Mixed-effects models

Sasha D. Hafner

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1. Data prep

```
pdat$inst <- factor(pdat$inst)
pdat$inst.meas.tech <- interaction(pdat$institute, pdat$meas.tech)
pdat$app.mthd <- factor(pdat$app.mthd)
pdat$digestion <- grepl('[Dd]igest', paste(pdat$man.trt1, pdat$man.trt2))
pdat$man.source.pig <- pdat$man.source == 'pig'
```

Get trailing hose (shoe?) subset

```
pdat1 <- pdat[!is.na(e.24) &
              !is.na(app.mthd) &
              !is.na(man.dm) &
              !is.na(man.source) &
              !is.na(air.temp.24) &
              !is.na(wind.2m.24) &
              !is.na(till) &
              !is.na(incorp) &
              !is.na(crop) &
              !acid &
              incorp == 'none' &
              e.24 > 0 &
              e.rel.24 < 1.0 &
              e.rel.final < 1.05 &
              e.rel.final > - 0.05 &
              man.source != 'conc' &
              man.dm <= 15 &
              app.mthd != 'pi' &
              app.mthd != 'bss' &
              meas.tech2 %in% c('micro met') &
              !inst %in% c(102, 107, 108) & # Exclude AUN, old Swiss (IUL/FAT), and JTI
              pmid != 1526 &                # See rows 1703 and 1728 and others in MU data. Check with
              !grepl('Exclude data from analysis', notes.plot) , ]
```

```
#dat <- pdat[app.mthd == 'bsth' & meas.tech2 == 'micro met', ]
#dat <- pdat[app.mthd == 'bsth', ]
dat <- pdat1[app.mthd %in% c('bsth', 'ts') & e.rel.final < 1.1, ]
```

Subset without outliers.

```
dat[, z := abs(scale(e.rel.final)), by = c('inst', 'app.mthd')]
dato <- dat[z < 2, ]
```

```r
table(dat[, acid])
```

```
##
## FALSE
##   273
```

```r
table(dat[, digestion])
```

```
##
## FALSE  TRUE
##   254    19
```

```r
names(dat)
```

```
##   [1] "inst"                 "eid"                  "pid"
##   [4] "pmid"                 "uptake"               "proj"
##   [7] "exper"                "exper2"               "institute"
##  [10] "country"              "submitter"            "file"
##  [13] "first.row.in.file.int" "last.row.in.file.int" "row.in.file.plot"
##  [16] "pub.id"               "pub.info"             "lat"
##  [19] "long"                 "topo"                 "field"
##  [22] "plot"                 "plot.area"            "treat"
##  [25] "rep"                  "rep2"                 "n.ints"
##  [28] "t.start.p"            "t.end.p"              "dt1"
##  [31] "dt.min"               "dt.max"               "ct.min"
##  [34] "ct.max"               "meas.tech"            "meas.tech2"
##  [37] "meas.tech.orig"       "meas.tech.det"        "j.NH31"
##  [40] "j.rel1"               "e.1"                  "e.4"
##  [43] "e.6"                  "e.12"                 "e.24"
##  [46] "e.48"                 "e.72"                 "e.96"
##  [49] "e.168"                "e.final"              "e.cum.1"
##  [52] "e.cum.4"              "e.cum.6"              "e.cum.12"
##  [55] "e.cum.24"             "e.cum.48"             "e.cum.72"
##  [58] "e.cum.96"             "e.cum.168"            "e.cum.final"
##  [61] "e.rel.1"              "e.rel.4"              "e.rel.6"
##  [64] "e.rel.12"             "e.rel.24"             "e.rel.48"
##  [67] "e.rel.72"             "e.rel.96"             "e.rel.168"
##  [70] "e.rel.final"          "clay"                 "silt"
##  [73] "sand"                 "oc"                   "soil.type"
##  [76] "soil.type2"           "soil.water"           "soil.water.v"
##  [79] "soil.moist"           "soil.ph"              "soil.dens"
##  [82] "crop.res"             "till"                 "air.temp.1"
##  [85] "air.temp.4"           "air.temp.6"           "air.temp.12"
##  [88] "air.temp.24"          "air.temp.48"          "air.temp.72"
##  [91] "air.temp.96"          "air.temp.168"         "air.temp.mn"
##  [94] "air.temp.z"           "soil.temp.1"          "soil.temp.4"
##  [97] "soil.temp.6"          "soil.temp.12"         "soil.temp.24"
## [100] "soil.temp.48"         "soil.temp.72"         "soil.temp.96"
## [103] "soil.temp.168"        "soil.temp.mn"         "soil.temp.surf.1"
## [106] "soil.temp.surf.4"     "soil.temp.surf.6"     "soil.temp.surf.12"
## [109] "soil.temp.surf.24"    "soil.temp.surf.48"    "soil.temp.surf.72"
## [112] "soil.temp.surf.96"    "soil.temp.surf.168"   "soil.temp.surf.mn"
## [115] "soil.temp.z"          "rad.1"                "rad.4"
## [118] "rad.6"                "rad.12"               "rad.24"
## [121] "rad.48"               "rad.72"               "rad.96"
```

```
## [124] "rad.168"              "rad.mn"              "wind.1"
## [127] "wind.4"               "wind.6"              "wind.12"
## [130] "wind.24"              "wind.48"             "wind.72"
## [133] "wind.96"              "wind.168"            "wind.mn"
## [136] "wind.z"               "wind.2m.1"           "wind.2m.4"
## [139] "wind.2m.6"            "wind.2m.12"          "wind.2m.24"
## [142] "wind.2m.48"           "wind.2m.72"          "wind.2m.96"
## [145] "wind.2m.168"          "wind.2m.mn"          "wind.loc"
## [148] "rain.1"               "rain.4"              "rain.6"
## [151] "rain.12"              "rain.24"             "rain.48"
## [154] "rain.72"              "rain.96"             "rain.168"
## [157] "rain.tot"             "rain.rate.1"         "rain.rate.4"
## [160] "rain.rate.6"          "rain.rate.12"        "rain.rate.24"
## [163] "rain.rate.48"         "rain.rate.72"        "rain.rate.96"
## [166] "rain.rate.168"        "rain.rate.mn"        "rh.1"
## [169] "rh.4"                 "rh.6"                "rh.12"
## [172] "rh.24"                "rh.48"               "rh.72"
## [175] "rh.96"                "rh.168"              "rh.mn"
## [178] "far.loc"              "man.source"          "man.source.orig"
## [181] "man.source.det"       "man.bed"             "man.con"
## [184] "man.trt1"             "man.trt2"            "man.trt3"
## [187] "man.stor"             "man.dm"              "man.vs"
## [190] "man.tkn"              "man.tan"             "man.vfa"
## [193] "man.tic"              "man.ua"              "man.ph"
## [196] "acid"                 "date.start"          "app.start"
## [199] "app.start.orig"       "app.end"             "app.end.orig"
## [202] "app.method"           "app.method2"         "app.method.orig"
## [205] "app.rate"             "tan.app"             "incorp"
## [208] "incorp.orig"          "time.incorp"         "man.area"
## [211] "dist.inj"             "furrow.z"            "furrow.w"
## [214] "crop"                 "crop.orig"           "crop.z"
## [217] "crop.area"            "lai"                 "notes.plot"
## [220] "flag.plot"            "app.date"            "app.mthd"
## [223] "inst.meas.tech"       "digestion"           "man.source.pig"
## [226] "z"
```

Models

```
m0 <- lmer(log10(e.rel.final) ~ man.source.pig + air.temp.24 + wind.2m.24 + man.dm + man.ph + (1|inst.m
summary(m0)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: log10(e.rel.final) ~ man.source.pig + air.temp.24 + wind.2m.24 +
##     man.dm + man.ph + (1 | inst.meas.tech)
##    Data: dat
##
## REML criterion at convergence: 41.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.4742 -0.5369  0.0355  0.6836  2.8193
##
## Random effects:
```

```
##  Groups          Name        Variance Std.Dev.
##  inst.meas.tech (Intercept) 0.01748  0.1322
##  Residual                   0.05634  0.2374
## Number of obs: 273, groups:  inst.meas.tech, 11
##
## Fixed effects:
##                     Estimate Std. Error t value
## (Intercept)        -1.615235   0.356226  -4.534
## man.source.pigTRUE -0.241390   0.046390  -5.204
## air.temp.24         0.000306   0.003633   0.084
## wind.2m.24          0.022818   0.008505   2.683
## man.dm              0.028369   0.008568   3.311
## man.ph              0.099512   0.044301   2.246
##
## Correlation of Fixed Effects:
##             (Intr) m..TRU ar..24 w.2.24 man.dm
## mn.src.TRUE -0.018
## air.temp.24 -0.078  0.149
## wind.2m.24  -0.256  0.022  0.268
## man.dm      -0.441  0.515  0.045  0.183
## man.ph      -0.965 -0.121 -0.079  0.142  0.294
```

```
coef(m0)
```

```
## $inst.meas.tech
##                (Intercept) man.source.pigTRUE  air.temp.24 wind.2m.24
## INRA.agm         -1.559482         -0.2413904 0.0003060248 0.02281804
## CAU-LU.bls       -1.668881         -0.2413904 0.0003060248 0.02281804
## INH-HAFL.bls     -1.827465         -0.2413904 0.0003060248 0.02281804
## AU.bLS           -1.563197         -0.2413904 0.0003060248 0.02281804
## ADAS-RR.ihf      -1.747051         -0.2413904 0.0003060248 0.02281804
## IMAG.ihf         -1.597026         -0.2413904 0.0003060248 0.02281804
## TEAGASC.ihf      -1.501853         -0.2413904 0.0003060248 0.02281804
## WUR.ihf          -1.737057         -0.2413904 0.0003060248 0.02281804
## DIAS.micro met   -1.573054         -0.2413904 0.0003060248 0.02281804
## AT.zinst         -1.528767         -0.2413904 0.0003060248 0.02281804
## AU.zinst         -1.463754         -0.2413904 0.0003060248 0.02281804
##                    man.dm     man.ph
## INRA.agm       0.02836917 0.09951232
## CAU-LU.bls     0.02836917 0.09951232
## INH-HAFL.bls   0.02836917 0.09951232
## AU.bLS         0.02836917 0.09951232
## ADAS-RR.ihf    0.02836917 0.09951232
## IMAG.ihf       0.02836917 0.09951232
## TEAGASC.ihf    0.02836917 0.09951232
## WUR.ihf        0.02836917 0.09951232
## DIAS.micro met 0.02836917 0.09951232
## AT.zinst       0.02836917 0.09951232
## AU.zinst       0.02836917 0.09951232
##
## attr(,"class")
## [1] "coef.mer"
```

```
sort(unlist(coef(m0)$inst.meas.tech[, 1]))
```

```
##  [1] -1.827465 -1.747051 -1.737057 -1.668881 -1.597026 -1.573054 -1.563197
```

```
##  [8] -1.559482 -1.528767 -1.501853 -1.463754
```

```
efdat$inst.meas.tech <- factor('AU.bLS')
efdat$air.temp.24 <- efdat$air.temp
efdat$wind.2m.24 <- efdat$wind.2m
efdat$man.source <- factor(efdat$man.source)
efdat$EFp <- 100 * 10^predict(m0, newdata = efdat)
```