Mixed-effects models

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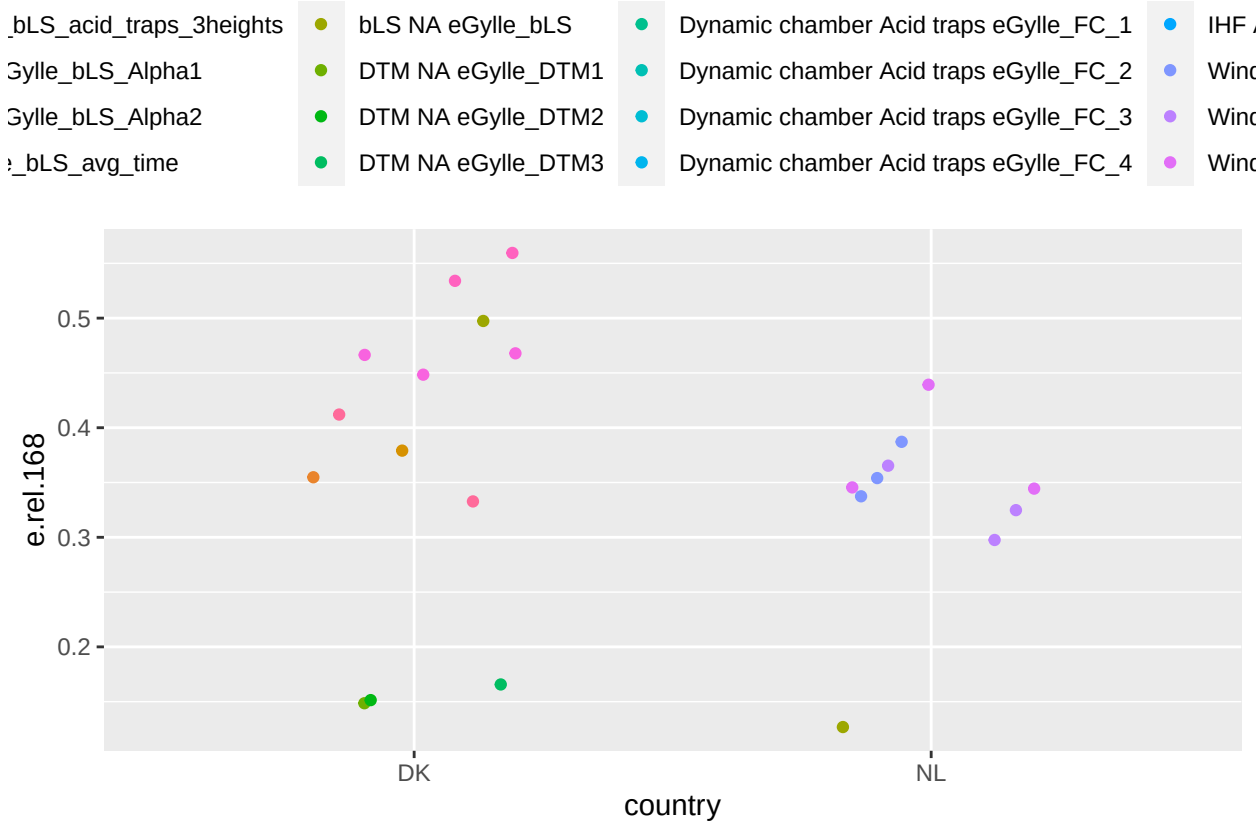
1. Take a look

```
pdat[, meas.tech.3 := paste(meas.tech, meas.tech.det, treat)]
ggplot(pdat, aes(country, e.rel.168, colour = meas.tech.3)) +
  geom_jitter(height = 0, width = 0.2) +
  theme(legend.position = 'top')
```

```
## Warning: Removed 7 rows containing missing values (`geom_point()`).
```



2. Mixed-effects models

```
pdat[, meas.level := paste(meas.tech, meas.tech.det, treat)]
pdat[, meas.level := gsub('bLS Alpha samplers.+$', 'bLS-alpha', meas.level)]
pdat[, meas.level := gsub('DTM.+$', 'DTM', meas.level)]
```

```
pdat[, meas.level := gsub('Wind tunnel NA', 'WT', meas.level)]
pdat[, meas.level := gsub('bLS NA eGylle_bLS', 'bLS-CRDS', meas.level)]
pdat[, meas.level := gsub('.+_FC_.+$', 'FC', meas.level)]
pdat[, meas.level := gsub('diluted$', '', meas.level)]
d1 <- pdat[country == 'DK', ]
d2 <- pdat[country == 'NL', ]
```

I-AU micromet

```
d1mm <- d1[meas.tech2 == 'micro met', ]
```

```
m1 <- lmer(e.rel.168 ~ 1|meas.level, data = d1mm)
summary(m1)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: e.rel.168 ~ 1 | meas.level
##    Data: d1mm
##
## REML criterion at convergence: -5.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -0.7730 -0.3206  0.1318  0.3865  0.6412
##
## Random effects:
##  Groups     Name        Variance  Std.Dev.
##  meas.level (Intercept) 0.0082889 0.09104
##  Residual               0.0002955 0.01719
## Number of obs: 3, groups:  meas.level, 2
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  0.43161    0.06523   6.617
```

```
VarCorr(m1)
```

```
##  Groups     Name        Std.Dev.
##  meas.level (Intercept) 0.091044
##  Residual               0.017190
```

```
m2 <- lmer(log10(e.rel.168) ~ 1|meas.level, data = d1mm)
summary(m2)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: log10(e.rel.168) ~ 1 | meas.level
##    Data: d1mm
##
## REML criterion at convergence: -5.5
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -0.7840 -0.3151  0.1538  0.3920  0.6302
##
## Random effects:
```

```
##  Groups     Name        Variance  Std.Dev.
##  meas.level (Intercept) 0.0084479 0.09191
##  Residual               0.0004142 0.02035
## Number of obs: 3, groups:  meas.level, 2
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept) -0.37024    0.06617  -5.595
```

```
VarCorr(m2)
```

```
##  Groups     Name        Std.Dev.
##  meas.level (Intercept) 0.091912
##  Residual               0.020352
```

```
100 * (10^(as.data.frame(VarCorr(m2))[, 5]) - 1)
```

```
## [1] 23.569771  4.797817
```

Total.

```
sqrt(sum(as.data.frame(VarCorr(m2))[, 5]^2))
```

```
## [1] 0.09413859
```

I-AU enclosure

```
d1en <- d1[meas.tech2 != 'micro met', ]
```

```
m1 <- lmer(e.rel.168 ~ 1|meas.level, data = d1en)
summary(m1)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: e.rel.168 ~ 1 | meas.level
##    Data: d1en
##
## REML criterion at convergence: -24.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.56605 -0.40378  0.01123  0.33245  1.55594
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  meas.level (Intercept) 0.028064 0.1675
##  Residual               0.000645 0.0254
## Number of obs: 10, groups:  meas.level, 4
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  0.38367    0.08416   4.559
```

```
VarCorr(m1)
```

```
##  Groups     Name        Std.Dev.
##  meas.level (Intercept) 0.167524
##  Residual               0.025397
```

```
m2 <- lmer(log10(e.rel.168) ~ 1|meas.level, data = d1en)
summary(m2)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: log10(e.rel.168) ~ 1 | meas.level
##    Data: d1en
##
## REML criterion at convergence: -19.4
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.45940 -0.37882 -0.03926  0.33695  1.47468
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  meas.level (Intercept) 0.058782 0.24245
##  Residual               0.001001 0.03164
## Number of obs: 10, groups:  meas.level, 4
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  -0.4601     0.1217  -3.782
```

```
VarCorr(m2)
```

```
##  Groups     Name        Std.Dev.
##  meas.level (Intercept) 0.242450
##  Residual               0.031637
```

```
100 * (10^(as.data.frame(VarCorr(m2))[, 5]) - 1)
```

```
## [1] 74.763381  7.556652
```

II-WUR micromet

```
d2mm <- d2[meas.tech2 == 'micro met', ]
d2mm[, .(meas.level, e.rel.168)]
```

```
##                                       meas.level e.rel.168
## 1:                                      bLS-CRDS   0.12683
## 2: bLS Acid traps eGylle_bLS_acid_traps_3heights        NA
## 3:             bLS CRDS avg. eGylle_bLS_avg_time        NA
## 4:                      IHF Acid traps eGylle_IHF        NA
```

```
d2mm[, .(meas.level, e.rel.final)]
```

```
##                                       meas.level e.rel.final
## 1:                                      bLS-CRDS     0.12844
## 2: bLS Acid traps eGylle_bLS_acid_traps_3heights     0.14881
## 3:             bLS CRDS avg. eGylle_bLS_avg_time     0.12428
## 4:                      IHF Acid traps eGylle_IHF     0.09831
```

Drop 3 heights and add replicate data (or some representation of it) manually. **Note: IHF value does not match Table 3–update ALFAM2 data!**

```r
dimpinger <- data.table(meas.level = 'bLS-impinger', e.rel.final = c(0.125, 0.148, 0.171))
sd(dimpinger[, e.rel.final])
```

```
## [1] 0.023
```

```r
mean(dimpinger[, e.rel.final])
```

```
## [1] 0.148
```

```r
d2mm <- d2mm[meas.level != 'bLS Acid traps eGylle_bLS_acid_traps_3heights', ]
d2mm <- rbind(d2mm, dimpinger, fill = TRUE)
d2mm[, .(meas.level, e.rel.final)]
```

```
##                          meas.level e.rel.final
## 1:                         bLS-CRDS     0.12844
## 2: bLS CRDS avg. eGylle_bLS_avg_time     0.12428
## 3:         IHF Acid traps eGylle_IHF     0.09831
## 4:                       bLS-impinger     0.12500
## 5:                       bLS-impinger     0.14800
## 6:                       bLS-impinger     0.17100
```

```r
m1 <- lmer(e.rel.final ~ 1|meas.level, data = d2mm)
summary(m1)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: e.rel.final ~ 1 | meas.level
##    Data: d2mm
##
## REML criterion at convergence: -21.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.01716 -0.56392 -0.08467  0.29274  1.49161
##
## Random effects:
##  Groups     Name        Variance  Std.Dev.
##  meas.level (Intercept) 0.0001909 0.01382
##  Residual               0.0004403 0.02098
## Number of obs: 6, groups:  meas.level, 4
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  0.12891    0.01139   11.32
```

```r
VarCorr(m1)
```

```
##  Groups     Name        Std.Dev.
##  meas.level (Intercept) 0.013817
##  Residual               0.020983
```

```r
m2 <- lmer(log10(e.rel.final) ~ 1|meas.level, data = d2mm)
summary(m2)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: log10(e.rel.final) ~ 1 | meas.level
##    Data: d2mm
##
```

```
## REML criterion at convergence: -9.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.00957 -0.58008  0.00164  0.30991  1.36761
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  meas.level (Intercept) 0.002795 0.05287
##  Residual               0.004123 0.06421
## Number of obs: 6, groups:  meas.level, 4
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept) -0.89863    0.03853  -23.32
```

```
VarCorr(m2)
```

```
##  Groups     Name        Std.Dev.
##  meas.level (Intercept) 0.052872
##  Residual               0.064207
```

```
100 * (10^(as.data.frame(VarCorr(m2))[, 5]) - 1)
```

```
## [1] 12.94623 15.93303
```

```
sqrt(sum(as.data.frame(VarCorr(m2))[, 5]^2))
```

```
## [1] 0.08317441
```

II-WUR enclosure

```
d2en <- d2[meas.tech2 != 'micro met' & meas.level %in% c('WT 20', 'FC') & !grepl('diluted', treat), ]
```

```
d2en[, .(meas.tech.orig, e.rel.168)]
```

```
##     meas.tech.orig e.rel.168
## 1:     Wind tunnel   0.35403
## 2:     Wind tunnel   0.38712
## 3:     Wind tunnel   0.33742
## 4: Dynamic chamber        NA
## 5: Dynamic chamber        NA
## 6: Dynamic chamber        NA
## 7: Dynamic chamber        NA
```

```
d2en[, .(meas.level, e.rel.168)]
```

```
##    meas.level e.rel.168
## 1:      WT 20   0.35403
## 2:      WT 20   0.38712
## 3:      WT 20   0.33742
## 4:         FC        NA
## 5:         FC        NA
## 6:         FC        NA
## 7:         FC        NA
```

```
d2en[, .(meas.level, e.rel.final)]
```

```
##    meas.level e.rel.final
## 1:      WT 20     0.35426
## 2:      WT 20     0.38741
## 3:      WT 20     0.33770
## 4:         FC     0.15707
## 5:         FC     0.16987
## 6:         FC     0.16513
## 7:         FC     0.22263
```

```
m1 <- lmer(e.rel.final ~ 1|meas.level, data = d2en)
summary(m1)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: e.rel.final ~ 1 | meas.level
##    Data: d2en
##
## REML criterion at convergence: -19.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -0.8083 -0.6282 -0.3524  0.4451  1.5268
##
## Random effects:
##  Groups     Name        Variance  Std.Dev.
##  meas.level (Intercept) 0.0161714 0.12717
##  Residual               0.0007882 0.02808
## Number of obs: 7, groups:  meas.level, 2
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  0.26905    0.09056   2.971
```

```
VarCorr(m1)
```

```
##  Groups     Name        Std.Dev.
##  meas.level (Intercept) 0.127167
##  Residual               0.028076
```

```
m2 <- lmer(log10(e.rel.final) ~ 1|meas.level, data = d2en)
summary(m2)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: log10(e.rel.final) ~ 1 | meas.level
##    Data: d2en
##
## REML criterion at convergence: -11.7
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -0.9709 -0.5004 -0.3632  0.3001  1.7348
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  meas.level (Intercept) 0.046344 0.21528
```

```
##  Residual               0.003135 0.05599
## Number of obs: 7, groups:  meas.level, 2
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  -0.5988     0.1537  -3.895
```

```
VarCorr(m2)
```

```
##  Groups     Name        Std.Dev.
##  meas.level (Intercept) 0.21528
##  Residual               0.05599
```

```
100 * (10^(as.data.frame(VarCorr(m2))[, 5]) - 1)
```

```
## [1] 64.16371 13.76005
```