data wrangling and plots

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Plots

Question: How does response vary with study covariates?

Hypothesis: SMD between constant and fluctuating environments is most affected by temperature parameters (range and mean) but is also likely affected by demographic parameters (age, size, organization level)

Initial conclusions: Flux_range and mean temperature appear to be the most important contributers to variation in yi, though organization also contributes.

```
full_rf_model<-rma.mv(yi, vi, data=dat_MA_ES, mods = ~flux_range +
                        exp_age + size + org_level + mean_temp_constant,
                random = ~1 | experiment_id/ study_id/ response_id,
                  method="REML")
full_rf_model
```

```
##
## Multivariate Meta-Analysis Model (k = 202; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
## sigma^2.1  0.0000  0.0002      3     no                       experiment_id
## sigma^2.2  0.5280  0.7267     22     no                 experiment_id/study_id
## sigma^2.3  0.3591  0.5993     57     no  experiment_id/study_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 196) = 5772.1402, p-val < .0001
##
## Test of Moderators (coefficients 2:6):
## QM(df = 5) = 140.6357, p-val < .0001
##
## Model Results:
##
##                     estimate      se      zval    pval    ci.lb    ci.ub
## intrcpt               3.7888  0.8027    4.7204  <.0001   2.2157   5.3620  ***
## flux_range           -0.0500  0.0107   -4.6653  <.0001  -0.0710  -0.0290  ***
## exp_age              -0.4120  0.3795   -1.0854  0.2777  -1.1558   0.3319
## size                 -0.3016  0.2840   -1.0617  0.2884  -0.8583   0.2551
## org_level            -0.6615  0.3217   -2.0563  0.0398  -1.2921  -0.0310    *
## mean_temp_constant   -0.0879  0.0081  -10.8714  <.0001  -0.1037  -0.0721  ***
```

```
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Relevant plots

Figure 1.

```
# boxplots of how fluctuation range influences SMD
ggplot(normalized, aes(x=flux_range, y=yi))+
  geom_point(alpha = 0.5)+
  theme_bw()+
  geom_smooth(method="lm", formula = y~x)+
  ggtitle("SMD across flux_range")
```

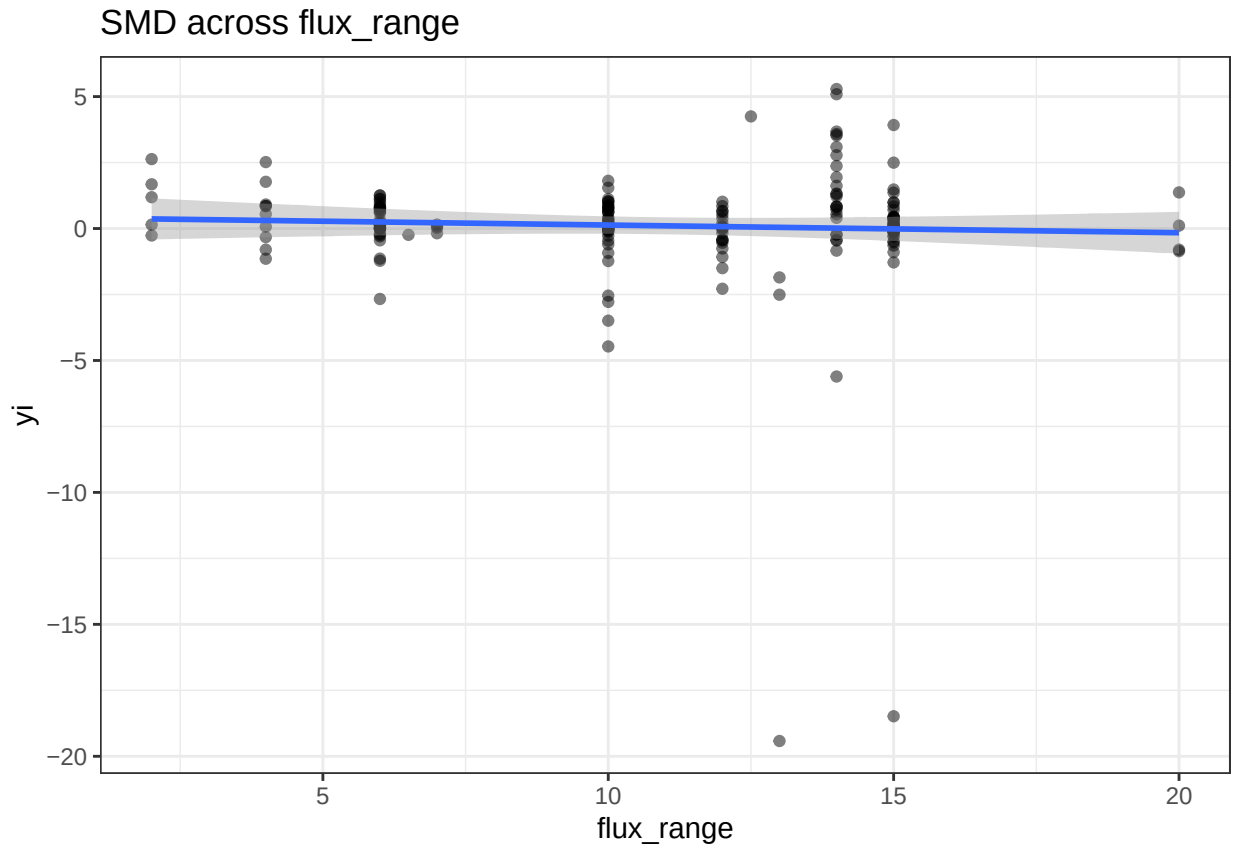


Figure 2.

```
# scatterplot of standardized mean response vs flux range colored and lm fit by org level
ggplot(normalized, aes(x=flux_range, y=yi, color = as.factor(org_level)))+
  geom_point()+
  geom_smooth(method="lm", formula = y~x)+
  theme_bw()+
```

```
  ggtitle("SMD across fluctuation ranges colored by organization level
          and fit with linear model")
```

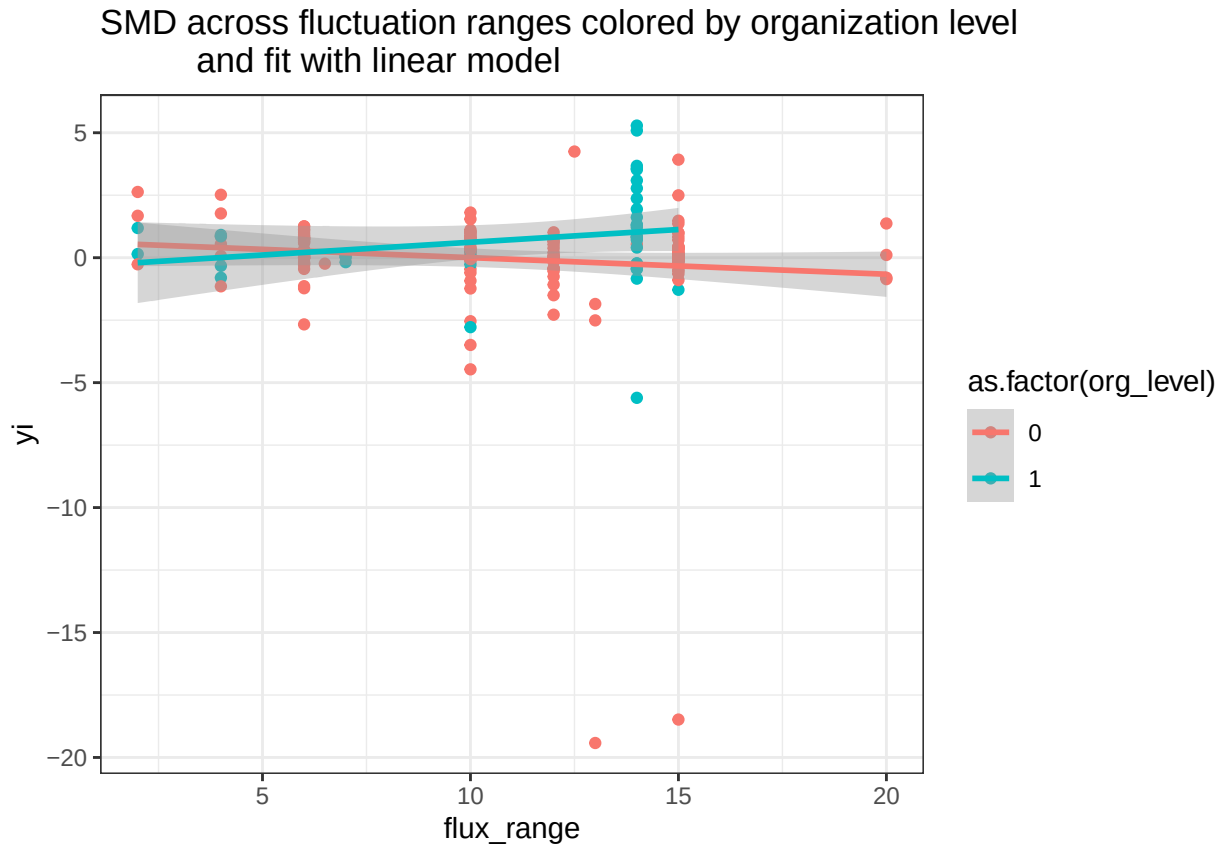


Figure 3.

```
#boxplot of SMD across levels of organization
ggplot(normalized, aes(x=as.factor(org_level), y=yi, fill=as.factor(org_level)))+
  geom_boxplot(alpha =0.7)+
  geom_point(alpha = 0.3)+
  scale_fill_tron()+
  theme_bw()+
  theme(legend.position = "bottom")+
  ggtitle("SMD across organization level")
```

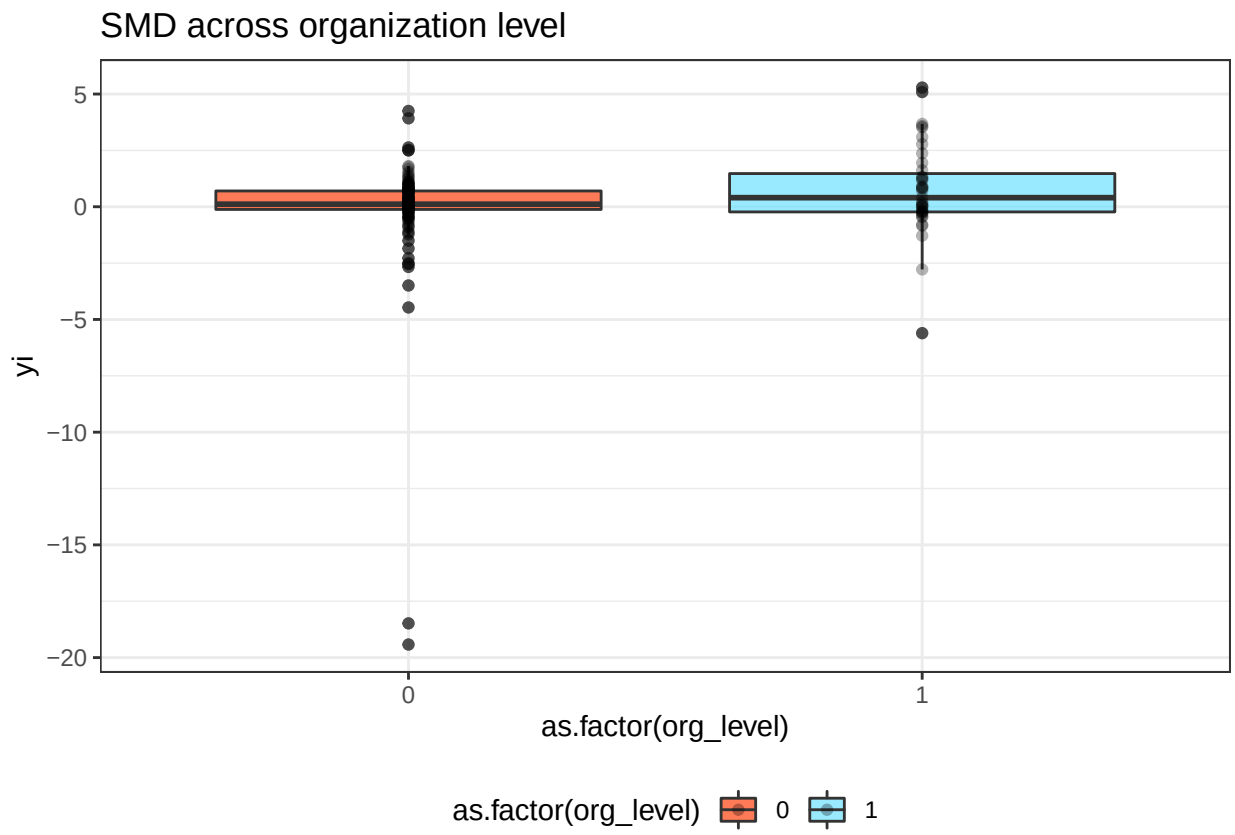
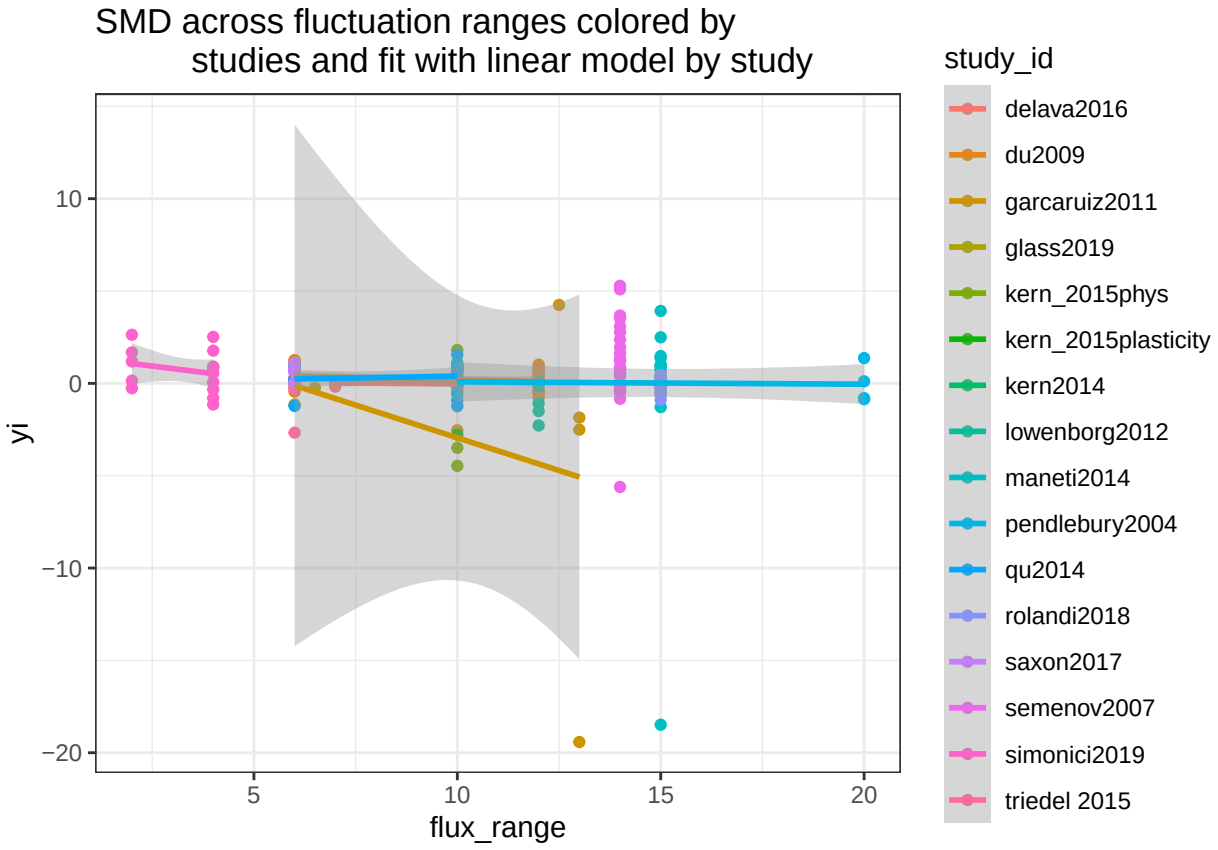


Figure 4.

```
#scatterplot of standardized mean difference across flux range colored by study fit with lm
ggplot(normalized, aes(x=flux_range, y=yi, color = study_id))+
  geom_point()+
  geom_smooth(method="lm", formula = y~x)+
  theme_bw()+
  ggtitle("SMD across fluctuation ranges colored by
          studies and fit with linear model by study")
```



Question: How does response compare across studies and experiments?

Hypothesis: There should be differences across studies because of differences in experimental designs and study organism that would mean different magnitudes of response.

Initial conclusions: The studies overall are different in their responses but not owing to study_id or experiment. However, the mixed effects model does suggest some differences when you include study _id as a mod.

```
#corresponding random effects model
fig1 <- rma.mv(yi, vi, data=dat_MA_ES,
               random = ~1 | experiment_id/ study_id,
                 method="REML")
fig1
```

```
##
## Multivariate Meta-Analysis Model (k = 202; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                  factor
## sigma^2.1  0.0000  0.0003      3     no           experiment_id
## sigma^2.2  0.5747  0.7581     22     no  experiment_id/study_id
##
## Test for Heterogeneity:
```

```
## Q(df = 201) = 6408.3572, p-val < .0001
##
## Model Results:
##
## estimate      se    zval    pval    ci.lb   ci.ub
##   0.1144  0.1644  0.6957  0.4866  -0.2078  0.4366
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#trying out mixed effects model
fig1me <- rma(yi, vi, data=dat_MA_ES, mods = ~study_id,
              method="FE")
fig1me
```

```
##
## Fixed-Effects with Moderators Model (k = 202)
##
## I^2 (residual heterogeneity / unaccounted variability): 96.33%
## H^2 (unaccounted variability / sampling variability):   27.22
##
## Test for Residual Heterogeneity:
## QE(df = 186) = 5063.4195, p-val < .0001
##
## Test of Moderators (coefficients 2:16):
## QM(df = 15) = 1344.9378, p-val < .0001
##
## Model Results:
##
##                              estimate      se      zval    pval    ci.lb
## intrcpt                        0.0006  0.0448    0.0127  0.9899  -0.0872
## study_iddu2009                 0.1754  0.0782    2.2433  0.0249   0.0222
## study_idgarcaruiz2011         -1.0855  0.0792  -13.7139  <.0001  -1.2407
## study_idglass2019             -0.0359  0.0636   -0.5638  0.5729  -0.1606
## study_idkern_2015phys          0.4404  0.0548    8.0347  <.0001   0.3330
## study_idkern_2015plasticity   -0.7988  0.3360   -2.3774  0.0174  -1.4574
## study_idkern2014               0.6921  0.1156    5.9871  <.0001   0.4655
## study_idlowenborg2012         -0.8458  0.1396   -6.0565  <.0001  -1.1195
## study_idmaneti2014             0.7240  0.1146    6.3198  <.0001   0.4995
## study_idpendlebury2004        -0.0100  0.1239   -0.0807  0.9357  -0.2529
## study_idqu2014                 0.3173  0.0858    3.6992  0.0002   0.1492
## study_idrolandi2018            0.0200  0.0467    0.4283  0.6684  -0.0716
## study_idsaxon2017              0.4966  0.0470   10.5578  <.0001   0.4044
## study_idsemenov2007            0.9931  0.2096    4.7384  <.0001   0.5823
## study_idsimonici2019           0.5785  0.0932    6.2079  <.0001   0.3958
## study_idtriedel 2015          -1.1246  0.1483   -7.5818  <.0001  -1.4153
##                                ci.ub
## intrcpt                       0.0883
## study_iddu2009                0.3287    *
## study_idgarcaruiz2011        -0.9304  ***
## study_idglass2019             0.0888
## study_idkern_2015phys         0.5479  ***
## study_idkern_2015plasticity  -0.1403    *
## study_idkern2014              0.9187  ***
```

```
## study_idlowenborg2012        -0.5721  ***
## study_idmaneti2014            0.9485  ***
## study_idpendlebury2004        0.2329
## study_idqu2014                0.4854  ***
## study_idrolandi2018           0.1116
## study_idsaxon2017             0.5888  ***
## study_idsemenov2007           1.4039  ***
## study_idsimonici2019          0.7611  ***
## study_idtriedel 2015         -0.8339  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Relevant Plots

Figure 5.

```
#SMD across all studies
ggplot(normalized, aes(x=reorder(study_id, -yi), y=yi, color = as.factor(experiment_id)))+
  geom_boxplot()+
  scale_color_tron()+
  theme_minimal()+
  theme(axis.text.x = element_text(face = "bold",
                                   size = 10, angle = 45,hjust = 1),
        legend.position = "bottom")+
  ggtitle("SMD across all studies")
```

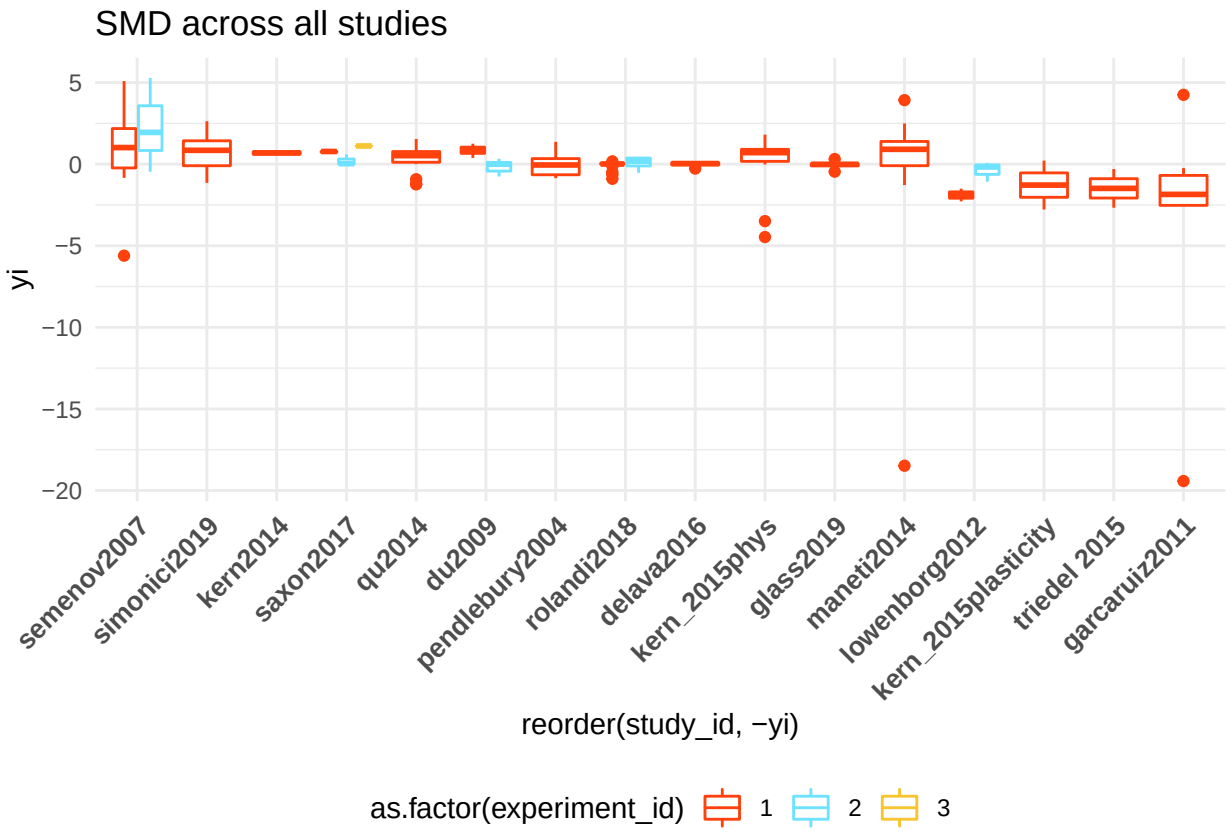

SMD across all studies
5
0
−5
−10
−15
−20
yi
semenov2007
simonici2019
kern2014
saxon2017
qu2014
du2009
pendlebury2004
rolandi2018
delava2016
kern_2015phys
glass2019
maneti2014
lowenborg2012
kern_2015plasticity
triedel 2015
garcaruiz2011
reorder(study_id, −yi)
as.factor(experiment_id)
1
2
3

Figure 6.

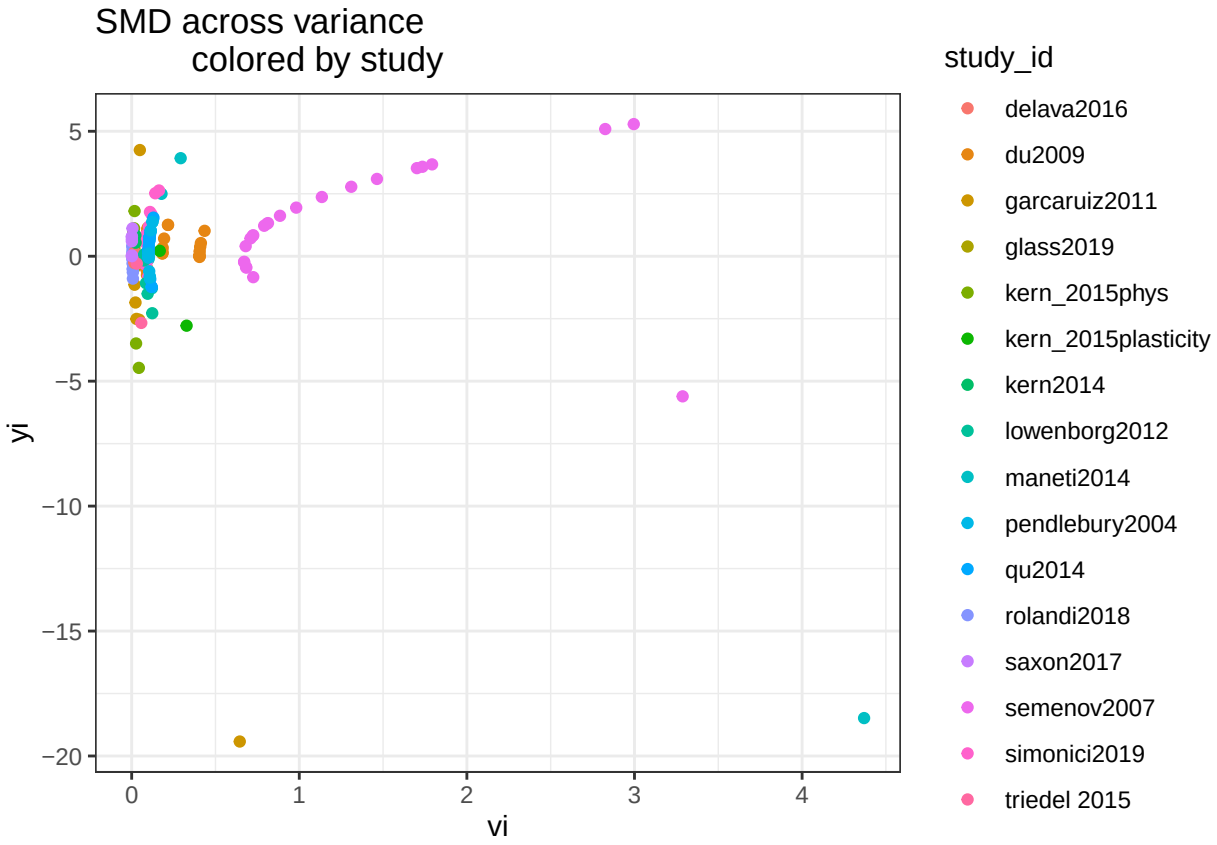


Figure 7.

```
#looking at yi across studies with the same temperature range (10 C)
ggplot(common_range, aes(y=yi, x=reorder(study_id, -yi), color = study_id))+
  geom_boxplot()+
  geom_point(alpha = 0.5)+
  theme_minimal()+
  theme(axis.text.x = element_text(face = "bold",
                                   size = 7, angle = 45))+
                                   ggtitle("SMD across studies with the same
                                           temperature fluctuation range (10 C)")
```

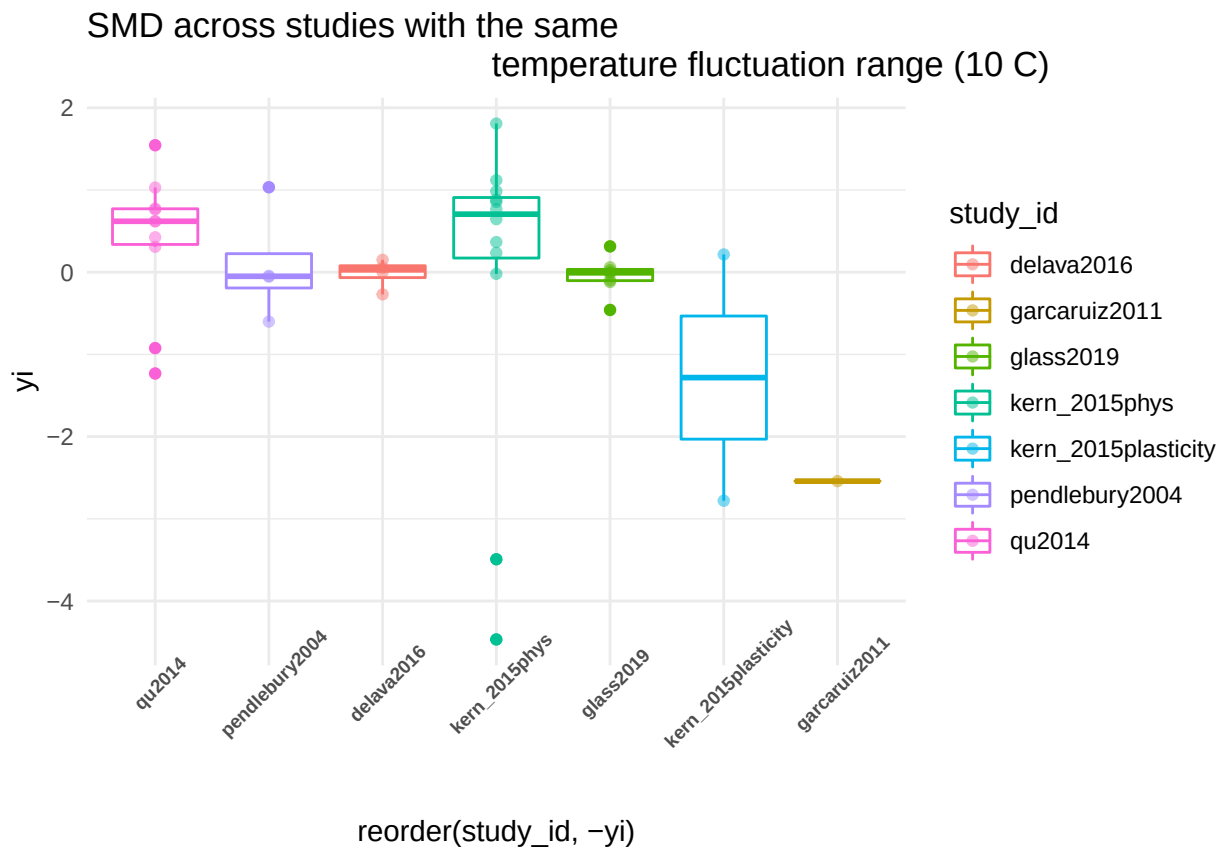
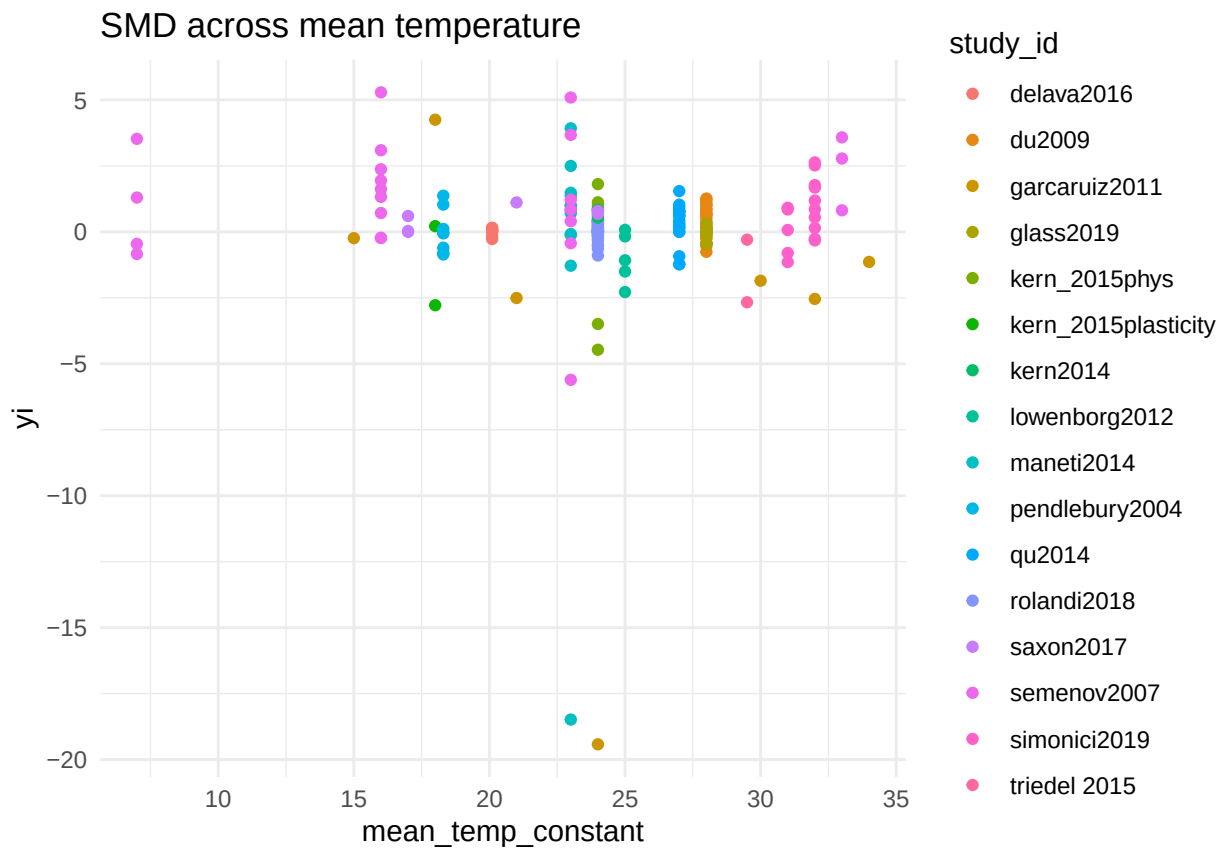


Figure 8.

```
# scatterplot of how mean temperature influences SMD
ggplot(normalized, aes(x=mean_temp_constant, y=yi, color = study_id))+
  geom_point()+
  theme_minimal()+
  ggtitle("SMD across mean temperature")
```



Supplementary Plots/Code

```
## Warning in rma.mv(yi, vi, data = common_range, random = ~1 | experiment_id/
## study_id, : Single-level factor(s) found in 'random' argument. Corresponding
## 'sigma2' value(s) fixed to 0.
```