Analysis_MovSpd_TempDisc

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November 3, 2016

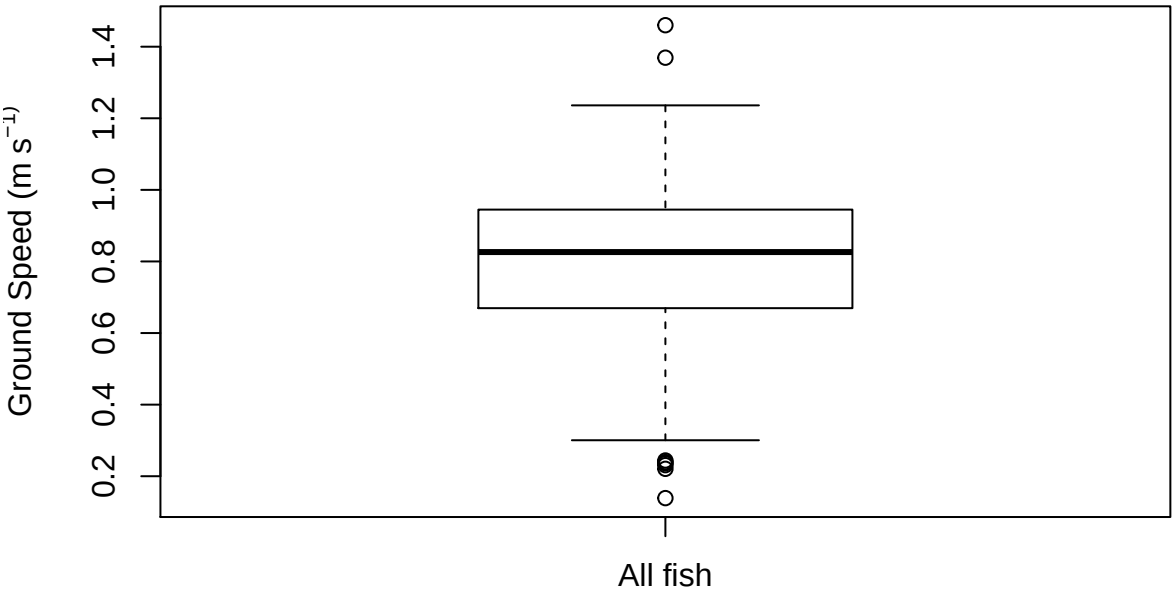
Movement Speed (mean spd per track)

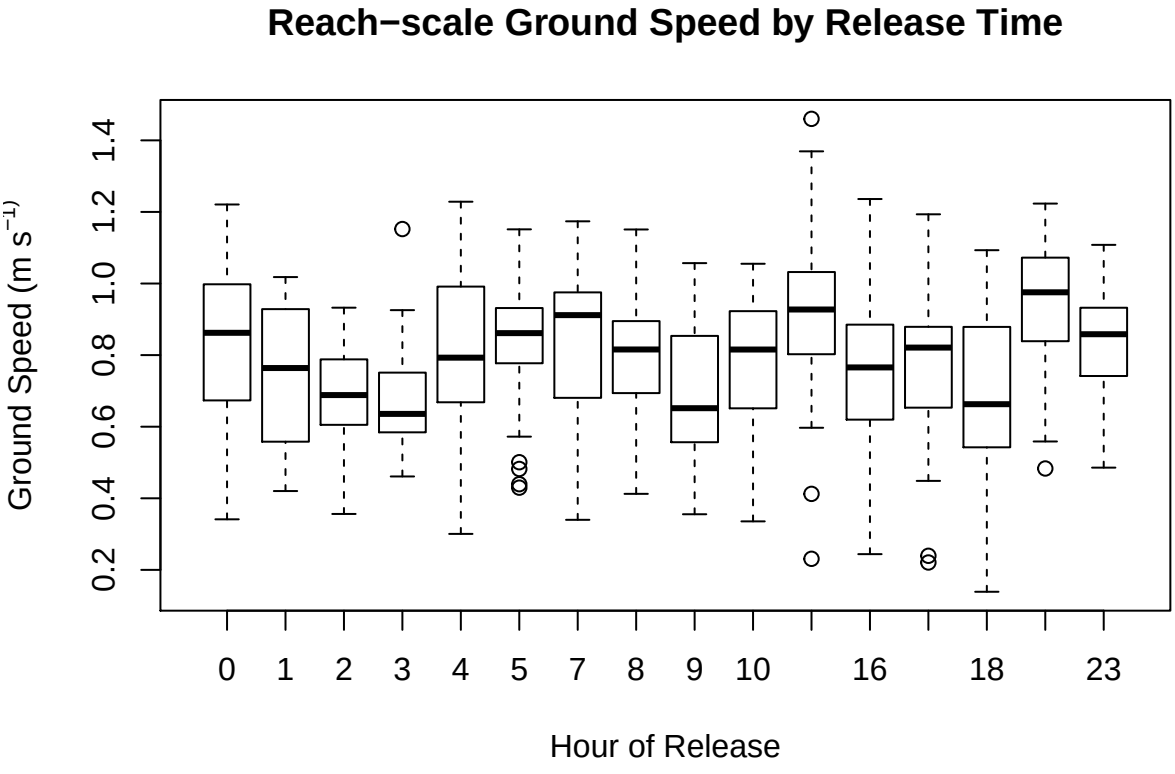
Using the dataset filtered and discretized by time, we'll calculate the mean movement speed per track
Visualize with a variety of plots

Calculate overall path speeds

Using path length and passage time

Plot all speeds





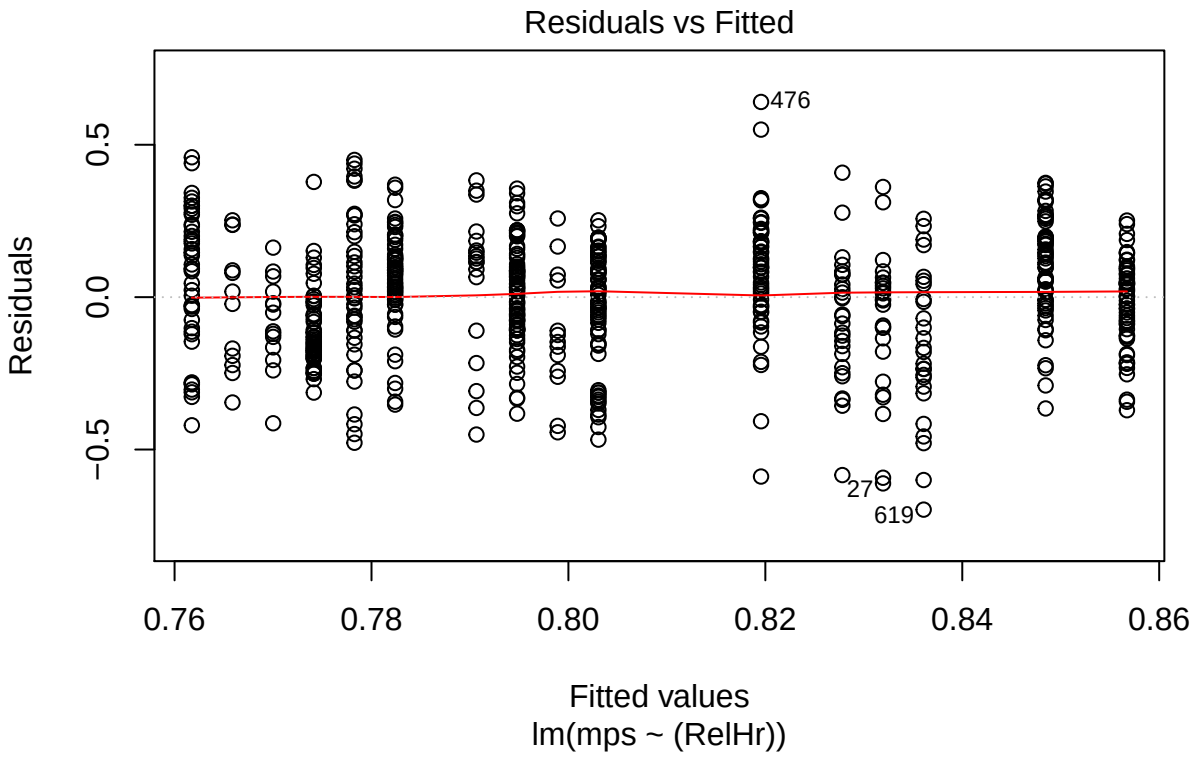
Statistical effect of release hour

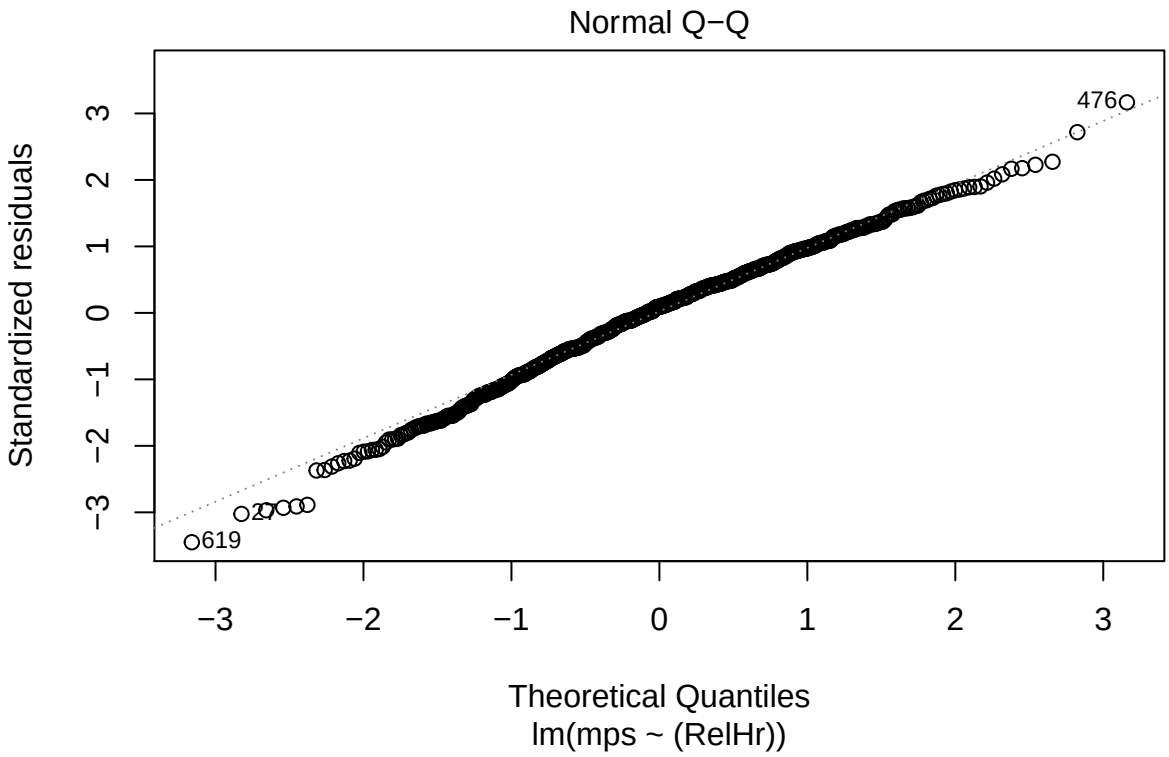
There is a significant effect of release hour, both then it is considered as a continuous variable and as a factor, but the models and the plots indicate that the effect is very small. We will include the release hour as a mixed effect in future models, but because there is such a huge spread in release hours we won't analyze these groups seperately.

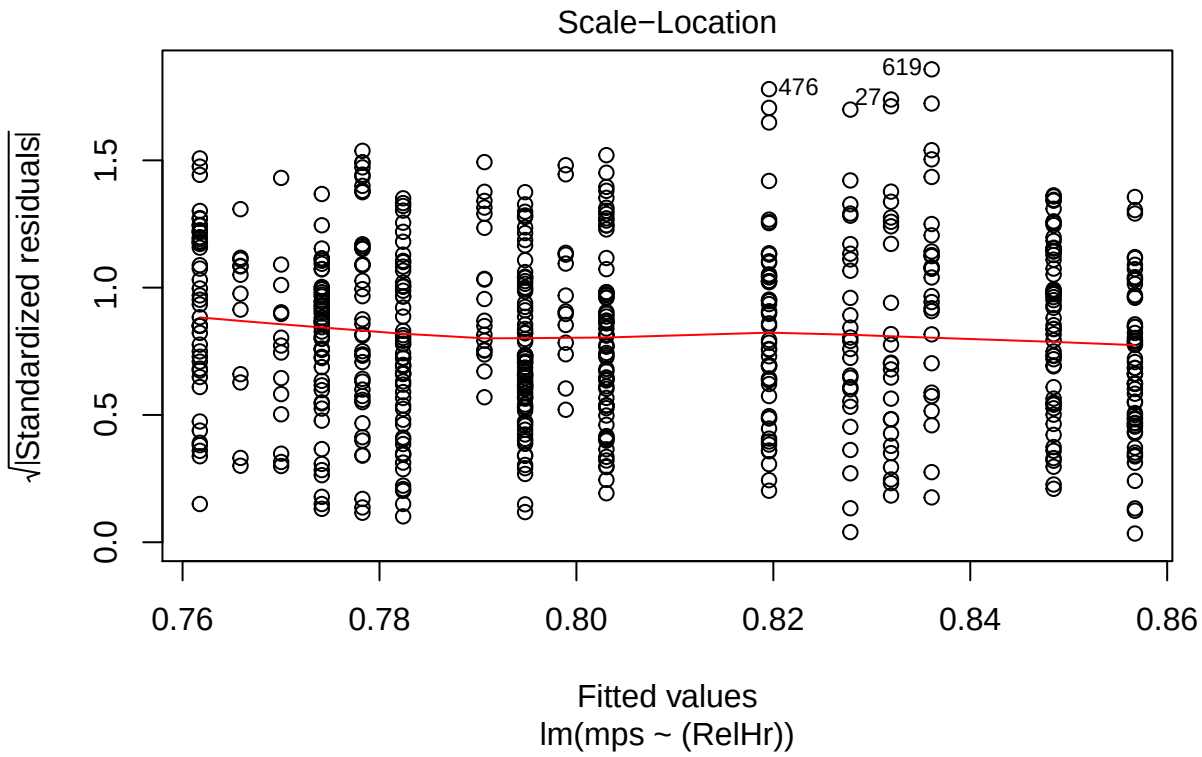
```
  mps.RelHr <- lm(mps ~ (RelHr), data=pathspd)
   summary(mps.RelHr)
```

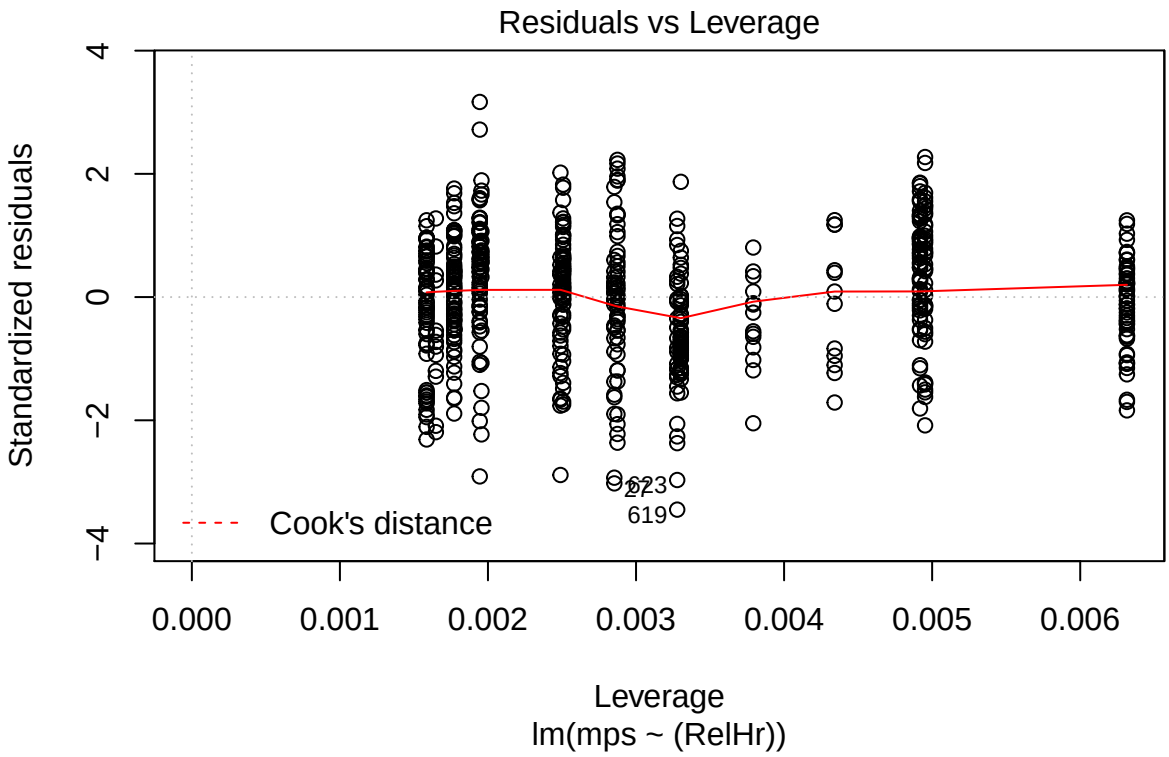
```
##
## Call:
## lm(formula = mps ~ (RelHr), data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.69721 -0.12522  0.01843  0.13486  0.64044
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.761754   0.014245  53.474  < 2e-16 ***
## RelHr       0.004129   0.001117   3.696 0.000238 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2024 on 632 degrees of freedom
## Multiple R-squared:  0.02116,    Adjusted R-squared:  0.01961
## F-statistic: 13.66 on 1 and 632 DF,  p-value: 0.0002378
```

```
   plot(mps.RelHr)  # meets assumptions beautifully! Both when RelHr is continuous (violates circ stats
```


Residuals vs Fitted
Residuals
0.5
0.0
−0.5
476
27
619
0.76
0.78
0.80
0.82
0.84
0.86
Fitted values
lm(mps ~ (RelHr))


Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(mps ~ (RelHr))
476
27
619
−3
−2
−1
0
1
2
3


Scale−Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
476
619
27
0.76
0.78
0.80
0.82
0.84
0.86
Fitted values
lm(mps ~ (RelHr))




```
  # post-hoc test designed for linear models with factor predictor: multcomp::glht() was recommended
    pathspd$RelHrfac = factor(pathspd$RelHr)
    testmod = lm(mps ~ 0+RelHrfac, data = pathspd)
     summary(testmod)
```

```
##
## Call:
## lm(formula = mps ~ 0 + RelHrfac, data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.68114 -0.10477  0.01449  0.12080  0.54796
##
## Coefficients:
##            Estimate Std. Error t value Pr(>|t|)
## RelHrfac0   0.82757    0.02873   28.81   <2e-16 ***
## RelHrfac1   0.74189    0.05501   13.49   <2e-16 ***
## RelHrfac2   0.68780    0.05093   13.51   <2e-16 ***
## RelHrfac3   0.67007    0.02668   25.11   <2e-16 ***
## RelHrfac4   0.80603    0.02940   27.41   <2e-16 ***
## RelHrfac5   0.84173    0.02546   33.05   <2e-16 ***
## RelHrfac7   0.84435    0.04492   18.80   <2e-16 ***
## RelHrfac8   0.80632    0.02215   36.40   <2e-16 ***
## RelHrfac9   0.67961    0.05285   12.86   <2e-16 ***
## RelHrfac10  0.76993    0.02346   32.82   <2e-16 ***
```

```
## RelHrfac14  0.91204    0.02569   35.49   <2e-16 ***
## RelHrfac16  0.75173    0.03667   20.50   <2e-16 ***
## RelHrfac17  0.75076    0.03811   19.70   <2e-16 ***
## RelHrfac18  0.67735    0.03737   18.12   <2e-16 ***
## RelHrfac21  0.95179    0.02569   37.04   <2e-16 ***
## RelHrfac23  0.83388    0.02546   32.75   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1906 on 618 degrees of freedom
## Multiple R-squared:  0.9487, Adjusted R-squared:  0.9474
## F-statistic: 714.4 on 16 and 618 DF,  p-value: < 2.2e-16
```

```
    posthoc.mod = glht(testmod, linfct = mcp(RelHrfac="Tukey"))
     summary(posthoc.mod)
```

```
## Warning in RET$pfunction("adjusted", ...): Completion with error > abseps

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##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
```
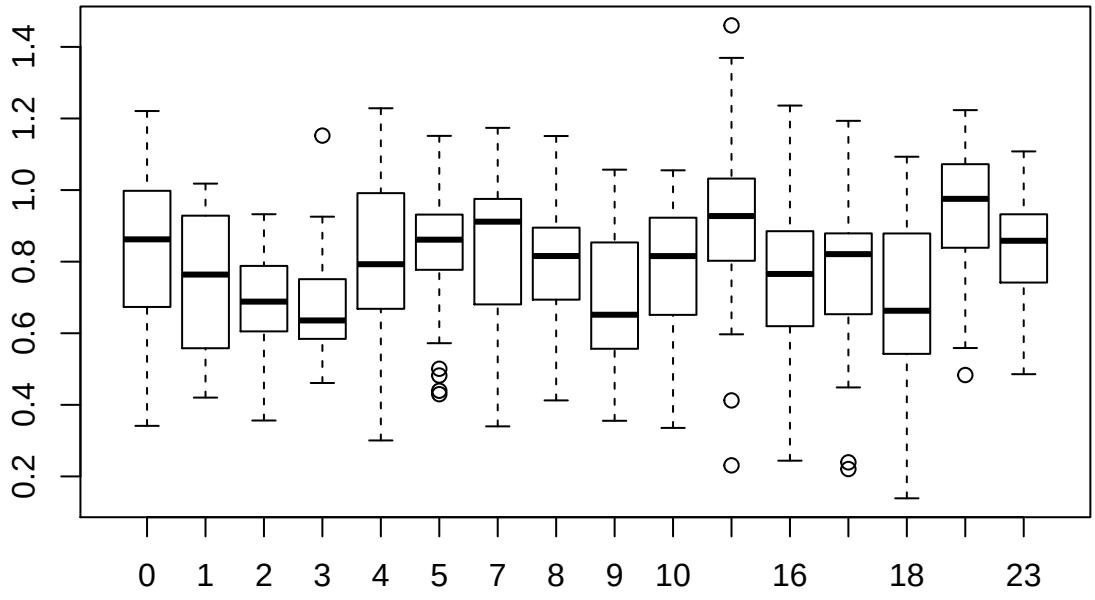

```
## Fit: lm(formula = mps ~ 0 + RelHrfac, data = pathspd)
##
## Linear Hypotheses:
##                Estimate Std. Error t value Pr(>|t|)
## 1 - 0 == 0   -0.0856821  0.0620590  -1.381   0.9909
## 2 - 0 == 0   -0.1397689  0.0584725  -2.390   0.5315
## 3 - 0 == 0   -0.1575022  0.0392083  -4.017    <0.01 **
## 4 - 0 == 0   -0.0215397  0.0411080  -0.524   1.0000
## 5 - 0 == 0    0.0141594  0.0383891   0.369   1.0000
## 7 - 0 == 0    0.0167766  0.0533164   0.315   1.0000
## 8 - 0 == 0   -0.0212540  0.0362766  -0.586   1.0000
## 9 - 0 == 0   -0.1479661  0.0601544  -2.460   0.4790
## 10 - 0 == 0  -0.0576403  0.0370874  -1.554   0.9719
## 14 - 0 == 0   0.0844662  0.0385423   2.192   0.6819
## 16 - 0 == 0  -0.0758417  0.0465853  -1.628   0.9579
## 17 - 0 == 0  -0.0768121  0.0477261  -1.609   0.9618
## 18 - 0 == 0  -0.1502210  0.0471372  -3.187   0.0967 .
## 21 - 0 == 0   0.1242144  0.0385423   3.223   0.0859 .
## 23 - 0 == 0   0.0063090  0.0383891   0.164   1.0000
## 2 - 1 == 0   -0.0540869  0.0749652  -0.721   1.0000
## 3 - 1 == 0   -0.0718201  0.0611396  -1.175   0.9984
## 4 - 1 == 0    0.0641424  0.0623749   1.028   0.9997
## 5 - 1 == 0    0.0998415  0.0606175   1.647   0.9536
## 7 - 1 == 0    0.1024587  0.0710169   1.443   0.9858
## 8 - 1 == 0    0.0644281  0.0593022   1.086   0.9993
## 9 - 1 == 0   -0.0622840  0.0762844  -0.816   1.0000
## 10 - 1 == 0   0.0280417  0.0598016   0.469   1.0000
## 14 - 1 == 0   0.1701482  0.0607146   2.802   0.2506
## 16 - 1 == 0   0.0098404  0.0661131   0.149   1.0000
## 17 - 1 == 0   0.0088700  0.0669219   0.133   1.0000
## 18 - 1 == 0  -0.0645389  0.0665032  -0.970   0.9998
## 21 - 1 == 0   0.2098965  0.0607146   3.457   0.0419 *
## 23 - 1 == 0   0.0919911  0.0606175   1.518   0.9773
## 3 - 2 == 0   -0.0177332  0.0574957  -0.308   1.0000
## 4 - 2 == 0    0.1182293  0.0588076   2.010   0.8026
## 5 - 2 == 0    0.1539284  0.0569402   2.703   0.3114
## 7 - 2 == 0    0.1565455  0.0679051   2.305   0.5972
## 8 - 2 == 0    0.1185149  0.0555379   2.134   0.7203
## 9 - 2 == 0   -0.0081972  0.0733963  -0.112   1.0000
## 10 - 2 == 0   0.0821286  0.0560708   1.465   0.9838
## 14 - 2 == 0   0.2242351  0.0570436   3.931    <0.01 **
## 16 - 2 == 0   0.0639273  0.0627587   1.019   0.9997
## 17 - 2 == 0   0.0629569  0.0636101   0.990   0.9998
## 18 - 2 == 0  -0.0104521  0.0631695  -0.165   1.0000
## 21 - 2 == 0   0.2639833  0.0570436   4.628    <0.01 ***
## 23 - 2 == 0   0.1460780  0.0569402   2.565   0.4019
## 4 - 3 == 0    0.1359625  0.0397063   3.424   0.0474 *
## 5 - 3 == 0    0.1716616  0.0368842   4.654    <0.01 ***
## 7 - 3 == 0    0.1742788  0.0522434   3.336   0.0614 .
## 8 - 3 == 0    0.1362482  0.0346802   3.929    <0.01 **
## 9 - 3 == 0    0.0095361  0.0592054   0.161   1.0000
## 10 - 3 == 0   0.0998618  0.0355274   2.811   0.2460
## 14 - 3 == 0   0.2419683  0.0370437   6.532    <0.01 ***
## 16 - 3 == 0   0.0816605  0.0453532   1.801   0.9061
```

```
## 17 - 3 == 0   0.0806901  0.0465243   1.734   0.9289
## 18 - 3 == 0   0.0072812  0.0459200   0.159   1.0000
## 21 - 3 == 0   0.2817166  0.0370437   7.605    <0.01 ***
## 23 - 3 == 0   0.1638112  0.0368842   4.441    <0.01 **
## 5 - 4 == 0    0.0356991  0.0388976   0.918   0.9999
## 7 - 4 == 0    0.0383162  0.0536837   0.714   1.0000
## 8 - 4 == 0    0.0002857  0.0368143   0.008   1.0000
## 9 - 4 == 0   -0.1264265  0.0604802  -2.090   0.7514
## 10 - 4 == 0  -0.0361007  0.0376135  -0.960   0.9999
## 14 - 4 == 0   0.1060058  0.0390488   2.715   0.3022
## 16 - 4 == 0  -0.0543020  0.0470052  -1.155   0.9987
## 17 - 4 == 0  -0.0552724  0.0481361  -1.148   0.9988
## 18 - 4 == 0  -0.1286813  0.0475523  -2.706   0.3074
## 21 - 4 == 0   0.1457541  0.0390488   3.733   0.0169 *
## 23 - 4 == 0   0.0278487  0.0388976   0.716   1.0000
## 7 - 5 == 0    0.0026172  0.0516314   0.051   1.0000
## 8 - 5 == 0   -0.0354134  0.0337512  -1.049   0.9996
## 9 - 5 == 0   -0.1621255  0.0586660  -2.764   0.2737
## 10 - 5 == 0  -0.0717998  0.0346212  -2.074   0.7621
## 14 - 5 == 0   0.0703067  0.0361755   1.943   0.8403
## 16 - 5 == 0  -0.0900011  0.0446469  -2.016   0.7991
## 17 - 5 == 0  -0.0909715  0.0458360  -1.985   0.8177
## 18 - 5 == 0  -0.1643804  0.0452225  -3.635   0.0230 *
## 21 - 5 == 0   0.1100550  0.0361755   3.042   0.1423
## 23 - 5 == 0  -0.0078504  0.0360121  -0.218   1.0000
## 8 - 7 == 0   -0.0380306  0.0500806  -0.759   1.0000
## 9 - 7 == 0   -0.1647427  0.0693587  -2.375   0.5403
## 10 - 7 == 0  -0.0744169  0.0506710  -1.469   0.9834
## 14 - 7 == 0   0.0676896  0.0517454   1.308   0.9948
## 16 - 7 == 0  -0.0926182  0.0579851  -1.597   0.9643
## 17 - 7 == 0  -0.0935886  0.0589055  -1.589   0.9663
## 18 - 7 == 0  -0.1669976  0.0584294  -2.858   0.2218
## 21 - 7 == 0   0.1074378  0.0517454   2.076   0.7601
## 23 - 7 == 0  -0.0104676  0.0516314  -0.203   1.0000
## 9 - 8 == 0   -0.1267121  0.0573060  -2.211   0.6687
## 10 - 8 == 0  -0.0363863  0.0322630  -1.128   0.9990
## 14 - 8 == 0   0.1057202  0.0339254   3.116   0.1158
## 16 - 8 == 0  -0.0545877  0.0428441  -1.274   0.9961
## 17 - 8 == 0  -0.0555581  0.0440818  -1.260   0.9965
## 18 - 8 == 0  -0.1289670  0.0434436  -2.969   0.1702
## 21 - 8 == 0   0.1454684  0.0339254   4.288    <0.01 **
## 23 - 8 == 0   0.0275630  0.0337512   0.817   1.0000
## 10 - 9 == 0   0.0903258  0.0578226   1.562   0.9707
## 14 - 9 == 0   0.2324323  0.0587664   3.955    <0.01 **
## 16 - 9 == 0   0.0721245  0.0643286   1.121   0.9991
## 17 - 9 == 0   0.0711540  0.0651595   1.092   0.9993
## 18 - 9 == 0  -0.0022549  0.0647294  -0.035   1.0000
## 21 - 9 == 0   0.2721805  0.0587664   4.632    <0.01 ***
## 23 - 9 == 0   0.1542751  0.0586660   2.630   0.3581
## 14 - 10 == 0  0.1421065  0.0347910   4.085    <0.01 **
## 16 - 10 == 0 -0.0182013  0.0435327  -0.418   1.0000
## 17 - 10 == 0 -0.0191717  0.0447514  -0.428   1.0000
## 18 - 10 == 0 -0.0925807  0.0441228  -2.098   0.7467
## 21 - 10 == 0  0.1818547  0.0347910   5.227    <0.01 ***
```

```
## 23 - 10 == 0  0.0639493  0.0346212   1.847   0.8869
## 16 - 14 == 0 -0.1603078  0.0447787  -3.580   0.0280 *
## 17 - 14 == 0 -0.1612782  0.0459644  -3.509   0.0362 *
## 18 - 14 == 0 -0.2346872  0.0453526  -5.175    <0.01 ***
## 21 - 14 == 0  0.0397482  0.0363380   1.094   0.9993
## 23 - 14 == 0 -0.0781572  0.0361755  -2.161   0.7035
## 17 - 16 == 0 -0.0009704  0.0528905  -0.018   1.0000
## 18 - 16 == 0 -0.0743794  0.0523597  -1.421   0.9879
## 21 - 16 == 0  0.2000561  0.0447787   4.468    <0.01 ***
## 23 - 16 == 0  0.0821507  0.0446469   1.840   0.8902
## 18 - 17 == 0 -0.0734089  0.0533773  -1.375   0.9912
## 21 - 17 == 0  0.2010265  0.0459644   4.374    <0.01 **
## 23 - 17 == 0  0.0831211  0.0458360   1.813   0.9014
## 21 - 18 == 0  0.2744354  0.0453526   6.051    <0.01 ***
## 23 - 18 == 0  0.1565300  0.0452225   3.461   0.0419 *
## 23 - 21 == 0 -0.1179054  0.0361755  -3.259   0.0793 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```r
boxplot(mps ~ RelHrfac, data = pathspd)
```



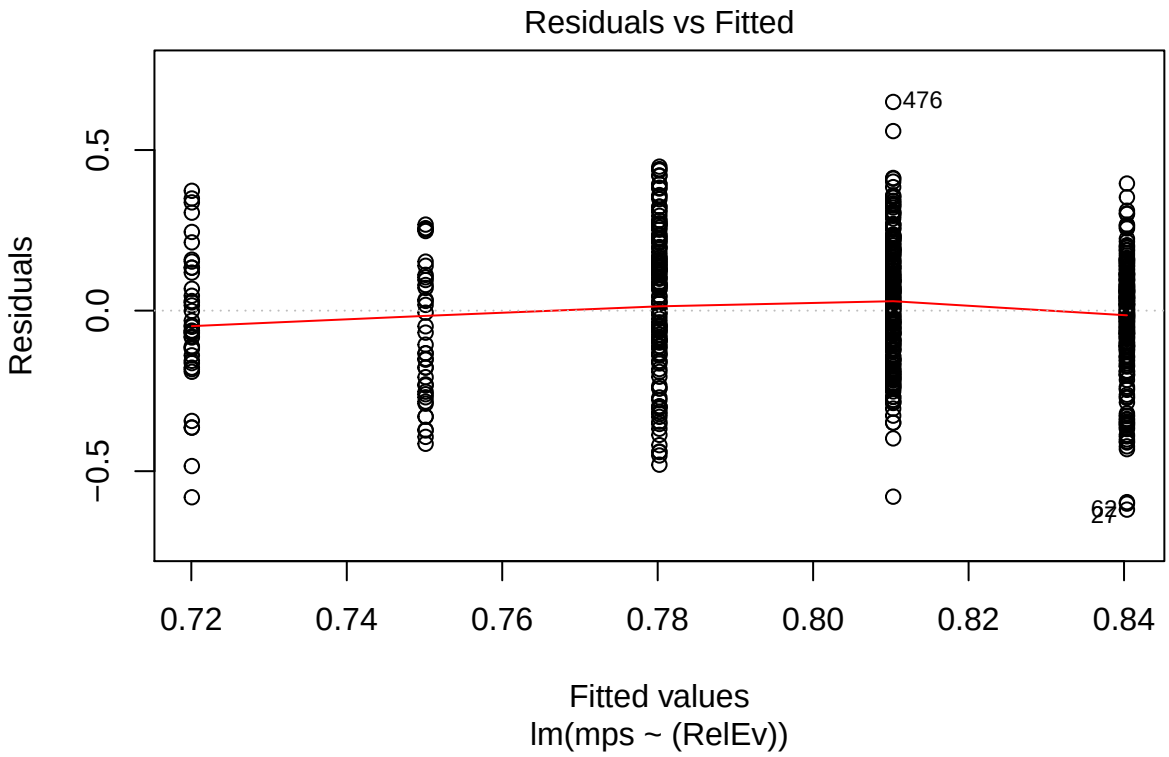
Statistical effect of release event

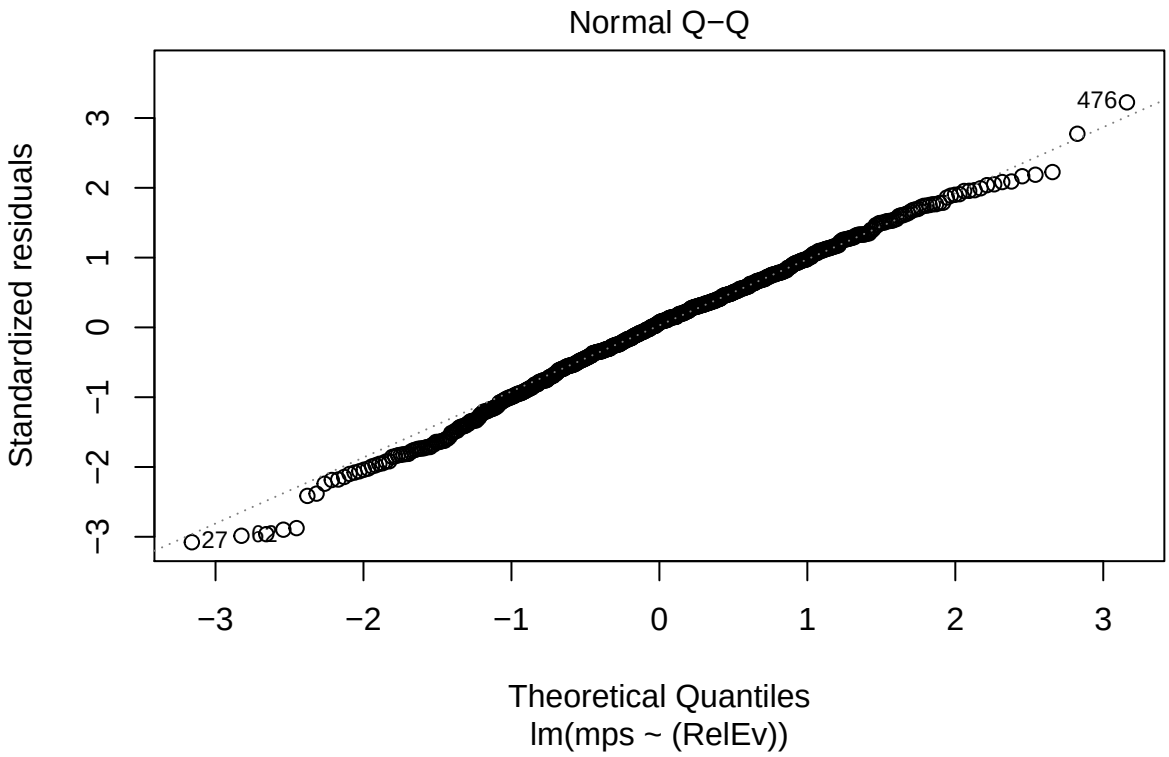
Release Events 1,2&3 are not significantly different from one another, nor are 4 and 5 significantly different from one another, but the two groups (1,2,3 vs 4,5) are different. This make sense, as 1,2 and 3 were released before over topping, and 4 and 5 were during the overtopping event.

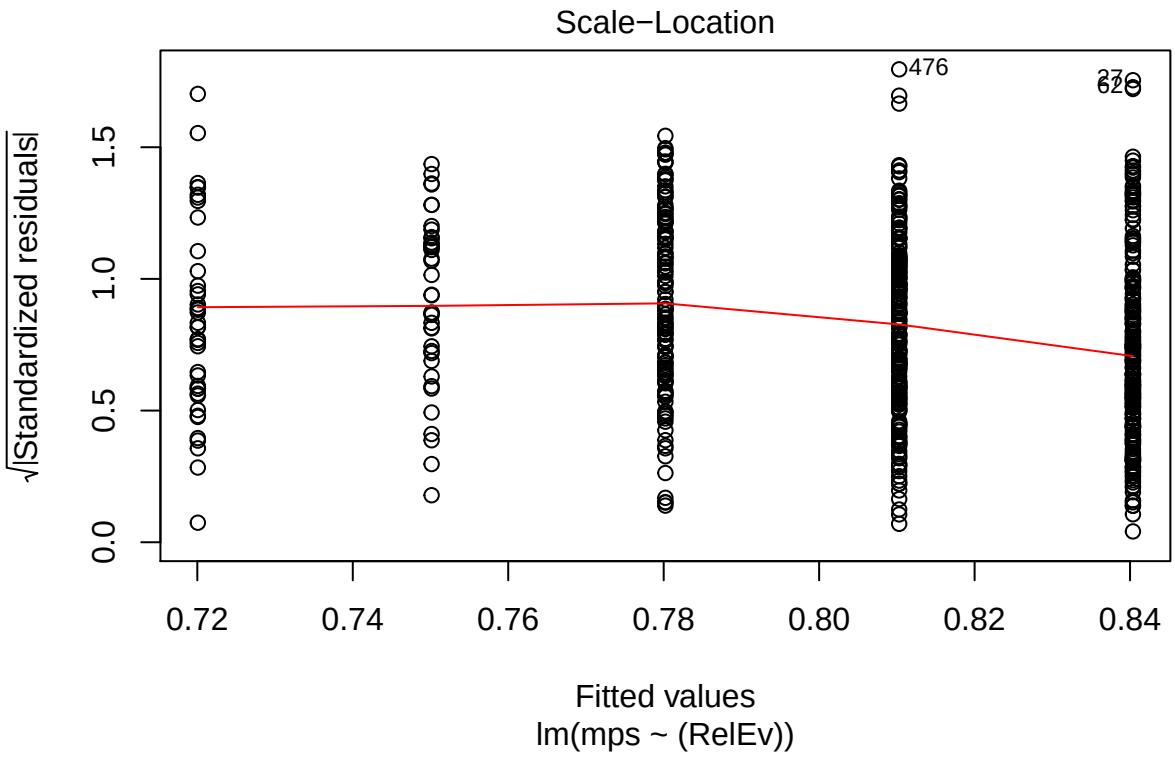
```
  mps.RelEv <- lm(mps ~ (RelEv), data=pathspd)
   summary(mps.RelEv)
```

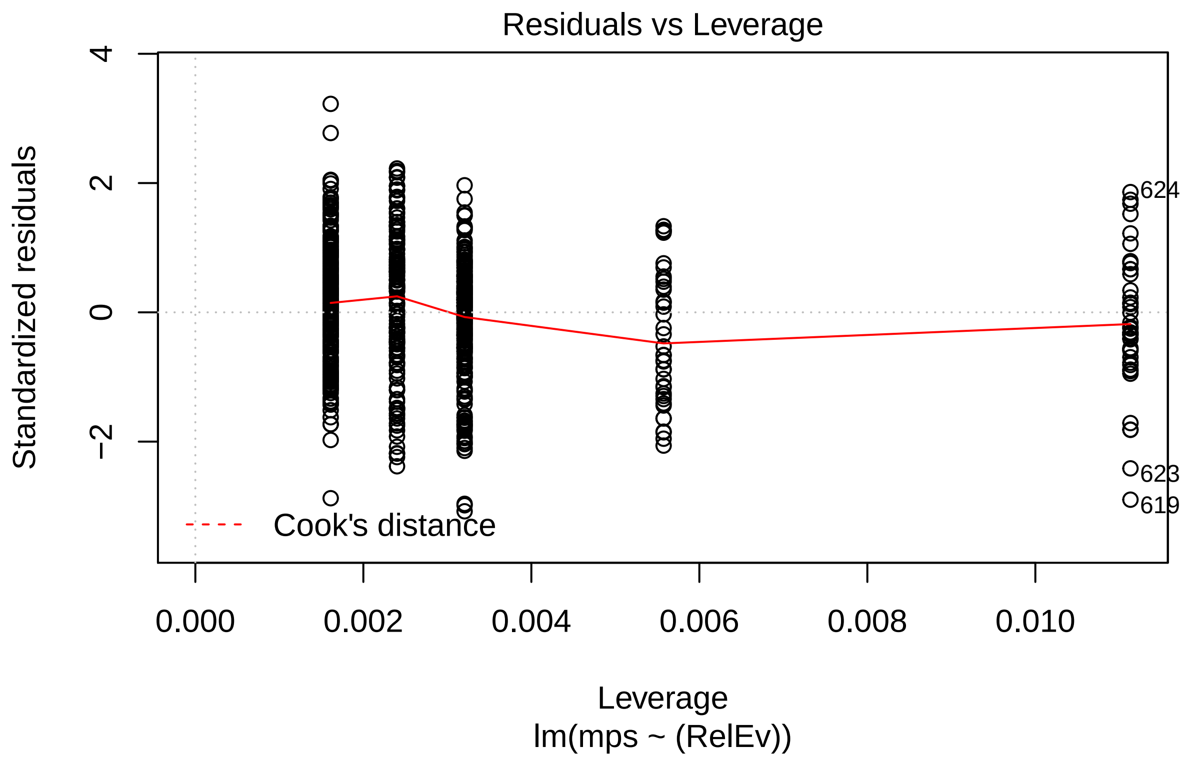
```
##
## Call:
## lm(formula = mps ~ (RelEv), data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.61969 -0.12258  0.01434  0.13441  0.64970
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.870451   0.017091   50.93  < 2e-16 ***
## RelEv       -0.030077   0.006962   -4.32 1.81e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2016 on 632 degrees of freedom
## Multiple R-squared:  0.02868,    Adjusted R-squared:  0.02715
## F-statistic: 18.66 on 1 and 632 DF,  p-value: 1.81e-05
```

```
   plot(mps.RelEv)  # meets assumptions beautifully! Both when RelEv is continuous (violates circ stats
```


Residuals vs Fitted
Residuals
0.5
0.0
−0.5
476
627
0.72
0.74
0.76
0.78
0.80
0.82
0.84
Fitted values
lm(mps ~ (RelEv))


Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(mps ~ (RelEv))
476
27
62
−3
−2
−1
0
1
2
3


Scale−Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
476
0.72
0.74
0.76
0.78
0.80
0.82
0.84
Fitted values
lm(mps ~ (RelEv))




```r
# as an anova test, with tukey posthoc test
  pathspd$RelEvfac = factor(pathspd$RelEv)
        bartlett.test(pathspd$RelEvfac~pathspd$RelEv)
```

```
## Warning in FUN(X[[i]], ...): Calling var(x) on a factor x is deprecated and will become an error.
##   Use something like 'all(duplicated(x)[-1L])' to test for a constant vector.

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```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  pathspd$RelEvfac by pathspd$RelEv
## Bartlett's K-squared = NaN, df = 4, p-value = NA
```

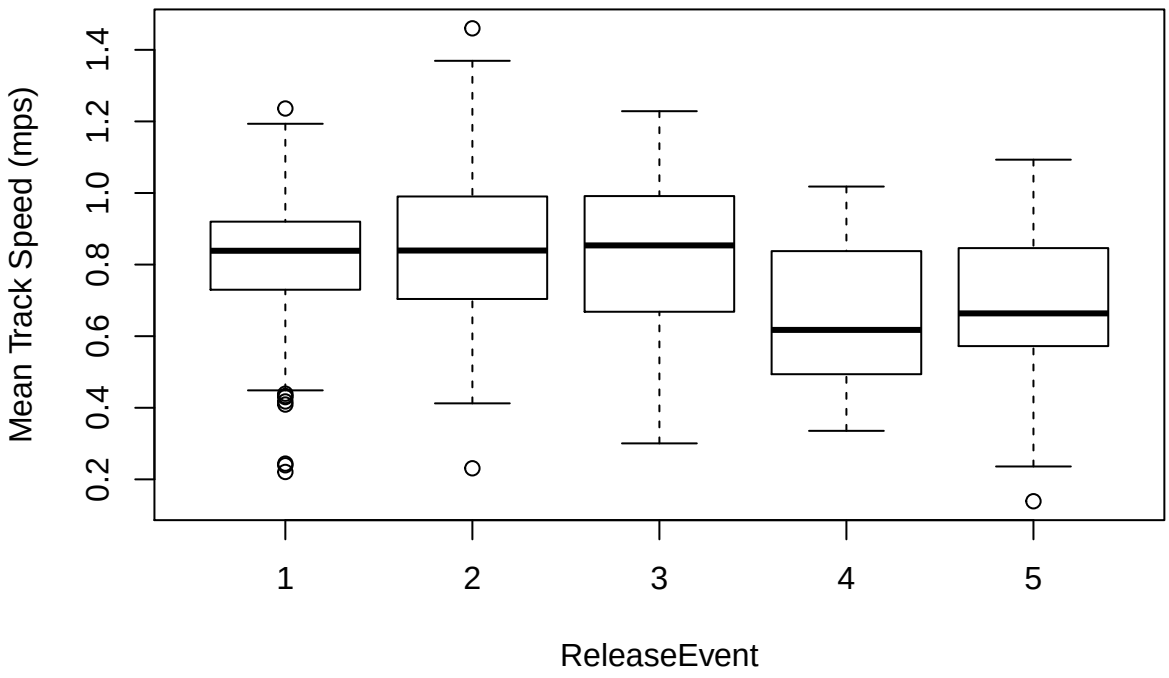
```
    testmod = aov(mps ~ 0+RelEvfac, data = pathspd)
     summary(testmod)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## RelEvfac     5  412.7   82.54    2090 <2e-16 ***
## Residuals 629   24.8    0.04
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
    TukeyHSD(testmod)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = mps ~ 0 + RelEvfac, data = pathspd)
##
## $RelEvfac
##              diff         lwr         upr     p adj
## 2-1  0.029552664 -0.02288752  0.08199285 0.5356545
## 3-1  0.003471058 -0.05763145  0.06457357 0.9998689
## 4-1 -0.145282993 -0.23987940 -0.05068659 0.0002926
## 5-1 -0.124946841 -0.21853628 -0.03135740 0.0026012
## 3-2 -0.026081606 -0.08728869  0.03512548 0.7709351
## 4-2 -0.174835657 -0.26949965 -0.08017167 0.0000057
## 5-2 -0.154499505 -0.24815725 -0.06084176 0.0000746
## 4-3 -0.148754050 -0.24847774 -0.04903036 0.0004851
## 5-3 -0.128417899 -0.22718691 -0.02964889 0.0036878
## 5-4  0.020336152 -0.10201695  0.14268925 0.9911770
```

```
    boxplot(mps ~ RelEvfac, data = pathspd, ylab="Mean Track Speed (mps)", xlab="ReleaseEvent")
```


Mean Track Speed (mps)
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1
2
3
4
5
ReleaseEvent