

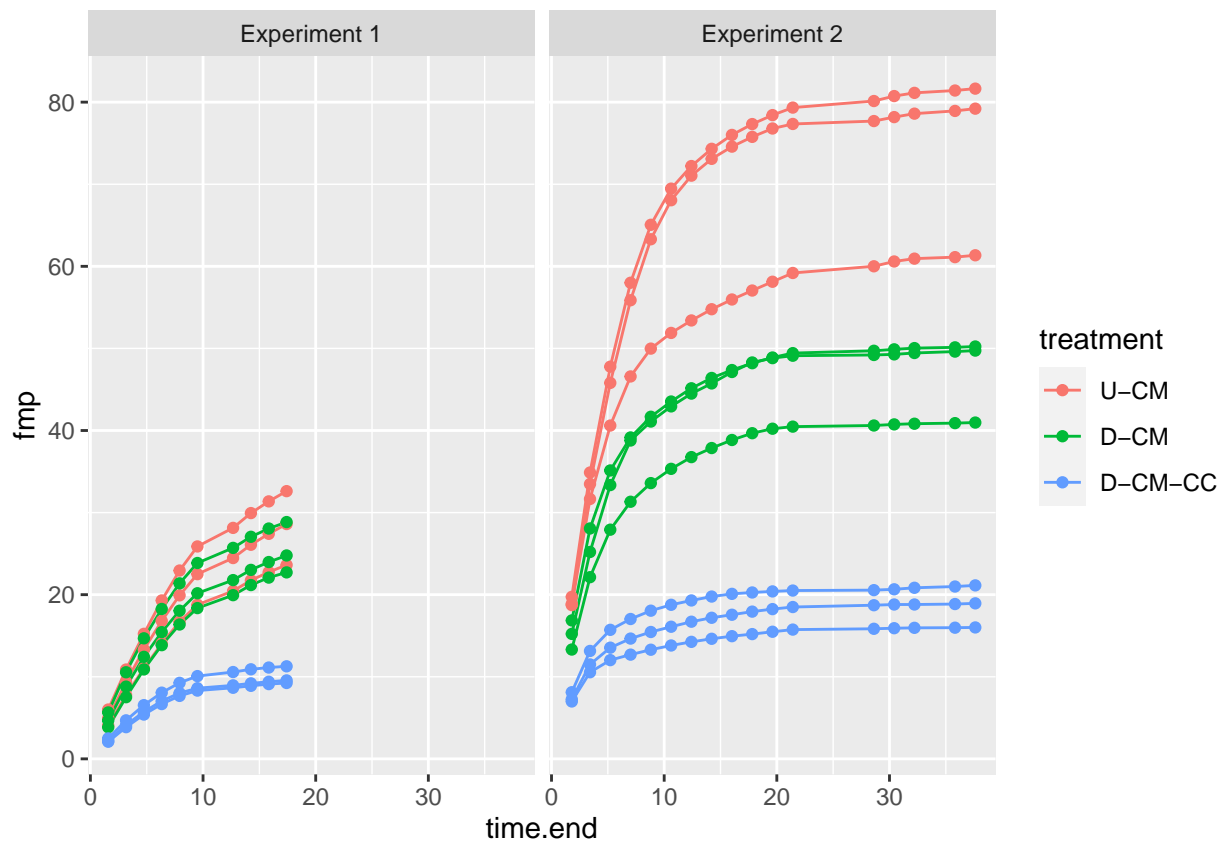
Data analysis for 4-methyl phenol from digestate experiments

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Plots

```
ggplot(dat, aes(time.end, fmp, colour = treatment, group = interaction(tunnel, treatment))) +  
  geom_line() +  
  geom_point() +  
  facet_wrap(~ experiment)
```



Stats

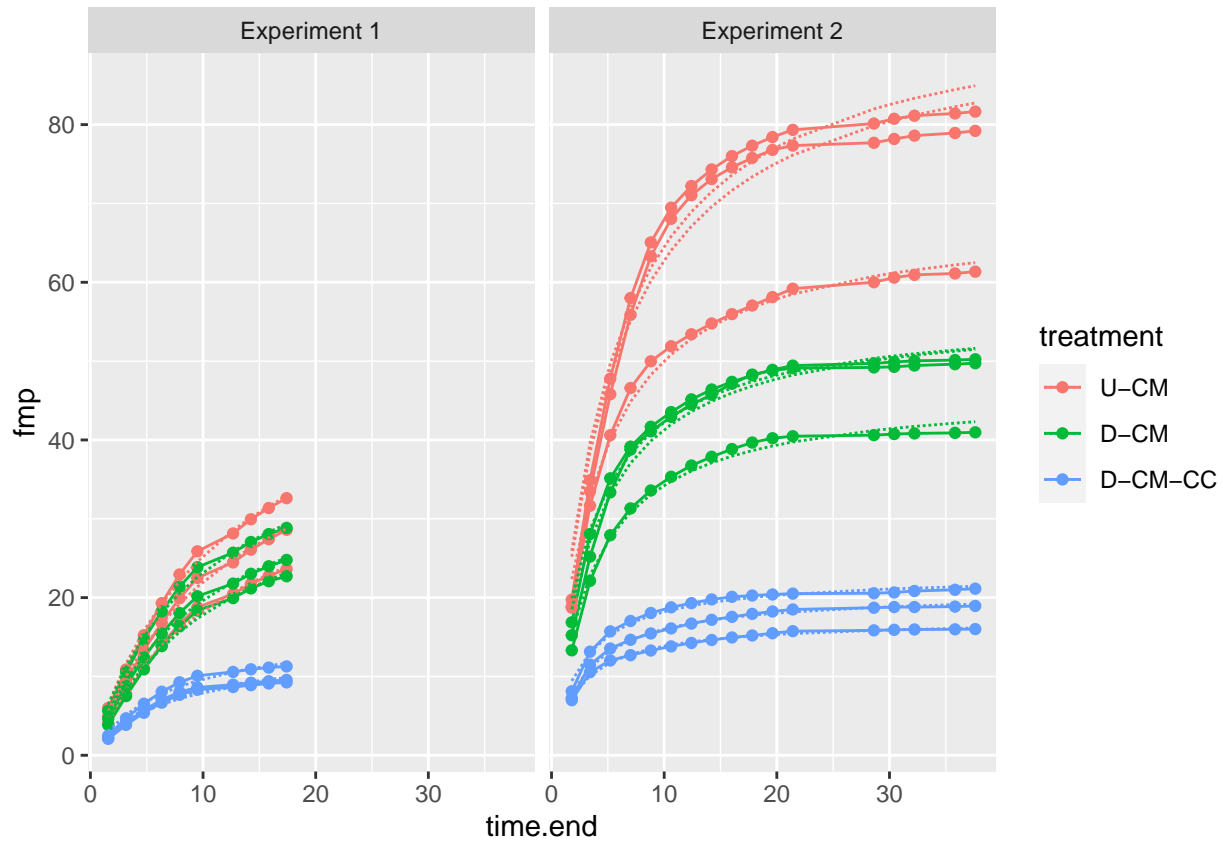
Set reference to untreated cattle manure.

Unit of analysis will be wind tunnel plot.

First fit model to each wind tunnel to get the ks.

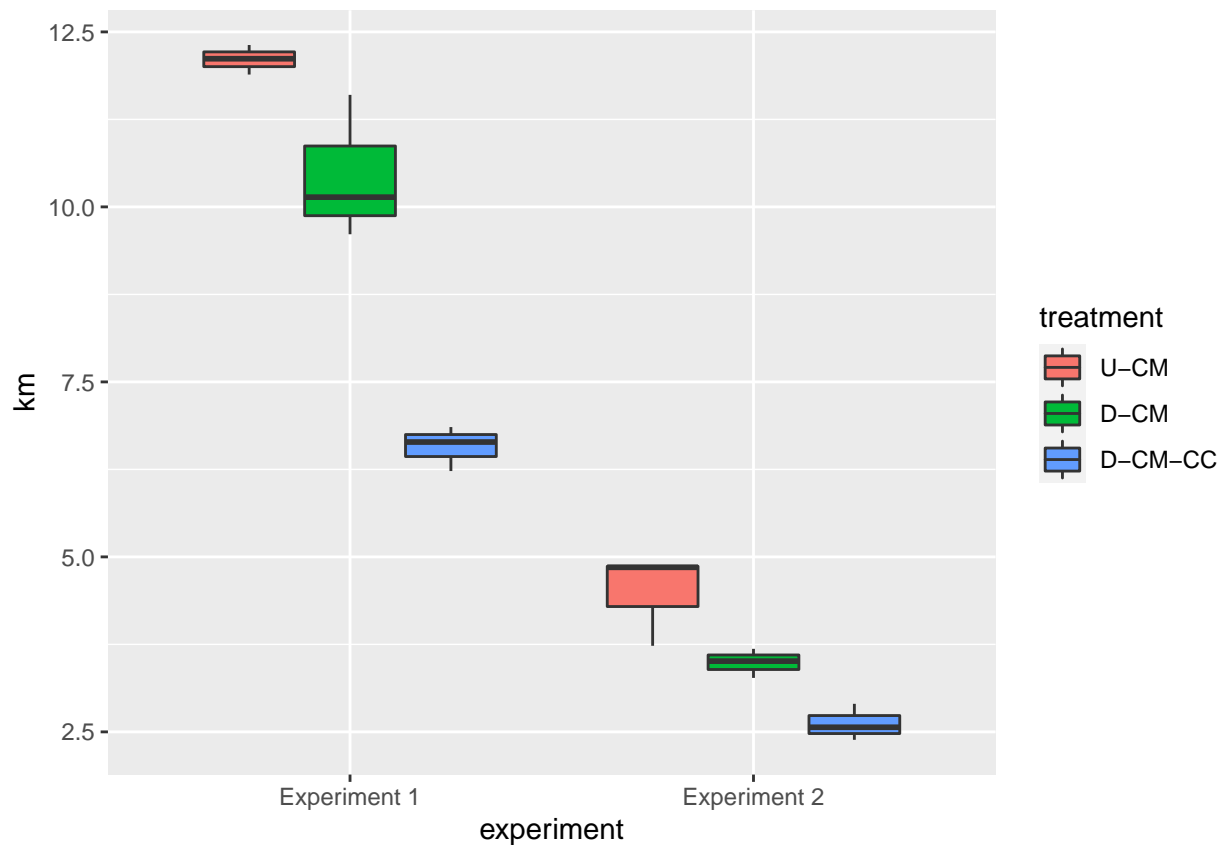
Look at fit.

```
ggplot(dat, aes(time.end, fmp, colour = treatment, group = interaction(tunnel, treatment))) +
  geom_line() +
  geom_point() +
  geom_line(aes(time.end, fmp.calc), lty = '11') +
  facet_wrap(~ experiment)
```



Take a look at km values.

```
ggplot(lmods, aes(experiment, km, fill = treatment)) +
  geom_boxplot()
```



Now analysis.

```
modk1 <- lm(km ~ treatment * experiment, data = lmods)
summary.aov(modk1)
```

```
##              Df Sum Sq Mean Sq F value    Pr(>F)
## treatment      2  42.19   21.10    72.25 2.03e-07 ***
## experiment      1 171.80  171.80   588.38 1.45e-11 ***
## treatment:experiment  2  11.44    5.72   19.59 0.000166 ***
## Residuals     12   3.50    0.29
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(modk1)
```

```
##
## Call:
## lm(formula = km ~ treatment * experiment, data = lmods)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.84027 -0.22806  0.01571  0.26198  1.15075
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    12.1068    0.3120   38.807 5.52e-14
## treatmentD-CM    -1.6571    0.4412   -3.756 0.00274
## treatmentD-CM-CC -5.5330    0.4412  -12.541 2.95e-08
```

```
## experimentExperiment 2          -7.6197      0.4412 -17.271 7.68e-10
## treatmentD-CM:experimentExperiment 2      0.6594      0.6239   1.057 0.31141
## treatmentD-CM-CC:experimentExperiment 2    3.6635      0.6239   5.872 7.58e-05
##
## (Intercept)                      ***
## treatmentD-CM                     **
## treatmentD-CM-CC                  ***
## experimentExperiment 2            ***
## treatmentD-CM:experimentExperiment 2
## treatmentD-CM-CC:experimentExperiment 2 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5404 on 12 degrees of freedom
## Multiple R-squared:  0.9847, Adjusted R-squared:  0.9783
## F-statistic: 154.4 on 5 and 12 DF,  p-value: 1.848e-10
```

Interactions complicated. Let's look by experiment. First experiment 1.

```
modexp1 <- aov(km ~ treatment, data = lmods, subset = experiment == 'Experiment 1')
summary(modexp1)
```

```
##              Df Sum Sq Mean Sq F value    Pr(>F)
## treatment      2  48.38   24.191    59.98 0.000108 ***
## Residuals      6   2.42    0.403
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
summary.lm(modexp1)
```

```
##
## Call:
## aov(formula = km ~ treatment, data = lmods, subset = experiment ==
##      "Experiment 1")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.84027 -0.31048  0.01001  0.20598  1.15075
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    12.1068     0.3667  33.019 5.13e-08 ***
## treatmentD-CM    -1.6571     0.5185  -3.196  0.0187 *
## treatmentD-CM-CC -5.5330     0.5185 -10.670 4.00e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6351 on 6 degrees of freedom
## Multiple R-squared:  0.9524, Adjusted R-squared:  0.9365
## F-statistic: 59.98 on 2 and 6 DF,  p-value: 0.0001081
coef(modexp1)
```

```
##      (Intercept)      treatmentD-CM treatmentD-CM-CC
##      12.106822         -1.657076         -5.532987
```

```
confint(modexp1)
```

```
##              2.5 %      97.5 %  
## (Intercept)    11.209638 13.0040052  
## treatmentD-CM  -2.925885 -0.3882665  
## treatmentD-CM-CC -6.801796 -4.2641780
```

```
model.tables(modexp1, type = 'means')
```

```
## Tables of means  
## Grand mean  
##  
## 9.710134  
##  
## treatment  
## treatment  
##      U-CM      D-CM D-CM-CC  
## 12.107 10.450 6.574
```

Use this model in paper. Both D-CM and CC-CM have lower k than reference in experiment 1.

Experiment 2 next.

```
modexp2 <- aov(km ~ treatment, data = lmods, subset = experiment == 'Experiment 2')  
summary(modexp2)
```

```
##              Df Sum Sq Mean Sq F value  Pr(>F)  
## treatment      2  5.250  2.6252   14.53 0.00501 **  
## Residuals      6  1.084  0.1806  
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary.lm(modexp2)
```

```
##  
## Call:  
## aov(formula = km ~ treatment, data = lmods, subset = experiment ==  
##      "Experiment 2")  
##  
## Residuals:  
##      Min       1Q   Median       3Q      Max   
## -0.7572 -0.2184  0.0214  0.2832  0.3935   
##  
## Coefficients:  
##              Estimate Std. Error t value Pr(>|t|)      
## (Intercept)     4.4871     0.2454  18.286 1.72e-06 ***  
## treatmentD-CM    -0.9977     0.3470  -2.875 0.02825 *    
## treatmentD-CM-CC -1.8695     0.3470  -5.387 0.00168 **   
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
##  
## Residual standard error: 0.425 on 6 degrees of freedom  
## Multiple R-squared:  0.8289, Adjusted R-squared:  0.7718   
## F-statistic: 14.53 on 2 and 6 DF,  p-value: 0.00501
```

```
coef(modexp2)
```

```
##      (Intercept)      treatmentD-CM treatmentD-CM-CC
```

```
##          4.4870881          -0.9976792          -1.8694707
```

```
confint(modexp2)
```

```
##          2.5 %      97.5 %
## (Intercept)    3.886645  5.0875311
## treatmentD-CM  -1.846834 -0.1485246
## treatmentD-CM-CC -2.718625 -1.0203161
```

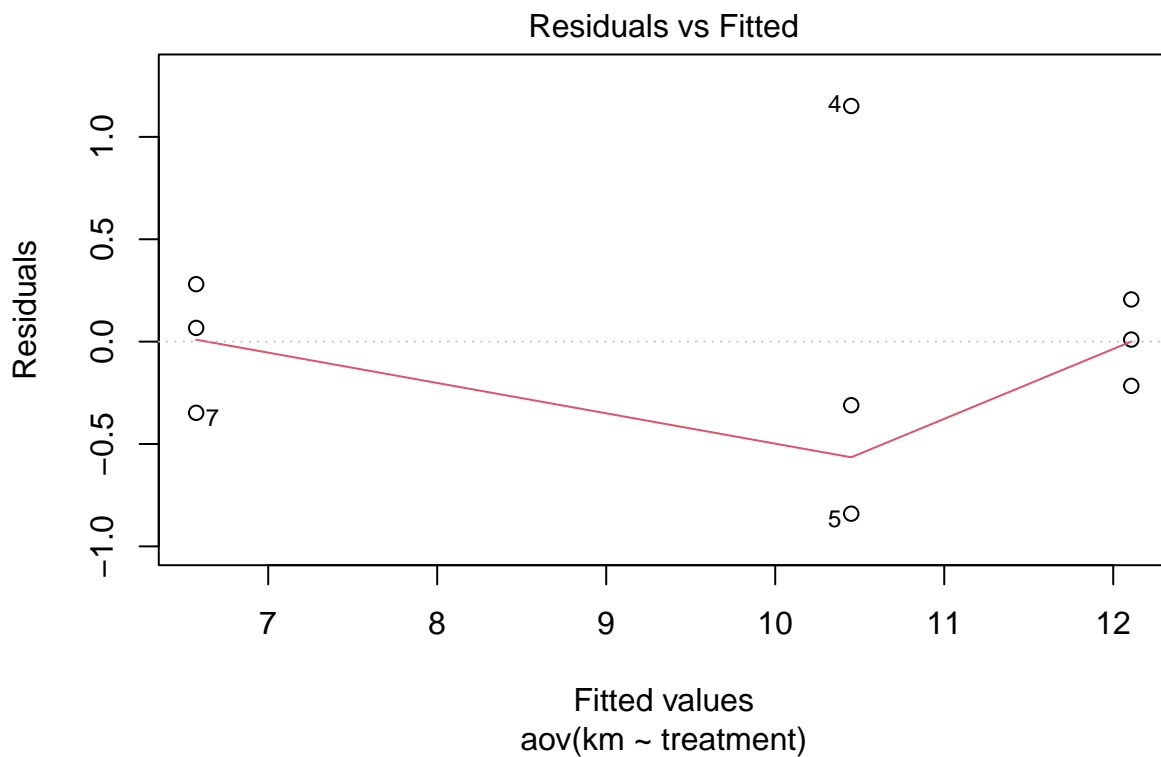
```
model.tables(modexp2, type = 'means')
```

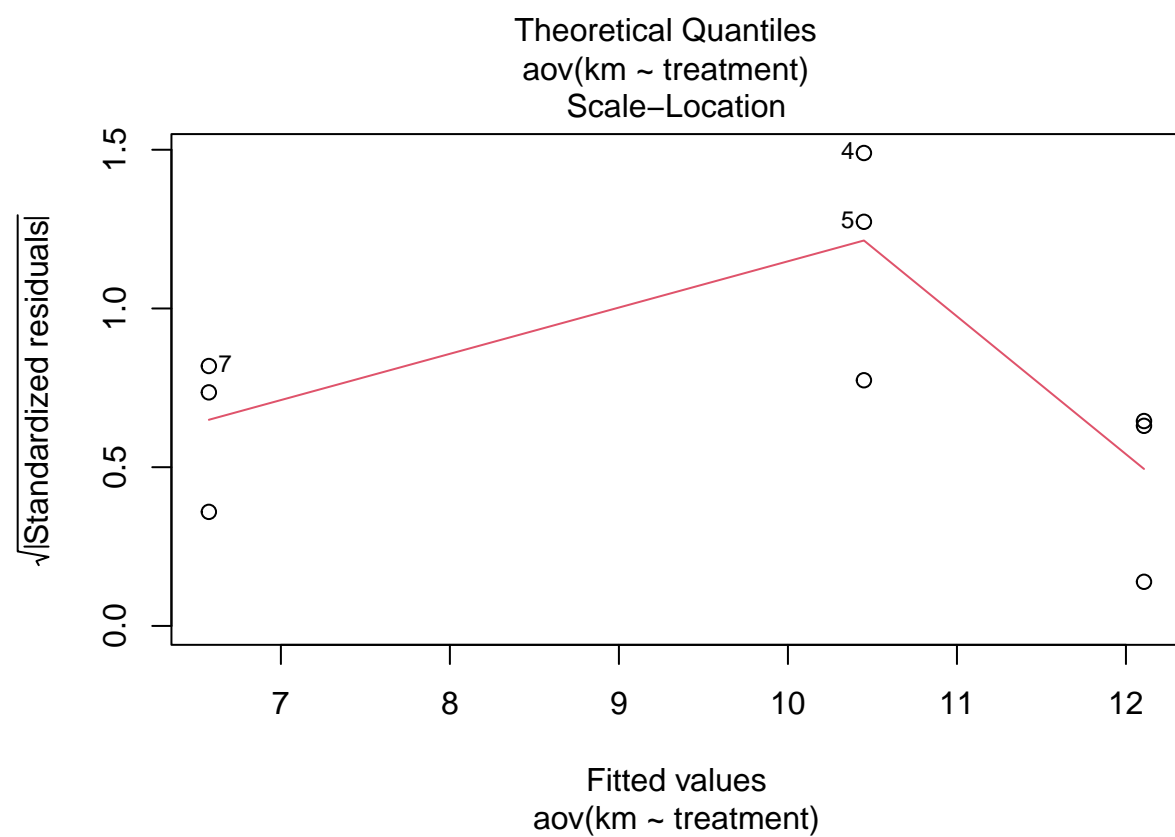
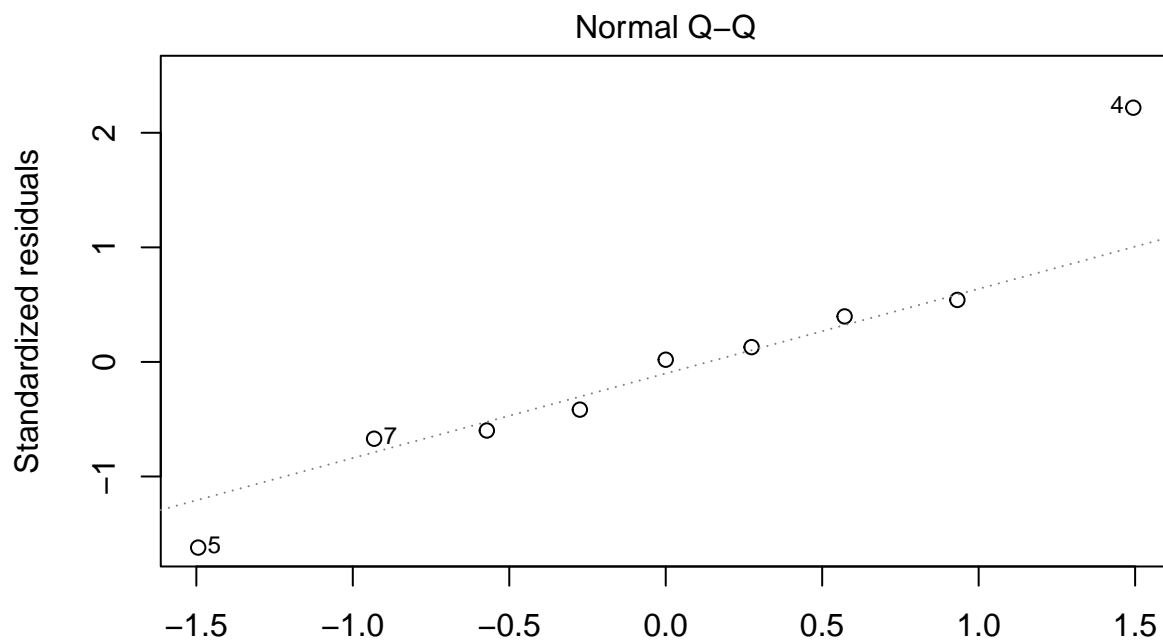
```
## Tables of means
## Grand mean
##
## 3.531371
##
## treatment
## treatment
##      U-CM      D-CM D-CM-CC
##    4.487    3.489    2.618
```

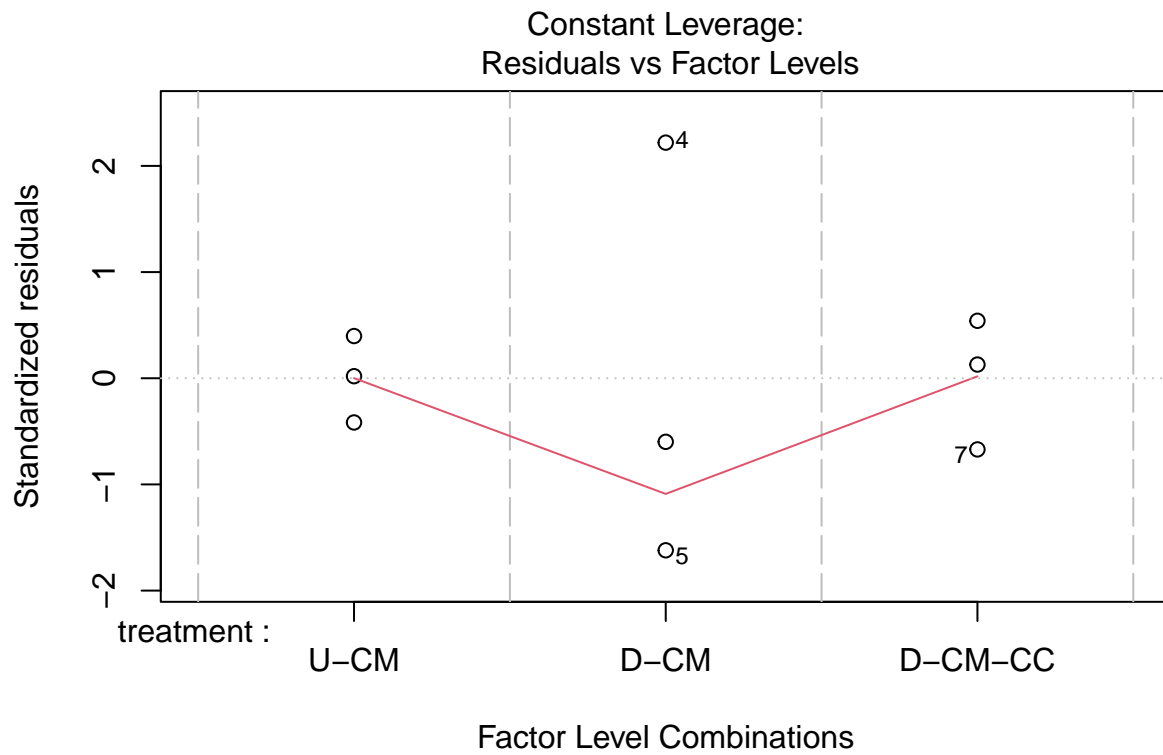
Both D-CM and CC-CM have lower k than reference in experiment 2. **Use this model in paper for experiment 2.**

Diagnostic plots.

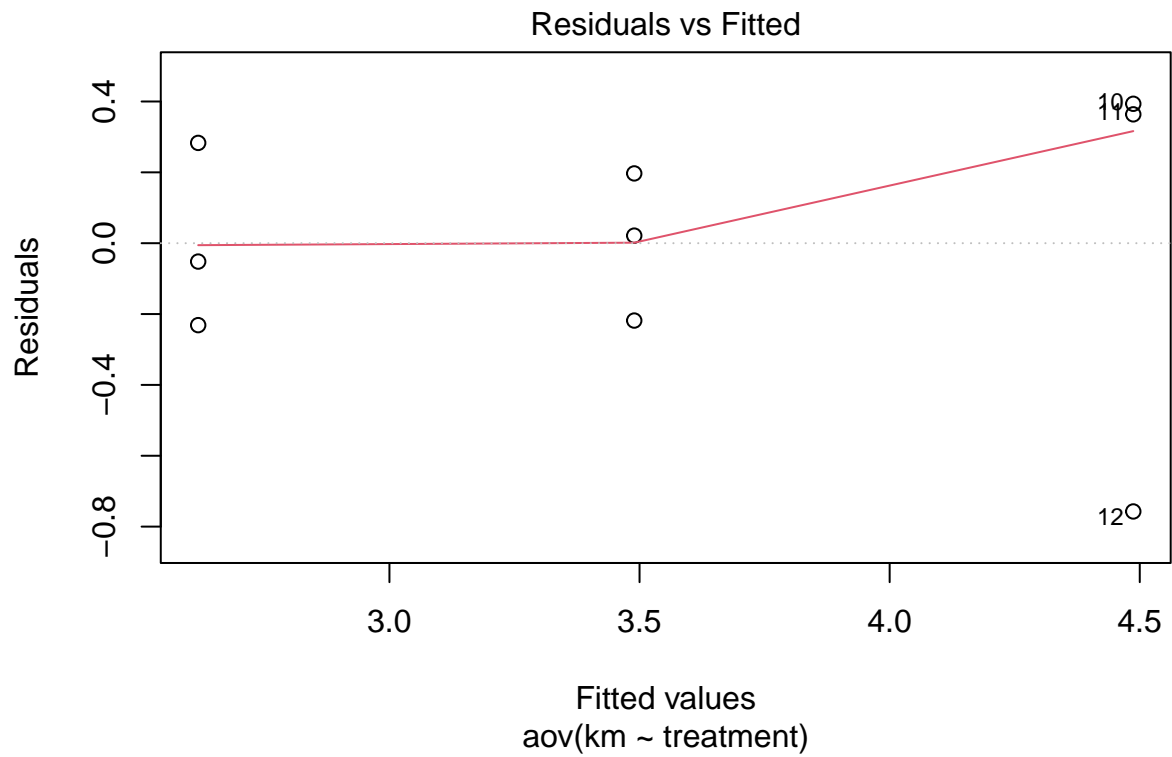
```
plot(modexp1, ask = FALSE)
```

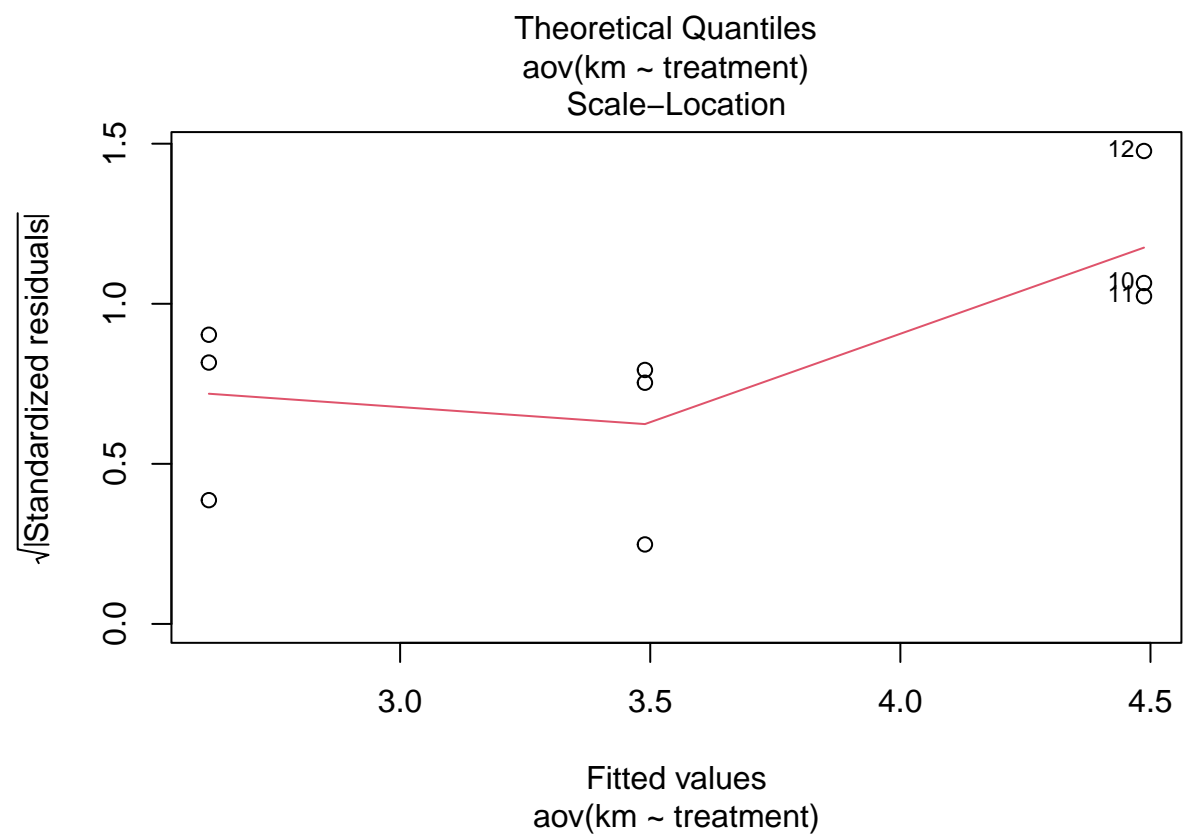
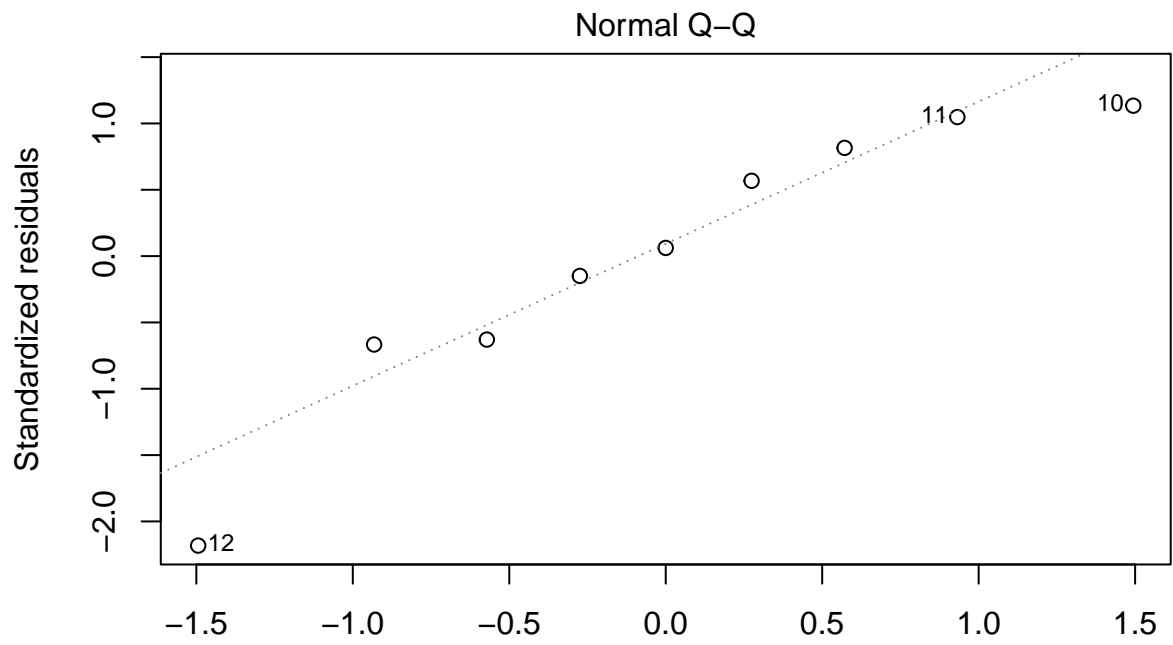


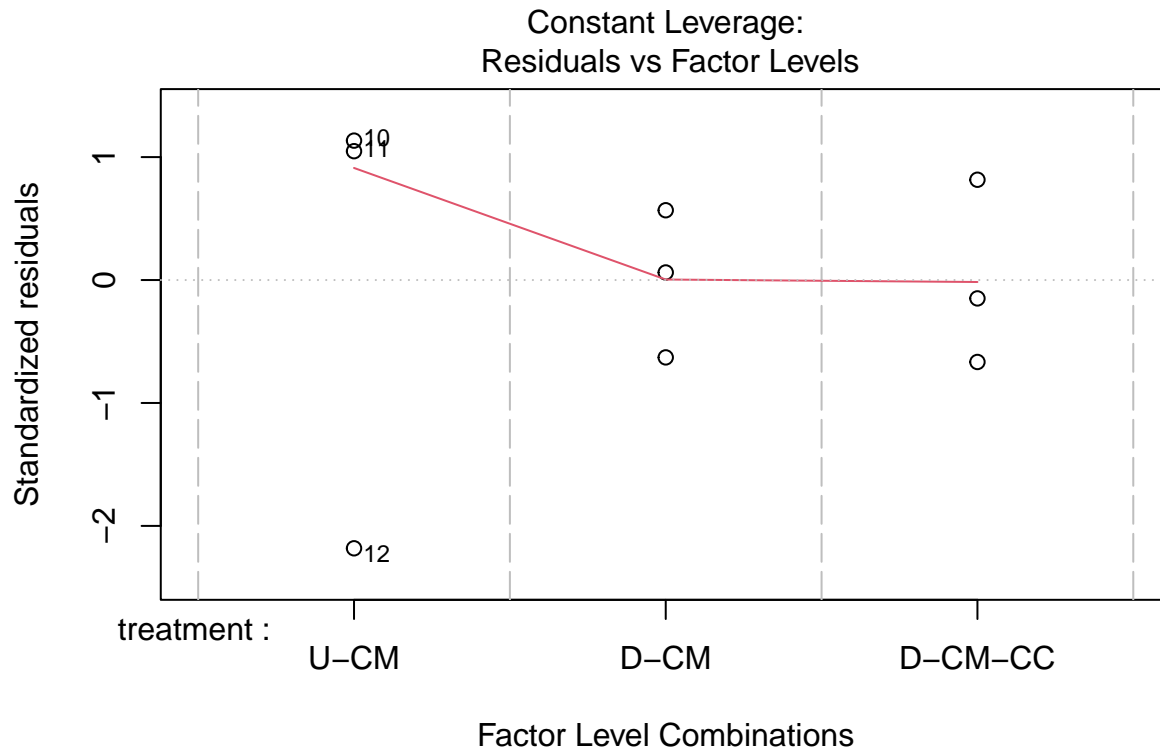




```
plot(modexp2, ask = FALSE)
```







Not terrible.

Now initial flux.

```
modf1 <- aov(log10(fmp) ~ experiment * treatment, data = d1)
summary(modf1)
```

```
##               Df Sum Sq Mean Sq F value    Pr(>F)
## experiment      1  1.3079   1.3079 395.964 1.48e-10 ***
## treatment       2   0.4860   0.2430  73.573 1.84e-07 ***
## experiment:treatment  2  0.0055   0.0027   0.826   0.461
## Residuals      12  0.0396   0.0033
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary.lm(modf1)
```

```
##
## Call:
## aov(formula = log10(fmp) ~ experiment * treatment, data = d1)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.085332 -0.023807 -0.002667  0.031886  0.085321
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.69339    0.03318  20.897 8.35e-11
## experimentExperiment 2      0.58785    0.04693  12.527 2.99e-08
## treatmentD-CM      -0.02403    0.04693  -0.512   0.618
## treatmentD-CM-CC     -0.34251    0.04693  -7.299 9.49e-06
## experimentExperiment 2:treatmentD-CM    -0.07923    0.06636  -1.194   0.256
```

```
## experimentExperiment 2:treatmentD-CM-CC -0.06699    0.06636  -1.010    0.333
##
## (Intercept) ***
## experimentExperiment 2 ***
## treatmentD-CM
## treatmentD-CM-CC ***
## experimentExperiment 2:treatmentD-CM
## experimentExperiment 2:treatmentD-CM-CC
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.05747 on 12 degrees of freedom
## Multiple R-squared:  0.9784, Adjusted R-squared:  0.9695
## F-statistic: 109 on 5 and 12 DF, p-value: 1.429e-09
```

```
100 * (1 - 10^coef(modf1))
```

```
##              (Intercept)              experimentExperiment 2
##              -393.613664              -287.122291
##              treatmentD-CM              treatmentD-CM-CC
##              5.382188              54.554974
## experimentExperiment 2:treatmentD-CM experimentExperiment 2:treatmentD-CM-CC
##              16.675567              14.295225
```

```
100 * (1 - 10^confint(modf1))
```

```
##              2.5 %      97.5 %
## (Intercept)      -317.91834 -483.01929
## experimentExperiment 2      -205.91907 -389.88011
## treatmentD-CM          25.22933  -19.73318
## treatmentD-CM-CC        64.08758   42.49204
## experimentExperiment 2:treatmentD-CM      40.27160  -16.24221
## experimentExperiment 2:treatmentD-CM-CC    38.56533  -19.56292
```