data wrangling and plots

Maggie Slein

4/2/21

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.

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

```
##
## Multivariate Meta-Analysis Model (k = 140; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
## sigma^2.1  0.0000  0.0002      2     no                       experiment_id
## sigma^2.2  0.4801  0.6929     19     no                 experiment_id/study_id
## sigma^2.3  0.3679  0.6065     54     no  experiment_id/study_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 133) = 4966.2128, p-val < .0001
##
## Test of Moderators (coefficients 2:7):
## QM(df = 6) = 188.5784, p-val < .0001
##
## Model Results:
##
##                               estimate      se     zval    pval    ci.lb
## intrcpt                         1.4408  0.8785   1.6400  0.1010  -0.2811
## flux_range                      0.2718  0.0488   5.5653  <.0001   0.1761
## mean_temp_constant              0.0170  0.0184   0.9255  0.3547  -0.0190
## exp_age                        -0.5708  0.3985  -1.4323  0.1520  -1.3519
## size                           -0.3056  0.2850  -1.0725  0.2835  -0.8641
```

```
## org_level                          -0.6683  0.3383  -1.9756  0.0482  -1.3314
## flux_range:mean_temp_constant      -0.0136  0.0020  -6.7104  <.0001  -0.0176
##                                     ci.ub
## intrcpt                            3.1626
## flux_range                         0.3675  ***
## mean_temp_constant                 0.0530
## exp_age                            0.2103
## size                               0.2529
## org_level                         -0.0053    *
## flux_range:mean_temp_constant     -0.0096  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#without interaction term
full_rf_model2<-rma.mv(yi, vi, data=dat_MA_ES, mods = ~flux_range + mean_temp_constant +
                         exp_age + size + org_level,
                random = ~1 | experiment_id/ study_id/ response_id,
                  method="REML")
full_rf_model2
```

```
##
## Multivariate Meta-Analysis Model (k = 140; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                                factor
## sigma^2.1  0.0000  0.0002      2     no                            experiment_id
## sigma^2.2  0.5921  0.7694     19     no                  experiment_id/study_id
## sigma^2.3  0.3692  0.6076     54     no  experiment_id/study_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 134) = 5082.0033, p-val < .0001
##
## Test of Moderators (coefficients 2:6):
## QM(df = 5) = 143.6740, p-val < .0001
##
## Model Results:
##
##                      estimate      se      zval    pval    ci.lb    ci.ub
## intrcpt                3.9455  0.8486    4.6492  <.0001   2.2822   5.6088  ***
## flux_range            -0.0468  0.0115   -4.0635  <.0001  -0.0694  -0.0242  ***
## mean_temp_constant    -0.0931  0.0083  -11.2776  <.0001  -0.1093  -0.0769  ***
## exp_age               -0.5211  0.4305   -1.2104  0.2261  -1.3649   0.3227
## size                  -0.2607  0.3052   -0.8542  0.3930  -0.8589   0.3375
## org_level             -0.5649  0.3434   -1.6453  0.0999  -1.2379   0.1080    .
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#full model split out by stocks/rates
full_rf_stocks<-rma.mv(yi, vi, data=dat_MA_ES, mods = ~flux_range + mean_temp_constant +
                         exp_age + size + org_level + resp_type,
```

```
               random = ~1 | experiment_id/ study_id/ response_id,
                 method="REML")
full_rf_stocks
```

```
##
## Multivariate Meta-Analysis Model (k = 140; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
## sigma^2.1  0.0000  0.0002      2     no                       experiment_id
## sigma^2.2  0.6413  0.8008     19     no                 experiment_id/study_id
## sigma^2.3  0.3492  0.5910     54     no  experiment_id/study_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 133) = 5044.3409, p-val < .0001
##
## Test of Moderators (coefficients 2:7):
## QM(df = 6) = 145.7976, p-val < .0001
##
## Model Results:
##
##                     estimate      se      zval    pval    ci.lb    ci.ub
## intrcpt               3.5009  0.9275    3.7746  0.0002   1.6831   5.3188  ***
## flux_range           -0.0463  0.0115   -4.0198  <.0001  -0.0689  -0.0237  ***
## mean_temp_constant   -0.0934  0.0083  -11.3076  <.0001  -0.1096  -0.0772  ***
## exp_age              -0.5082  0.4413   -1.1516  0.2495  -1.3730   0.3567
## size                 -0.2895  0.3117   -0.9287  0.3530  -0.9004   0.3214
## org_level            -0.5581  0.3381   -1.6505  0.0988  -1.2209   0.1046    .
## resp_typetrait        0.5324  0.3899    1.3654  0.1721  -0.2318   1.2965
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#full model split out by life history outcomes
full_rf_thermal<-rma.mv(yi, vi, data=dat_MA_ES, mods = ~flux_range + mean_temp_constant +
                          exp_age + size + org_level + stressful ,
               random = ~1 | experiment_id/ study_id/ response_id,
                 method="REML")
```

```
## Warning in rma.mv(yi, vi, data = dat_MA_ES, mods = ~flux_range +
## mean_temp_constant + : Rows with NAs omitted from model fitting.
```

```
full_rf_thermal
```

```
##
## Multivariate Meta-Analysis Model (k = 132; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
## sigma^2.1  0.0000  0.0002      2     no                       experiment_id
```

```
## sigma^2.2  0.6271  0.7919     18     no              experiment_id/study_id
## sigma^2.3  0.3784  0.6151     53     no  experiment_id/study_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 125) = 2792.3174, p-val < .0001
##
## Test of Moderators (coefficients 2:7):
## QM(df = 6) = 12.8046, p-val = 0.0462
##
## Model Results:
##
##                     estimate      se     zval    pval    ci.lb    ci.ub
## intrcpt              -0.1022  1.1577  -0.0883  0.9297  -2.3711   2.1668
## flux_range           -0.0132  0.0168  -0.7831  0.4336  -0.0461   0.0198
## mean_temp_constant    0.0843  0.0330   2.5559  0.0106   0.0196   0.1489   *
## exp_age              -0.1052  0.4536  -0.2319  0.8166  -0.9941   0.7838
## size                 -0.8962  0.3367  -2.6615  0.0078  -1.5562  -0.2362  **
## org_level            -0.5430  0.3507  -1.5483  0.1216  -1.2304   0.1444
## stressfuly           -0.0232  0.0851  -0.2729  0.7849  -0.1901   0.1437
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Relevant plots

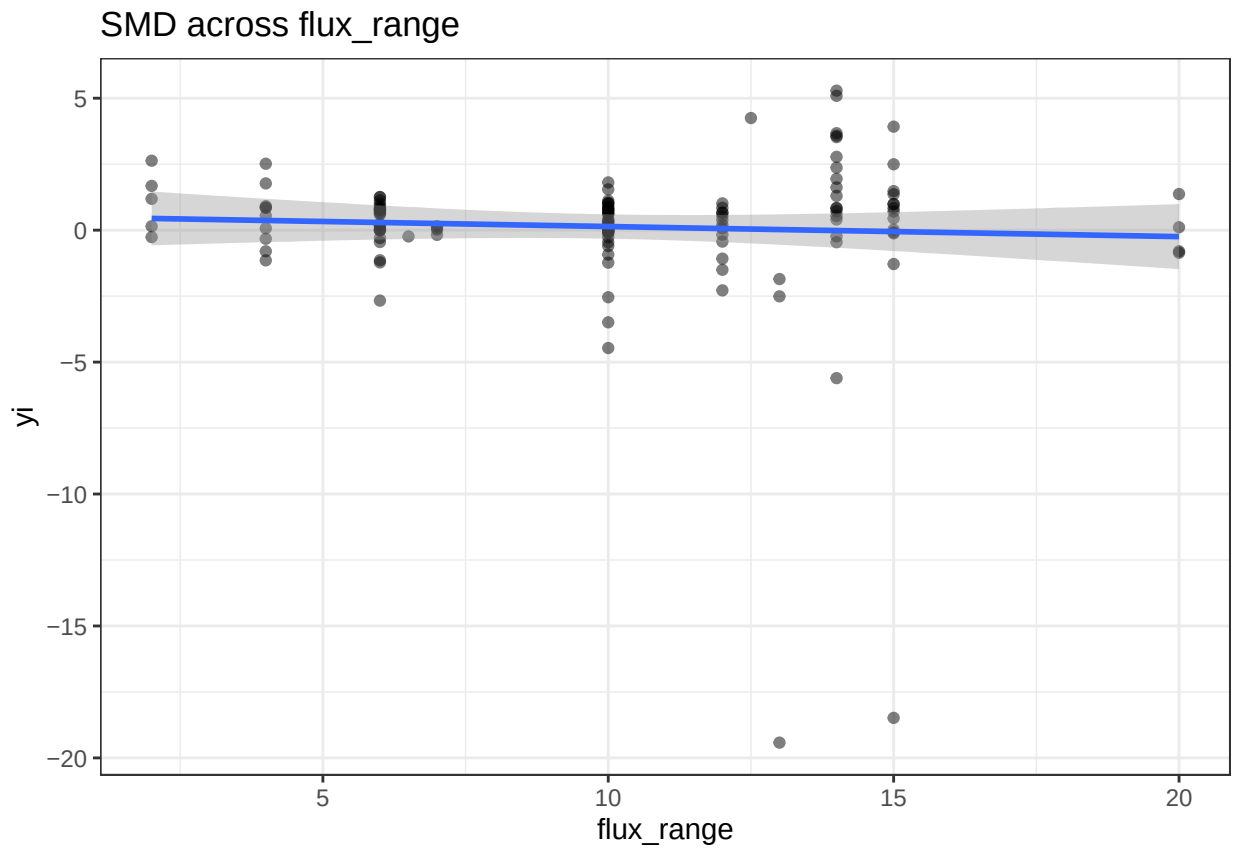

Figure 1. Data visualization supports model findings that there is a differene between shorter fluctuation

ranges and longer fluctuation ranges.

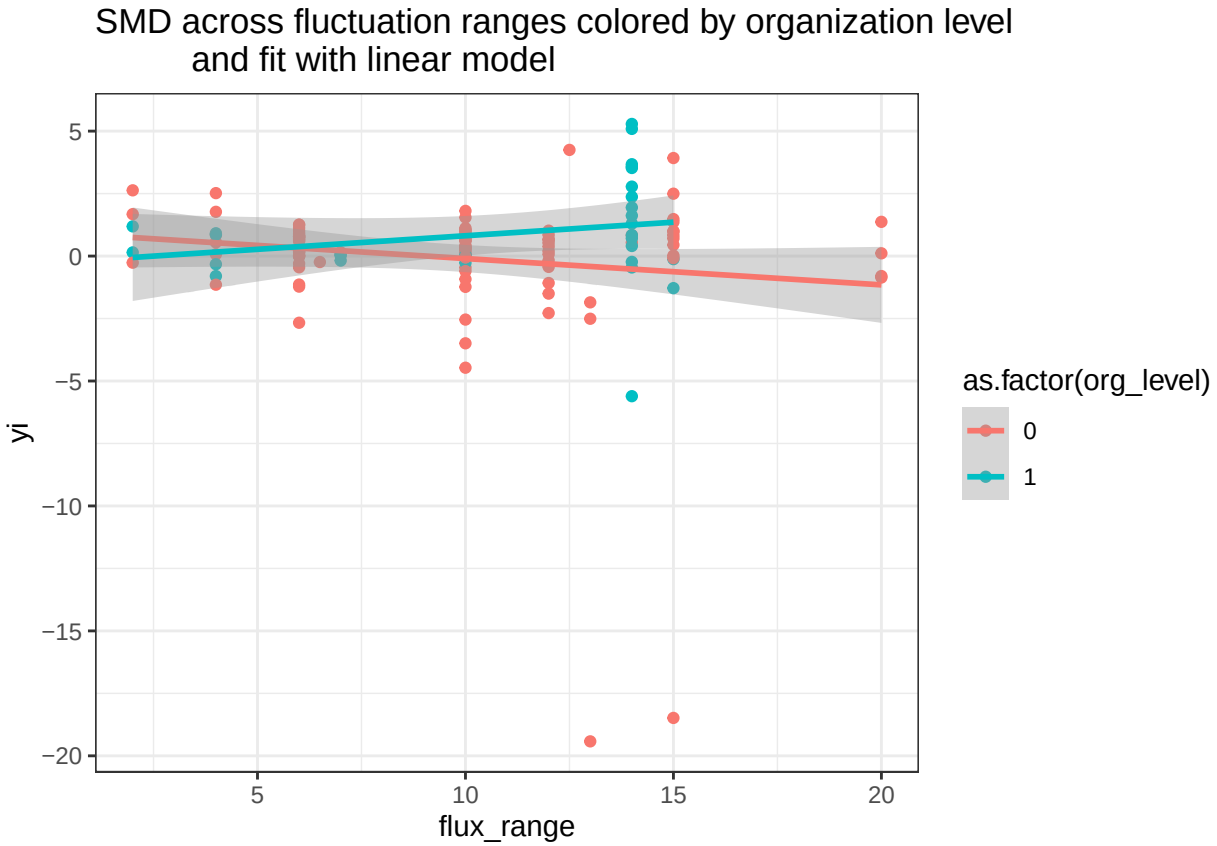

Figure 2. We can also see that there a difference in effect size in organization level responses across fluctuation range. Population level reponses trended positively across fluctuation ranges, while organism level responses trended negatively across fluctuation ranges.

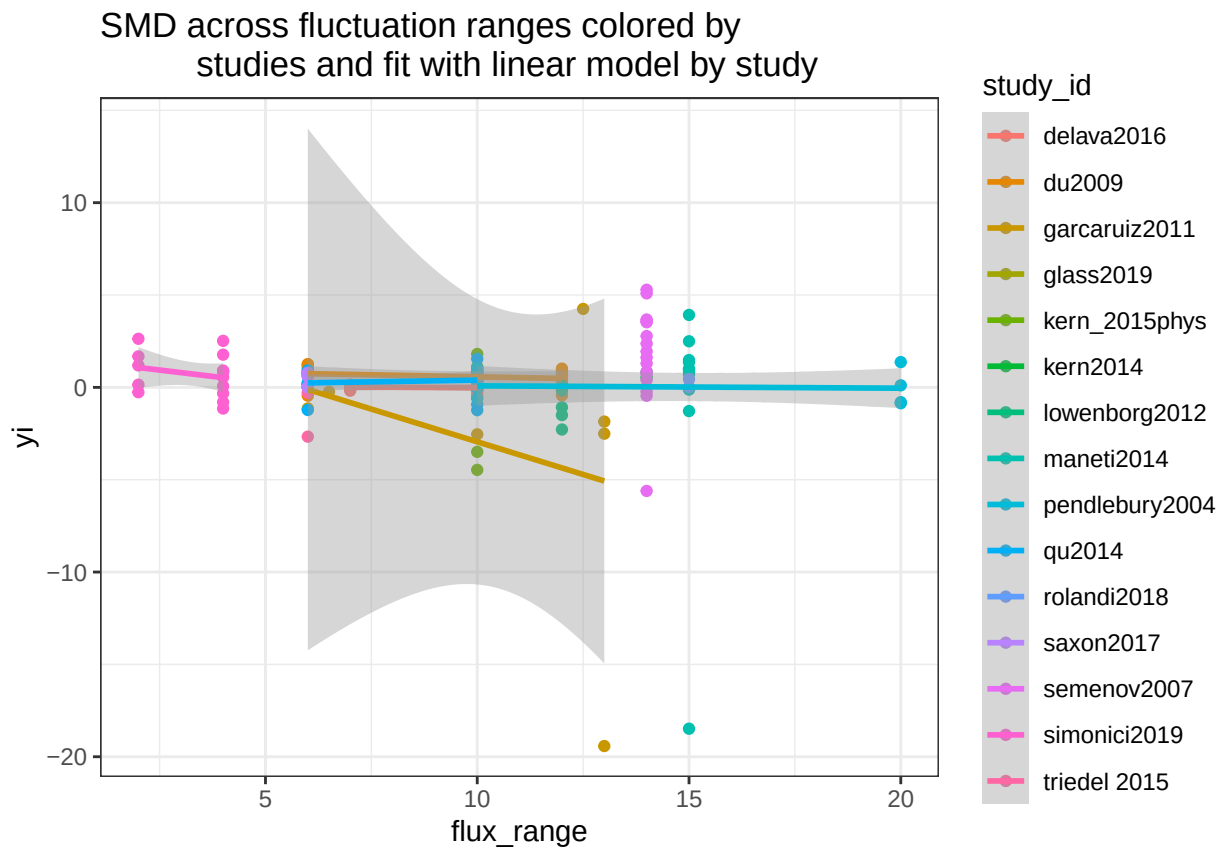

Figure 3. When broken out by study, we can see that there is disagreement in the effect of fluctuation range on effect size.

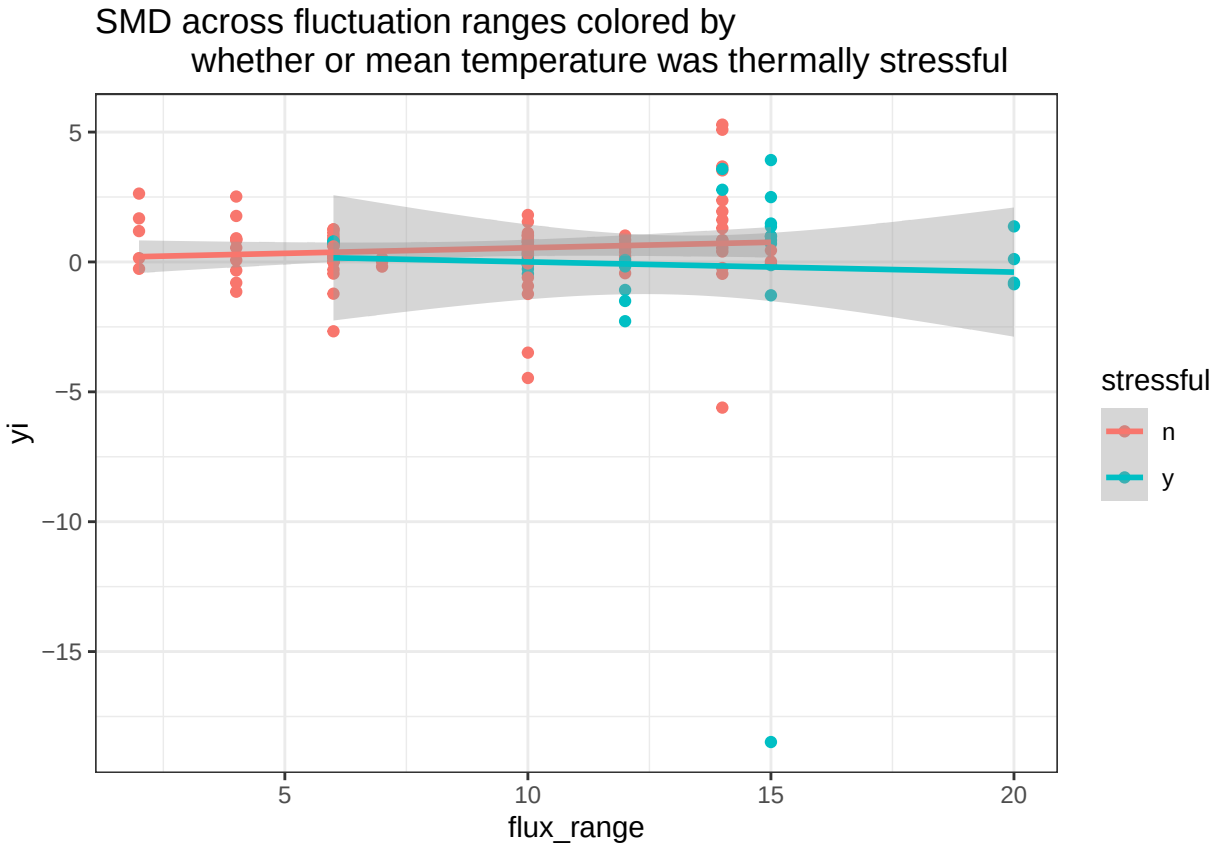

Figure 4. When we consider where the temperatures in the fluctuation range reach thermally stressful levels, there is a small difference between responses to stressful temperatures (negative) and non-stressful temperatures (positive).

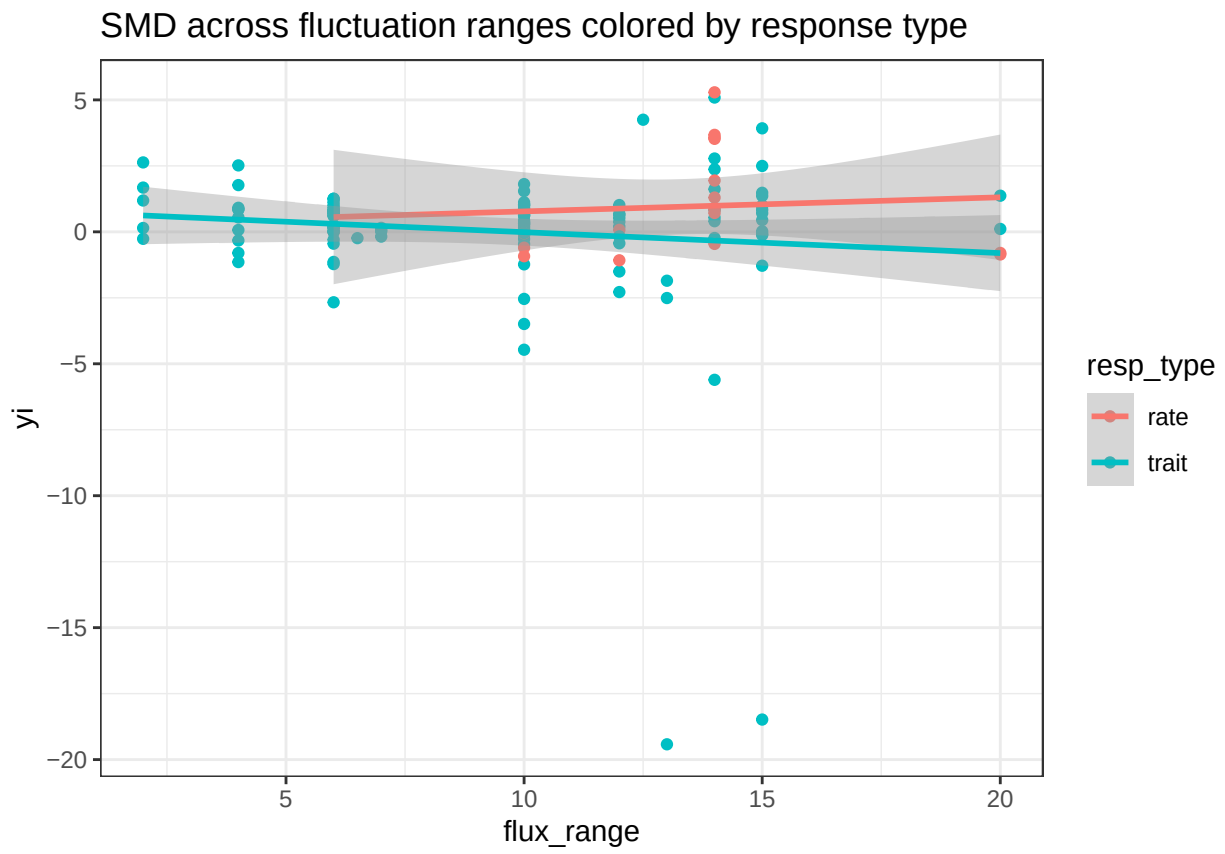

Figure 5.

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.

```
##
## Multivariate Meta-Analysis Model (k = 140; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                 factor
## sigma^2.1  0.0000  0.0002      2     no          experiment_id
## sigma^2.2  0.5980  0.7733     19     no  experiment_id/study_id
##
## Test for Heterogeneity:
## Q(df = 139) = 5373.4640, p-val < .0001
##
## Model Results:
##
## estimate      se    zval    pval    ci.lb   ci.ub
```

```
##   0.1261  0.1808  0.6976  0.4854  -0.2282  0.4804
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Relevant Plots

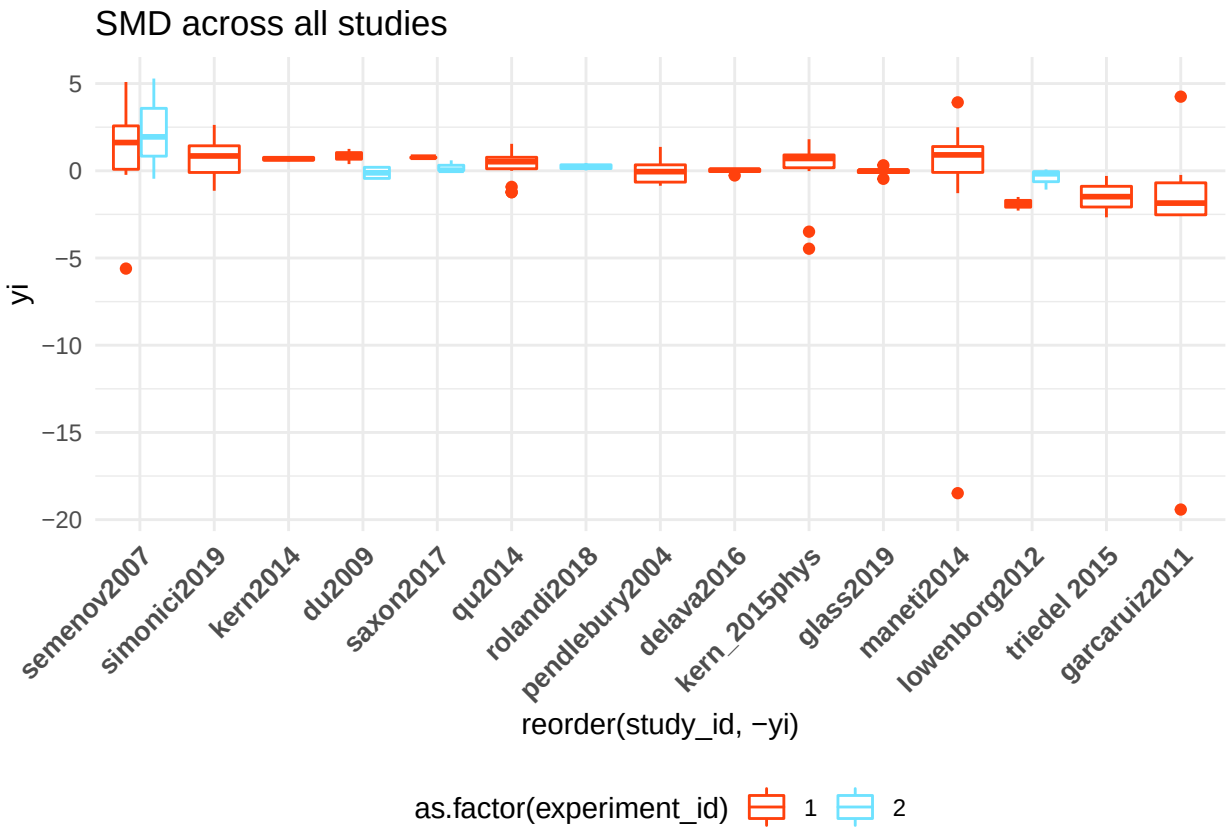

Figure 6. When we look at experiment and study, we can see across the 15 studies included in this meta-analysis there are differences across and within experiments.

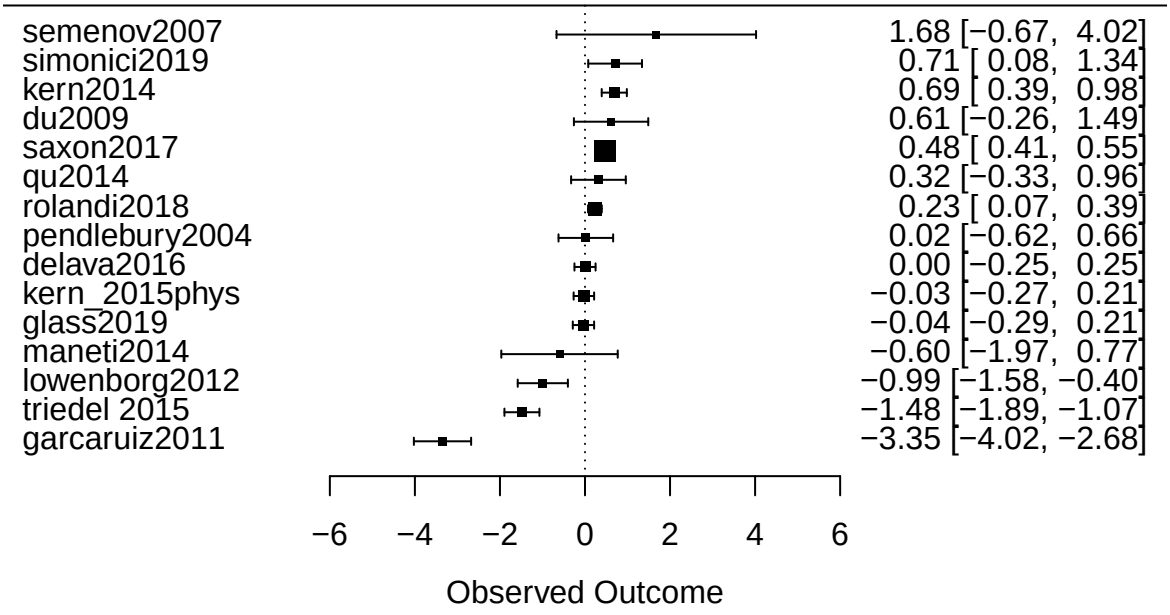

Figure 7. I kind of like this figure better than the boxplot in Figure 5 as an overall figure?

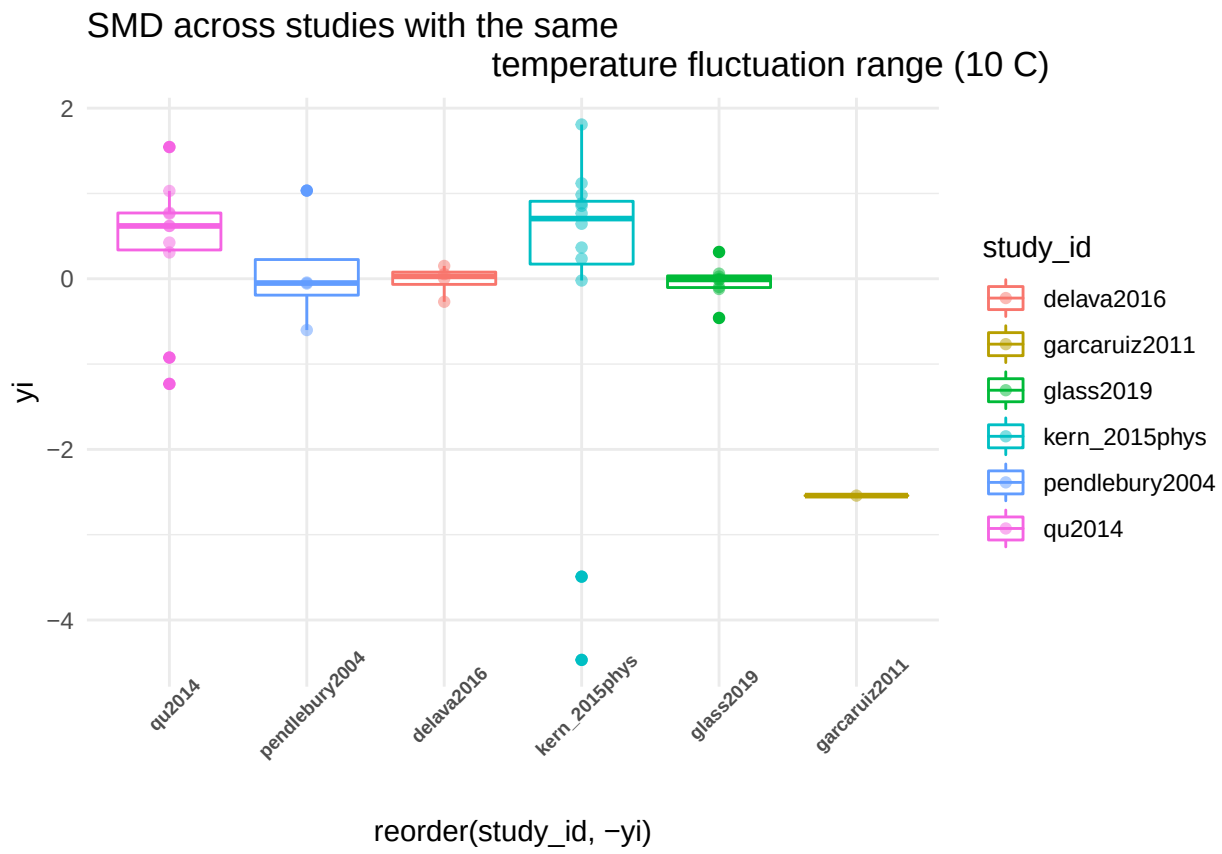
SMD across studies with the same
temperature fluctuation range (10 C)
yi
2
0
−2
−4
qu2014
pendlebury2004
delava2016
kern_2015phys
glass2019
garcaruiz2011
reorder(study_id, −yi)
study_id
delava2016
garcaruiz2011
glass2019
kern_2015phys
pendlebury2004
qu2014

Figure 8.

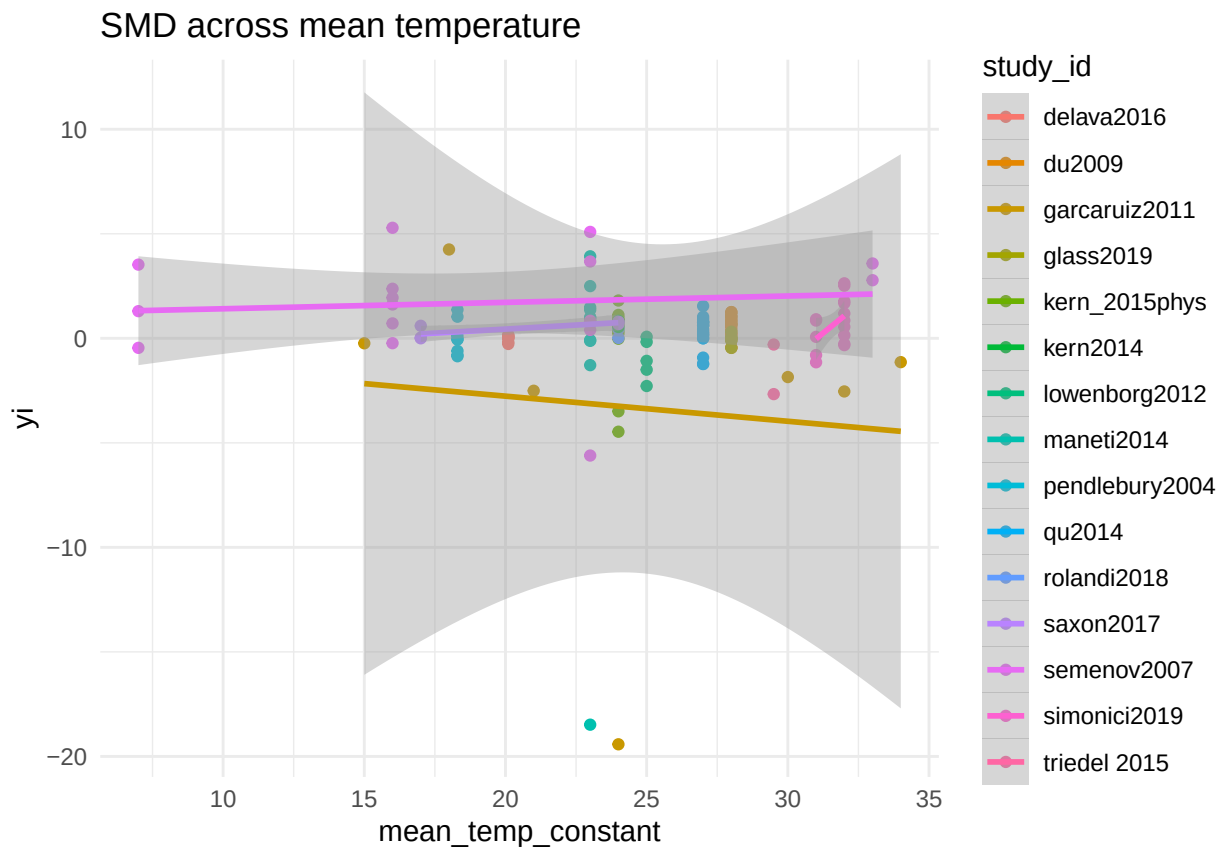
SMD across mean temperature
yi
10
0
−10
−20
10
15
20
25
30
35
mean_temp_constant
study_id
delava2016
du2009
garcaruiz2011
glass2019
kern_2015phys
kern2014
lowenborg2012
maneti2014
pendlebury2004
qu2014
rolandi2018
saxon2017
semenov2007
simonici2019
triedel 2015

Figure 9.

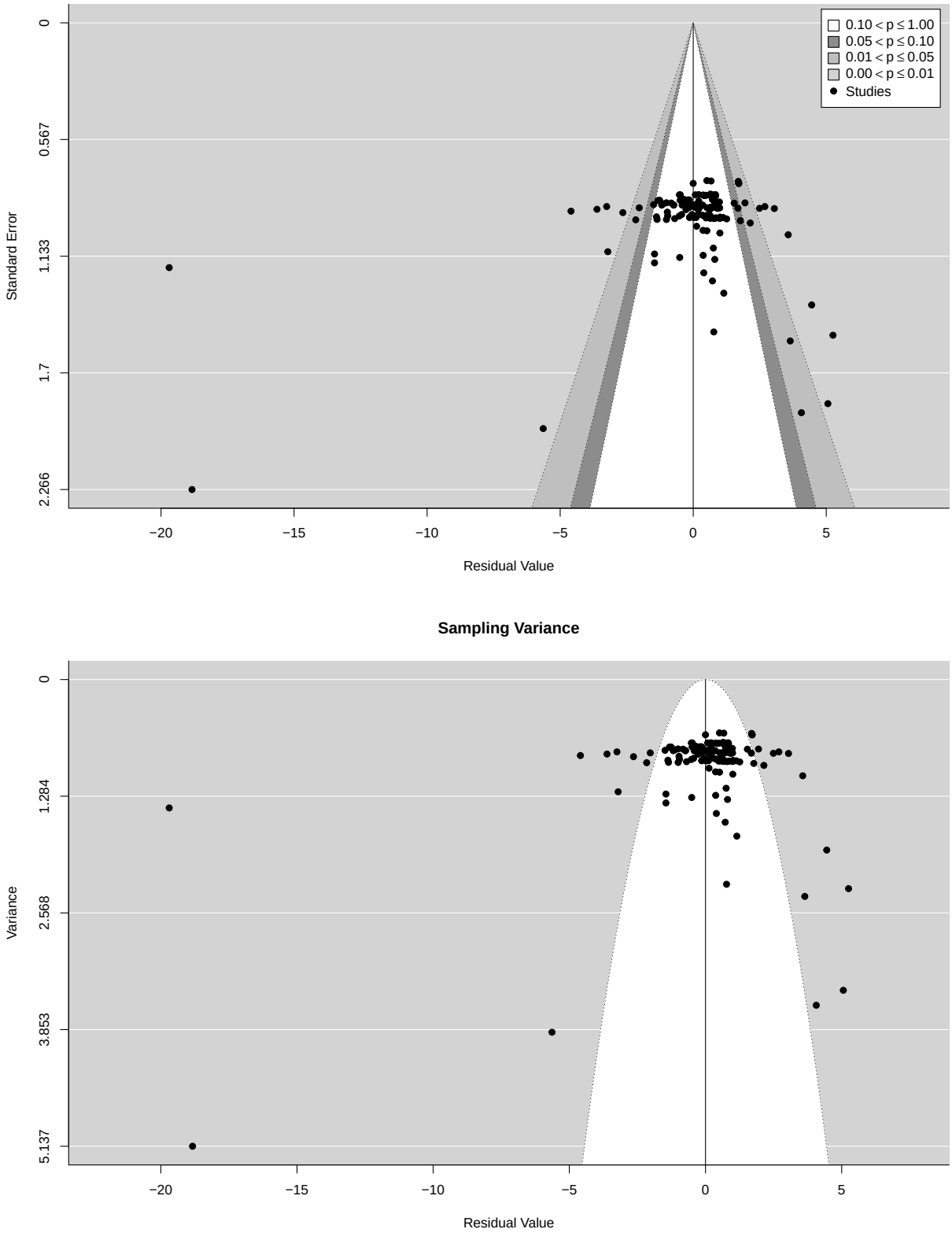

Figure 10. Well, from what I can gather, a majority of the effect sizes from our meta-analysis have a

non-signficant effect size value. However, there is a population of a couple influential effect sizes that are significantly important.

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.
```