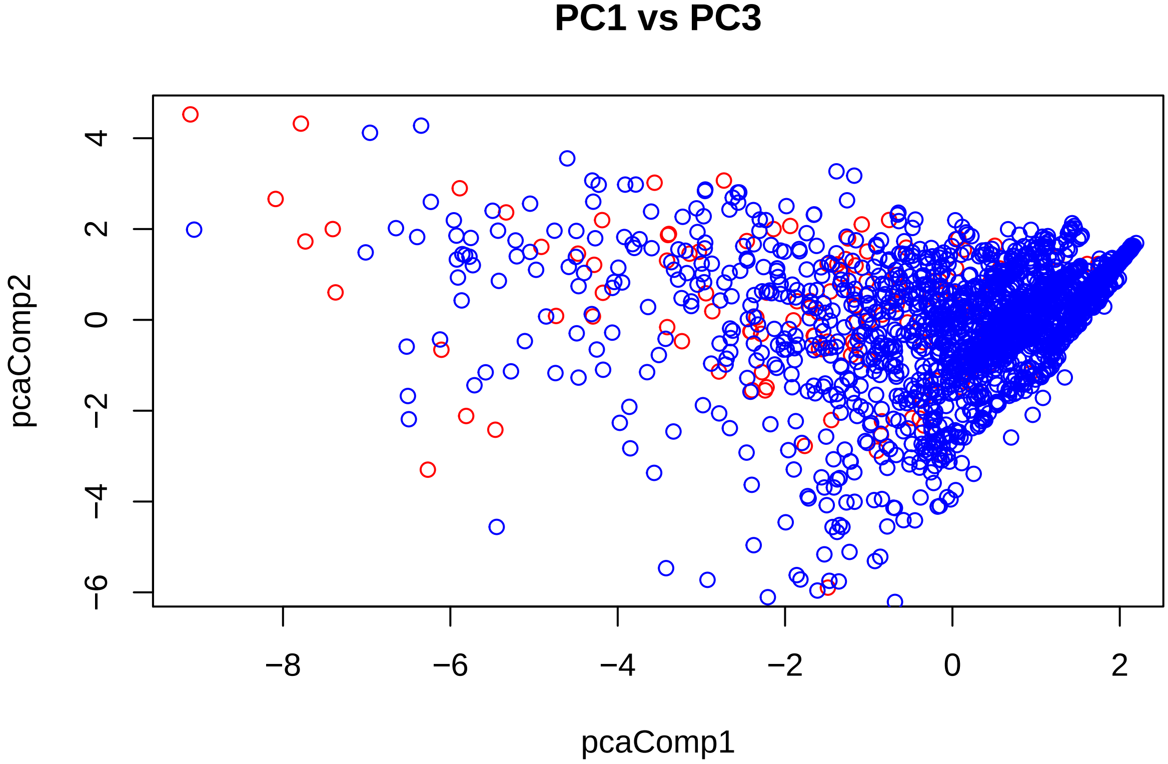
```
nbumps5        -1.604e+01  5.354e+02  -0.030 0.976095
energy          1.622e-06  4.033e-05   0.040 0.967929
maxenergy      -7.101e-06  3.969e-05  -0.179 0.858012
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(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

[1] 0.9277606


glm.pred    0    1
       0 1778  111
       1   29   20

[1] 0.1526718

[1] 0.9839513

[1] 0.9226006


glm.pred   0   1
       0 593  36
       1  14   3

[1] 0.07692308

[1] 0.9769357
```


ROC Curve
True Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
AUC: 0.756
1.0
0.5
0.0
False Positive Rate

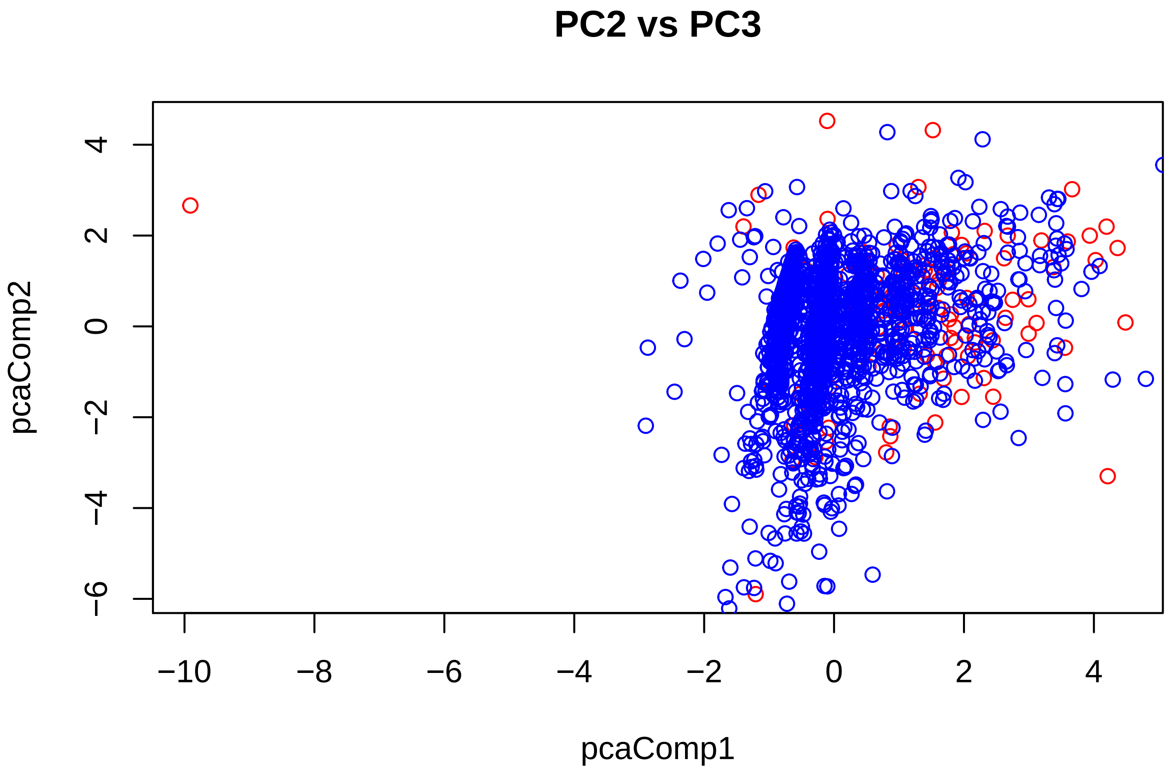

pc.comp
Variances
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Comp.1
Comp.3
Comp.5
Comp.7
Comp.9



PC1 vs PC2



PC1 vs PC3


PC2 vs PC3
pcaComp2
4
2
0
−2
−4
−6
pcaComp1
−10
−8
−6
−4
−2
0
2
4