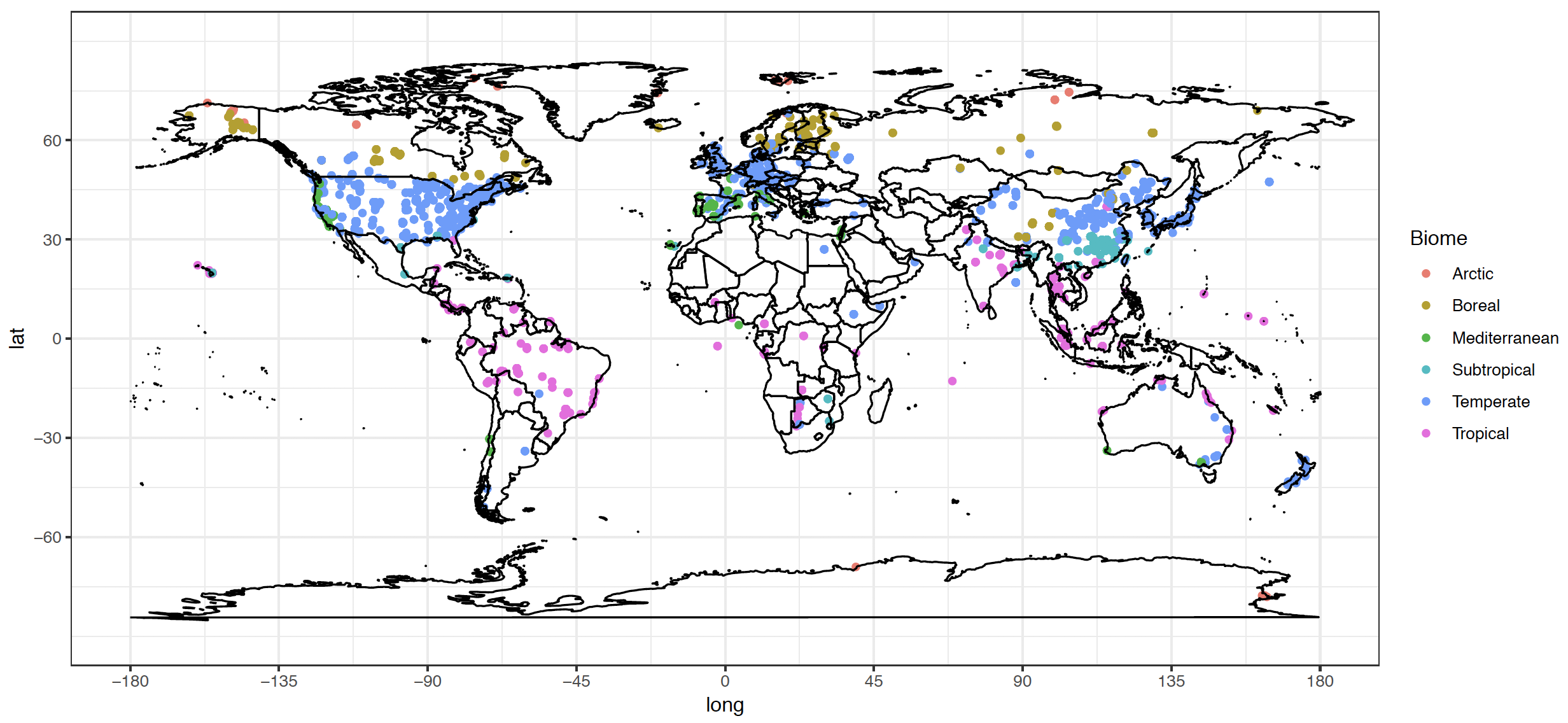
|  |
| --- |
| Title: Can soil respiration measured at mean temperature represents actual soil respiration |
| author: “Jinshi” |
| date: “March 26, 2019” |
| output: |
| html\_document: |
| df\_print: paged |
| bibliography: bibliography.ris |

# 1. The spatial destribution of global Rs sites

* We have much more measured Rs from the middle latitude region
* It is difficult to measure soil respiration all year around in the cold region
* Developed contries most located at Middle latitude region, thus recieved more funds to support the Rs measurements



Global spatial destribution of soil repiration sites

* Rs measurements from cold region is more importent, but how to increase the measurements?
* Making equipment works normal in cold condition
* Increase funds input
* Measured once per day to get daily mean
* Measure once per year to get a annual Rs mean? **Bahn’s approach** [Bahn et al. (2004) Biogeosciences]
* Rs measured at annuam mean temperature linearly related with annual Rs rate
* Rs at mean temperature: soil respiration measured at annual mean temperature / monthly mean temperature / daily mean temperature
* Rs\_annual ~ Rs\_mat (Rs\_bahn)
* Rs\_annual = 455.8 \* Rs\_mat^1.0054 (R^2 = 0.94, p<0.001)

# 2. The object of this analysis are

* Whether Rs measured at annuam mean soil temperature can represent annual Rs rate?
* Annuam mean air temperature (e.g., average of 12 monthes’ air temperature of 2000) / Mean annual air temperature (1964-2014)
* If not, when and what is the mechanism?
* Update the model?

# 3. Mthods

**Data**

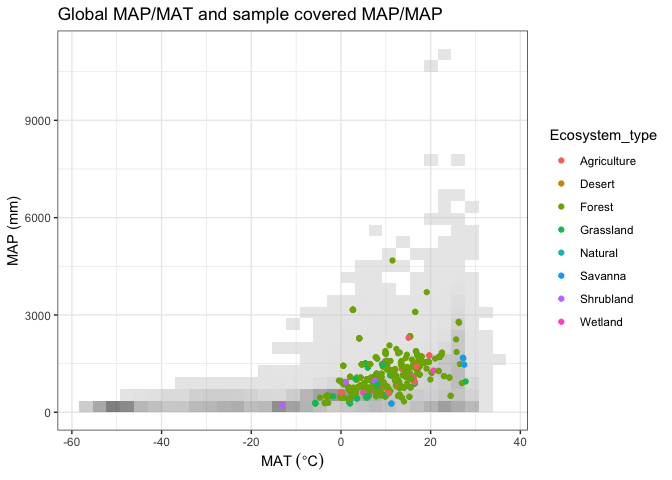
* SRDB\_V4 – Rs\_Annual
* Annual mean soil temperature (reported in the papers or can be calculated with simple assumption)
* Relationship between Rs and soil temperature (SRDB\_V4)
* Air temperature (University of Daleware global precipitation and air temperature data, 1964-2014, half degree spatial resolusion)
* 823 records from 253 studies

**Statistics**

* According the the relationship between Rs and Ts, we can estimate Rs\_mat base on the annual mean soil temperature / T\_Annual / MAT
* Using Bahn (2010, Biogeoscience model: Rs\_annual = 455.8 \* Rs\_mat^1.0054) to predict Rs\_annual based on Rs\_mat
* Comparing Rs\_annual and Rs\_annual\_bahn to evaluate the performance of Bahn model across the global

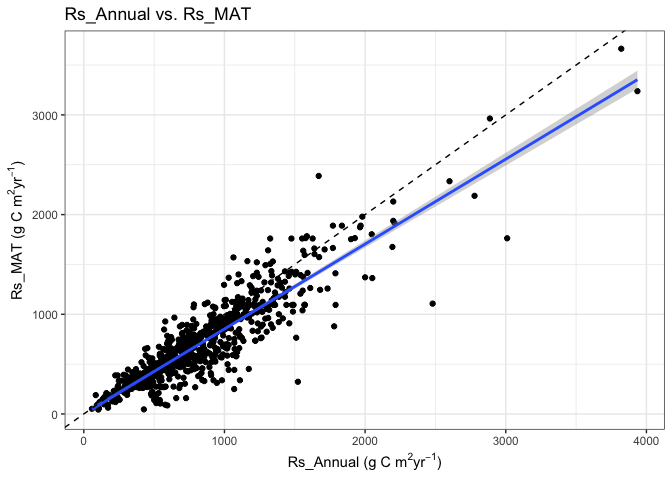
**Update Bahn’s model**

* If Bahn (2010) model does not predict Rs\_annual in all conditions
* Update Bahn (2010) model (e.g., including drought parameter, other parameters?)
* Regression tree modeling?



## 3.2 test the relationship between Rs\_annual and Rs\_mat

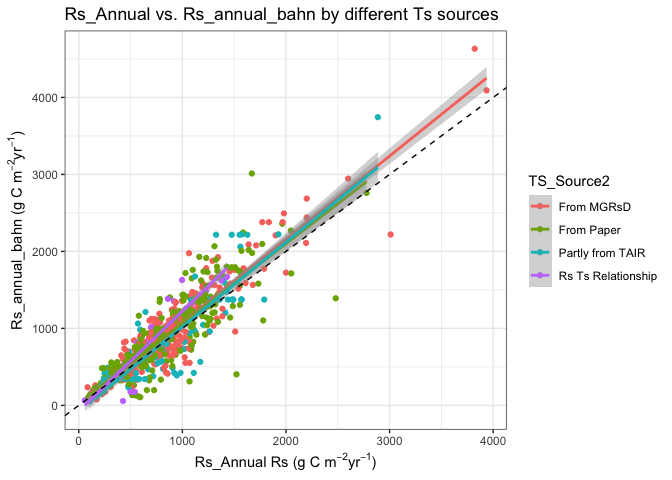
## Wed Apr 3 11:03:03 2019 -------------------  
## Wed Apr 3 11:03:03 2019 Bahn relationship for these data:  
##   
## Call:  
## lm(formula = Rs\_TAIR ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1006.45 -84.72 14.90 93.38 964.58   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.64266 13.67584 0.047 0.963   
## Rs\_annual 0.85184 0.01466 58.126 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 185.1 on 821 degrees of freedom  
## Multiple R-squared: 0.8045, Adjusted R-squared: 0.8043   
## F-statistic: 3379 on 1 and 821 DF, p-value: < 2.2e-16



## [1] "test intercept=0 and slope=1"  
## [1] "p\_intercept = 0.9625, p\_slope = 0"

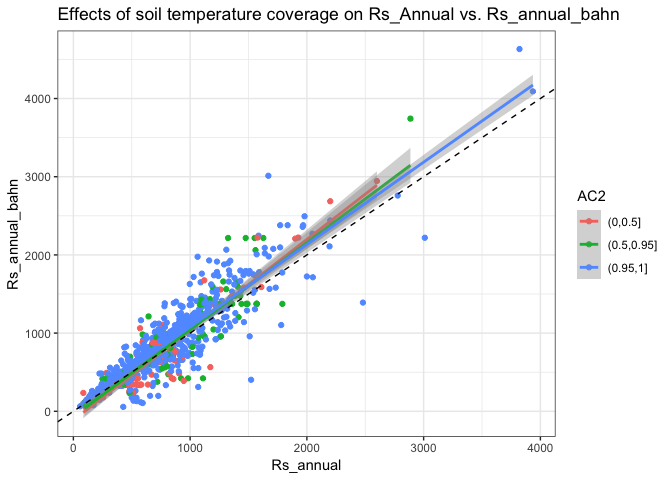
## 3.3 Ts sources (MGRsD, MGRsD\_TAIR, From paper, Rs\_Ts\_relationship)

## Saving 7 x 5 in image

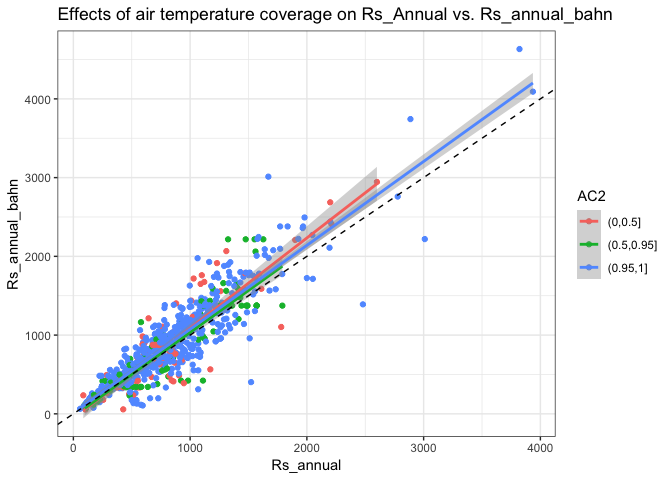


## 3.4 Annual Rs or Ts coverage effect

## Saving 7 x 5 in image



## Saving 7 x 5 in image



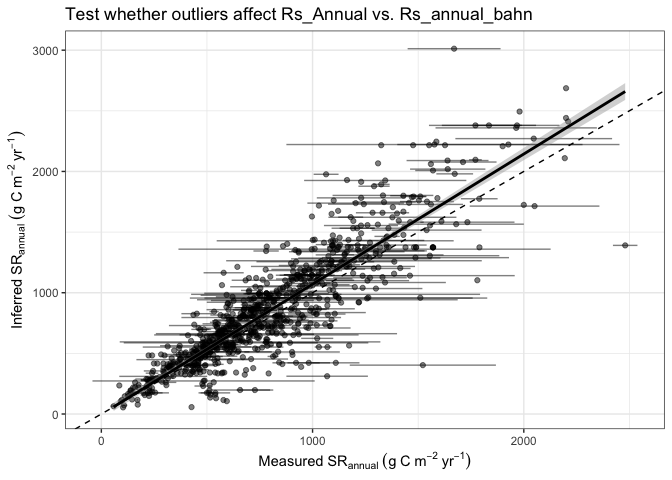
## 3.4.1 Test whether outliers affect the regression (need update)

* Conclusion: need update the code and results

## Wed Apr 3 11:03:06 2019 -------------------  
## Wed Apr 3 11:03:06 2019 3.4.1\_Test outlier  
## Wed Apr 3 11:03:06 2019 -------------------  
## Wed Apr 3 11:03:06 2019 Doing main figure comparing Rs\_annual and Rs\_annual\_bahn

## Wed Apr 3 11:03:07 2019 Saving outputs/4.2.1-Rs (Figure 2)-3.4.1\_Test outlier.pdf

## Saving 7 x 5 in image

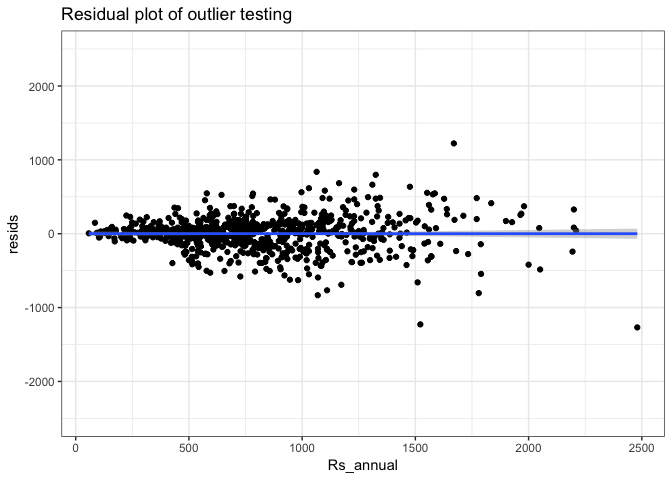


## Wed Apr 3 11:03:07 2019 -------------------  
## Wed Apr 3 11:03:07 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:07 2019 sdata rows = 817 cols = 35  
## Wed Apr 3 11:03:07 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1268.81 -106.13 19.11 112.93 1222.65   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -3.44879 18.40984 -0.187 0.851   
## Rs\_annual 1.07364 0.02057 52.207 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 229.6 on 815 degrees of freedom  
## Multiple R-squared: 0.7698, Adjusted R-squared: 0.7695   
## F-statistic: 2726 on 1 and 815 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:07 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:07 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:07 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:07 2019 Test H0 of intercept=0: p-value = 0.8514454  
## Wed Apr 3 11:03:07 2019 Test H0 of slope=1: p-value = 0.0003626346

## [1] 0.8514454

## [1] 0.0003626346

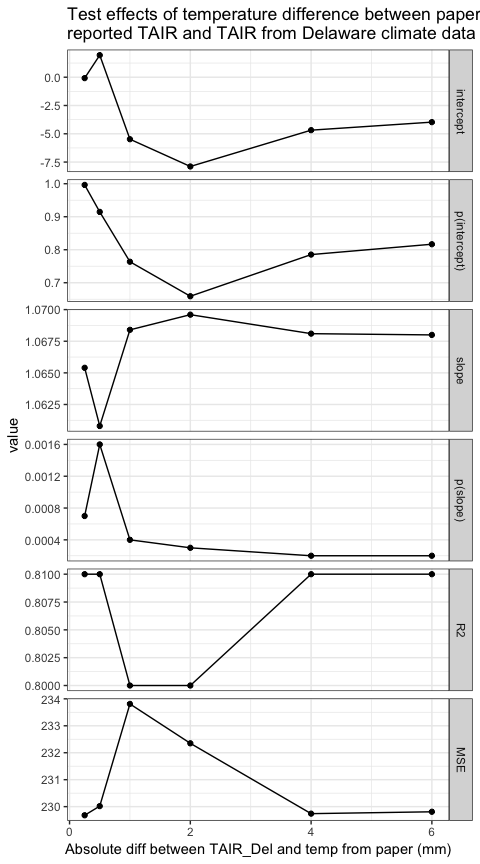
## 3.4.2 Effect of maximum allowed divergence between global climate data set and site-specific air temperature

* Does TAIR\_dev and TAIR\_LT<\_dev affect the relationship – YES!!!!!
* TAIR\_LTM\_dev = with( srdb, abs( MAT\_Del - MAT ) )
* Does TAIR\_LTM\_dev () pull the slope off 1? – YES!!!!!
* TAIR\_dev <- with( srdb, abs( TAnnual\_Del - Study\_temp ) )
* Figure E. Effect of maximum allowed divergence between global climate data set and site-specific air temperature, when given. As we throw out data points with high divergence, R2 goes up (top panel) and RSE goes down (bottom, g C m-2 yr-1).

## Wed Apr 3 11:03:08 2019 srdb rows = 823 cols = 35  
## Wed Apr 3 11:03:08 2019 srdb rows = 823 cols = 35  
## Wed Apr 3 11:03:08 2019 srdb rows = 823 cols = 35  
## Wed Apr 3 11:03:08 2019 srdb rows = 823 cols = 35  
## Wed Apr 3 11:03:08 2019 srdb rows = 823 cols = 35  
## Wed Apr 3 11:03:08 2019 srdb rows = 823 cols = 35

## Wed Apr 3 11:03:08 2019 -------------------

## TAIR\_LTM\_dev intercept p(intercept) slope p(slope) R2 MSE n  
## 1 6.00 -3.97 0.8167 1.0680 0.0002 0.81 229.81 800  
## 2 4.00 -4.68 0.7853 1.0681 0.0002 0.81 229.74 797  
## 3 2.00 -7.89 0.6591 1.0696 0.0003 0.80 232.35 764  
## 4 1.00 -5.48 0.7636 1.0684 0.0004 0.80 233.81 751  
## 5 0.50 1.95 0.9146 1.0608 0.0016 0.81 230.02 725  
## 6 0.25 -0.08 0.9964 1.0654 0.0007 0.81 229.68 712

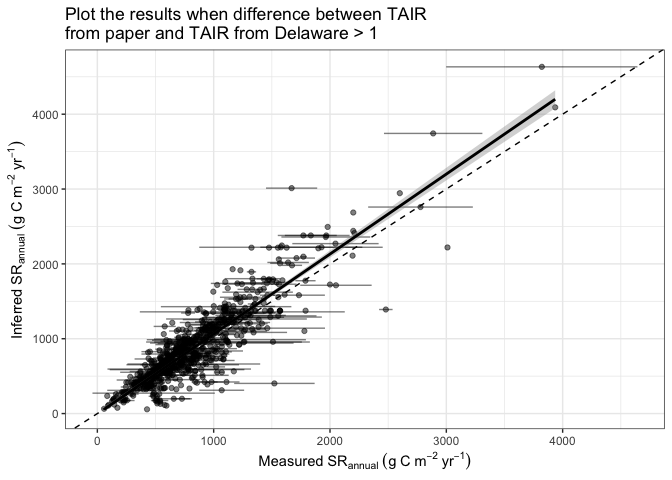


## Wed Apr 3 11:03:08 2019 srdb rows = 823 cols = 35

## Wed Apr 3 11:03:08 2019 -------------------  
## Wed Apr 3 11:03:08 2019 3.4.2\_TAIR\_LTM\_dev set to 1  
## Wed Apr 3 11:03:08 2019 -------------------  
## Wed Apr 3 11:03:08 2019 Doing main figure comparing Rs\_annual and Rs\_annual\_bahn

## Wed Apr 3 11:03:09 2019 Saving outputs/4.2.1-Rs (Figure 2)-3.4.2\_TAIR\_LTM\_dev set to 1.pdf

## Saving 7 x 5 in image

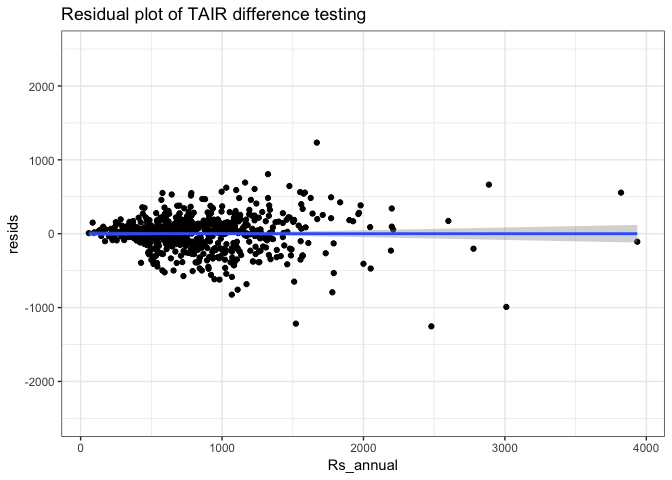


## Wed Apr 3 11:03:09 2019 -------------------  
## Wed Apr 3 11:03:09 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:09 2019 sdata rows = 751 cols = 35  
## Wed Apr 3 11:03:09 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1253.85 -107.92 22.54 117.26 1233.39   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -5.47844 18.20691 -0.301 0.764   
## Rs\_annual 1.06843 0.01938 55.121 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 233.8 on 749 degrees of freedom  
## Multiple R-squared: 0.8022, Adjusted R-squared: 0.802   
## F-statistic: 3038 on 1 and 749 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:09 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:09 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:09 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:10 2019 Test H0 of intercept=0: p-value = 0.7635749  
## Wed Apr 3 11:03:10 2019 Test H0 of slope=1: p-value = 0.0004404997

## [1] 0.7635749

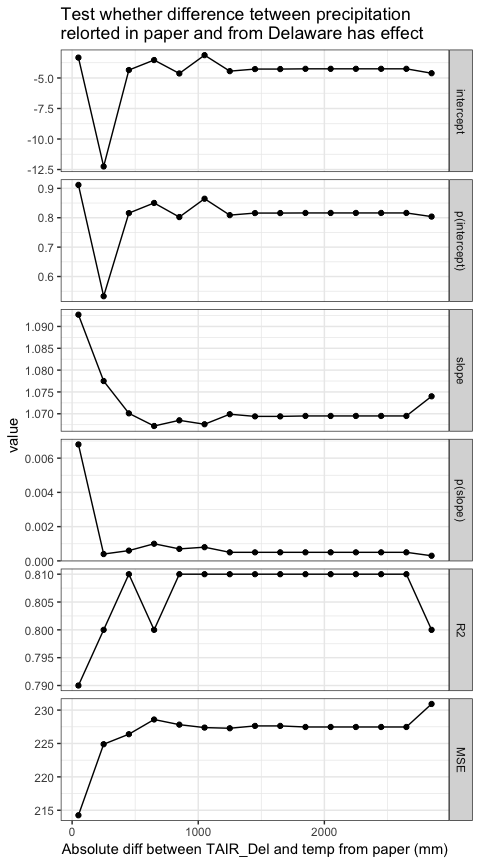
## [1] 0.0004404997

## 3.4.3 Effect of maximum allowed divergence between annual precipitation from paper and Del

## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
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## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36  
## Wed Apr 3 11:03:10 2019 srdb rows = 823 cols = 36

## Wed Apr 3 11:03:10 2019 -------------------

## PRECIP\_MAP\_dev intercept p(intercept) slope p(slope) R2 MSE n  
## 1 50 -3.33 0.9117 1.0927 0.0068 0.79 214.25 283  
## 2 250 -12.25 0.5329 1.0775 0.0004 0.80 224.89 610  
## 3 450 -4.35 0.8158 1.0701 0.0006 0.81 226.39 651  
## 4 650 -3.53 0.8503 1.0672 0.0010 0.80 228.59 671  
## 5 850 -4.63 0.8023 1.0685 0.0007 0.81 227.82 677  
## 6 1050 -3.13 0.8647 1.0676 0.0008 0.81 227.38 685  
## 7 1250 -4.44 0.8089 1.0699 0.0005 0.81 227.28 687  
## 8 1450 -4.27 0.8159 1.0694 0.0005 0.81 227.63 691  
## 9 1650 -4.27 0.8159 1.0694 0.0005 0.81 227.63 691  
## 10 1850 -4.25 0.8163 1.0695 0.0005 0.81 227.47 692  
## 11 2050 -4.25 0.8163 1.0695 0.0005 0.81 227.47 692  
## 12 2250 -4.25 0.8163 1.0695 0.0005 0.81 227.47 692  
## 13 2450 -4.25 0.8163 1.0695 0.0005 0.81 227.47 692  
## 14 2650 -4.25 0.8163 1.0695 0.0005 0.81 227.47 692  
## 15 2850 -4.61 0.8039 1.0740 0.0003 0.80 230.92 696

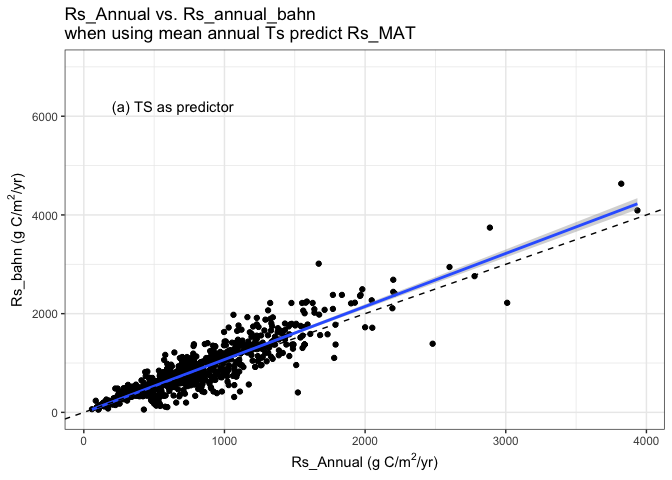


# 4. Results

## 4.1 Using Ts, TAnnual or MAT

### 4.1.1 Using soil temperature

##   
## Call:  
## lm(formula = bahn ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1270.56 -106.41 19.13 116.92 1221.77   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -4.35814 17.24982 -0.253 0.801   
## Rs\_annual 1.07472 0.01849 58.140 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 233.5 on 821 degrees of freedom  
## Multiple R-squared: 0.8046, Adjusted R-squared: 0.8043   
## F-statistic: 3380 on 1 and 821 DF, p-value: < 2.2e-16

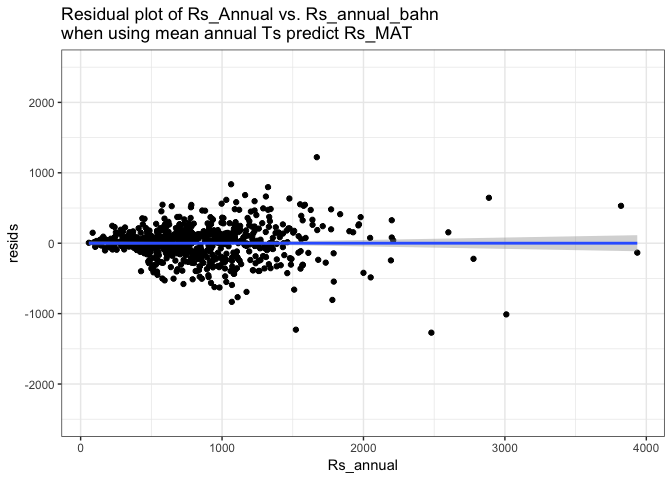


## Wed Apr 3 11:03:11 2019 -------------------  
## Wed Apr 3 11:03:11 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:11 2019 sdata rows = 823 cols = 143  
## Wed Apr 3 11:03:11 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1270.56 -106.41 19.13 116.92 1221.77   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -4.35814 17.24982 -0.253 0.801   
## Rs\_annual 1.07472 0.01849 58.140 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 233.5 on 821 degrees of freedom  
## Multiple R-squared: 0.8046, Adjusted R-squared: 0.8043   
## F-statistic: 3380 on 1 and 821 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:11 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:11 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:11 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:11 2019 Test H0 of intercept=0: p-value = 0.800603  
## Wed Apr 3 11:03:11 2019 Test H0 of slope=1: p-value = 5.798985e-05

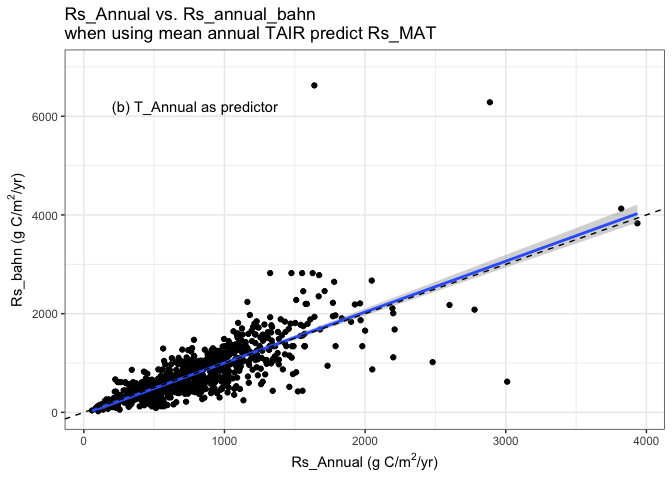
## [1] 0.800603

## [1] "slope = 0.075"

## [1] 5.798985e-05

### 4.1.2 Using T\_Annual

##   
## Call:  
## lm(formula = bahn ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -2450.9 -173.4 -0.7 152.1 4964.1   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -29.03769 27.56454 -1.053 0.292   
## Rs\_annual 1.03055 0.02954 34.889 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 373.1 on 821 degrees of freedom  
## Multiple R-squared: 0.5972, Adjusted R-squared: 0.5967   
## F-statistic: 1217 on 1 and 821 DF, p-value: < 2.2e-16

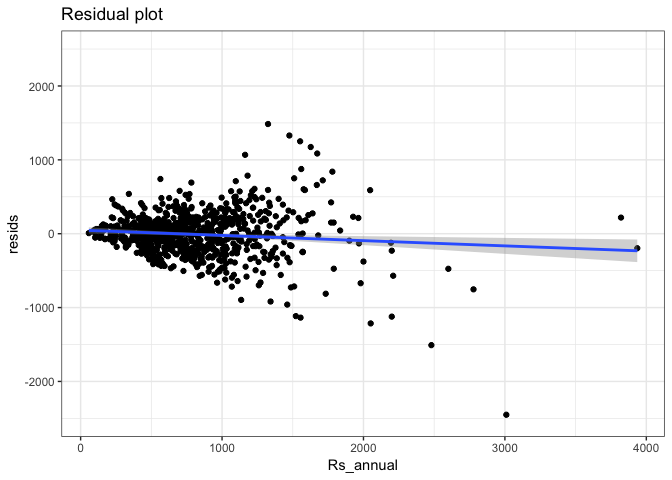


## Wed Apr 3 11:03:12 2019 -------------------  
## Wed Apr 3 11:03:12 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:12 2019 sdata rows = 823 cols = 143  
## Wed Apr 3 11:03:12 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -2450.9 -173.4 -0.7 152.1 4964.1   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -29.03769 27.56454 -1.053 0.292   
## Rs\_annual 1.03055 0.02954 34.889 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 373.1 on 821 degrees of freedom  
## Multiple R-squared: 0.5972, Adjusted R-squared: 0.5967   
## F-statistic: 1217 on 1 and 821 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:12 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:12 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:12 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:12 2019 Test H0 of intercept=0: p-value = 0.2924477  
## Wed Apr 3 11:03:12 2019 Test H0 of slope=1: p-value = 0.3012956

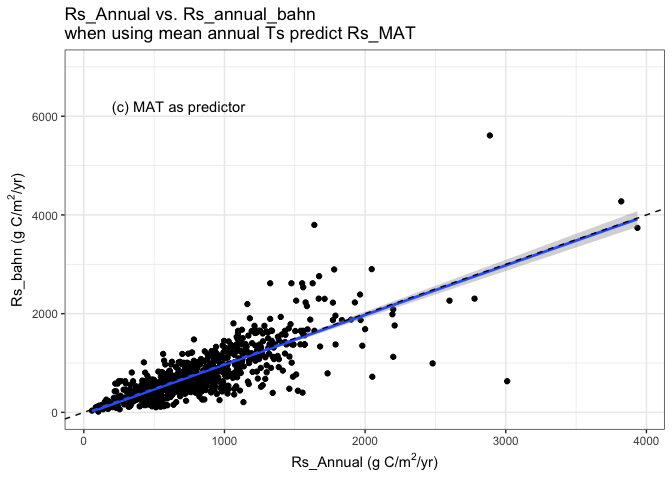
## [1] 0.2924477

## [1] "slope = 0.031"

## [1] 0.3012956

### 4.1.3 Using MAT

##   
## Call:  
## lm(formula = bahn ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -2357.10 -167.81 -1.63 142.82 2745.59   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -32.10088 24.31519 -1.32 0.187   
## Rs\_annual 1.00343 0.02606 38.51 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 329.1 on 821 degrees of freedom  
## Multiple R-squared: 0.6437, Adjusted R-squared: 0.6432   
## F-statistic: 1483 on 1 and 821 DF, p-value: < 2.2e-16

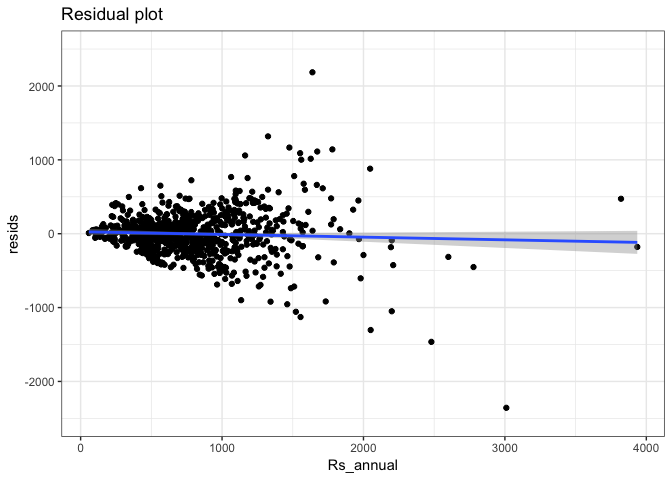


## Wed Apr 3 11:03:13 2019 -------------------  
## Wed Apr 3 11:03:13 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:13 2019 sdata rows = 823 cols = 143  
## Wed Apr 3 11:03:13 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -2357.10 -167.81 -1.63 142.82 2745.59   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -32.10088 24.31519 -1.32 0.187   
## Rs\_annual 1.00343 0.02606 38.51 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 329.1 on 821 degrees of freedom  
## Multiple R-squared: 0.6437, Adjusted R-squared: 0.6432   
## F-statistic: 1483 on 1 and 821 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:13 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:13 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:13 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:13 2019 Test H0 of intercept=0: p-value = 0.1871366  
## Wed Apr 3 11:03:13 2019 Test H0 of slope=1: p-value = 0.8953088

## [1] 0.1871366

## [1] "slope = 0.003"

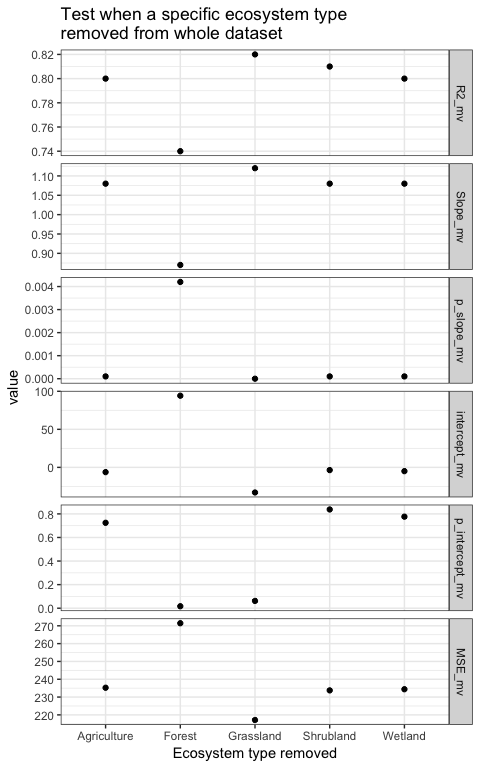
## [1] 0.8953088

## 4.2 Analysis when Rs\_mat cannot represent Rs\_annual

## 4.2.2 Does Ecosystem\_type affects the relationship between Rs\_annual and Rs\_mat

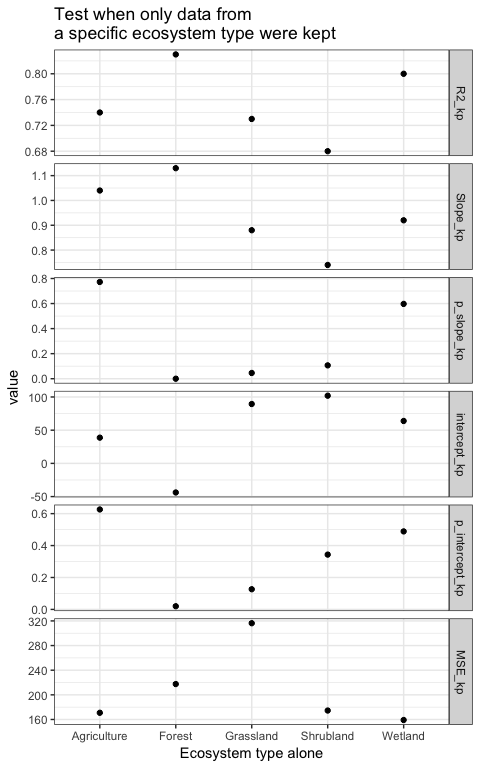
## Ecosystem R2\_mv Slope\_mv p\_slope\_mv intercept\_mv  
## Rs\_annual Agriculture 0.80 1.08 0.0001 -6.25  
## Rs\_annual1 Forest 0.74 0.87 0.0042 94.20  
## Rs\_annual2 Grassland 0.82 1.12 0.0000 -33.00  
## Rs\_annual3 Shrubland 0.81 1.08 0.0001 -3.57  
## Rs\_annual4 Wetland 0.80 1.08 0.0001 -4.97  
## p\_intercept\_mv MSE\_mv  
## Rs\_annual 0.7245 235.24  
## Rs\_annual1 0.0167 271.45  
## Rs\_annual2 0.0617 217.13  
## Rs\_annual3 0.8376 233.75  
## Rs\_annual4 0.7765 234.40

## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?



## Ecosystem R2\_kp Slope\_kp p\_slope\_kp intercept\_kp  
## Rs\_annual Agriculture 0.74 1.04 0.7725 38.73  
## Rs\_annual1 Forest 0.83 1.13 0.0000 -43.81  
## Rs\_annual2 Grassland 0.73 0.88 0.0459 89.44  
## Rs\_annual3 Shrubland 0.68 0.74 0.1066 101.92  
## Rs\_annual4 Wetland 0.80 0.92 0.5972 63.88  
## p\_intercept\_kp MSE\_kp  
## Rs\_annual 0.6262 170.87  
## Rs\_annual1 0.0199 217.52  
## Rs\_annual2 0.1264 316.26  
## Rs\_annual3 0.3434 174.53  
## Rs\_annual4 0.4887 159.16

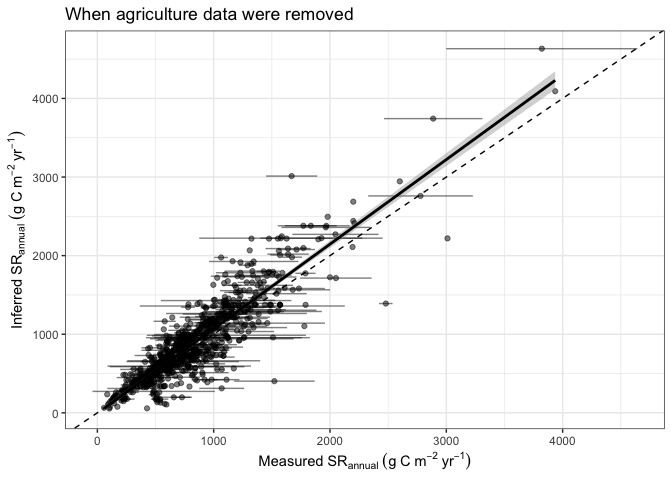
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?



## Wed Apr 3 11:03:15 2019 -------------------  
## Wed Apr 3 11:03:15 2019 -------------------  
## Wed Apr 3 11:03:15 2019 Doing main figure comparing Rs\_annual and Rs\_annual\_bahn

## Wed Apr 3 11:03:16 2019 Saving outputs/4.2.1-Rs (Figure 2).pdf

## Saving 7 x 5 in image

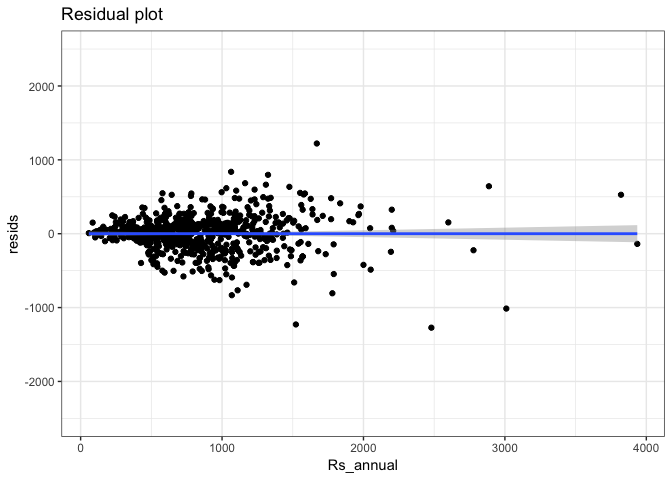


## Wed Apr 3 11:03:16 2019 -------------------  
## Wed Apr 3 11:03:16 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:16 2019 sdata rows = 799 cols = 35  
## Wed Apr 3 11:03:16 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1272.24 -109.95 18.01 118.71 1221.26   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -6.25256 17.73532 -0.353 0.725   
## Rs\_annual 1.07616 0.01884 57.115 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 235.2 on 797 degrees of freedom  
## Multiple R-squared: 0.8037, Adjusted R-squared: 0.8034   
## F-statistic: 3262 on 1 and 797 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:16 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:16 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:16 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:16 2019 Test H0 of intercept=0: p-value = 0.7245201  
## Wed Apr 3 11:03:16 2019 Test H0 of slope=1: p-value = 5.815127e-05

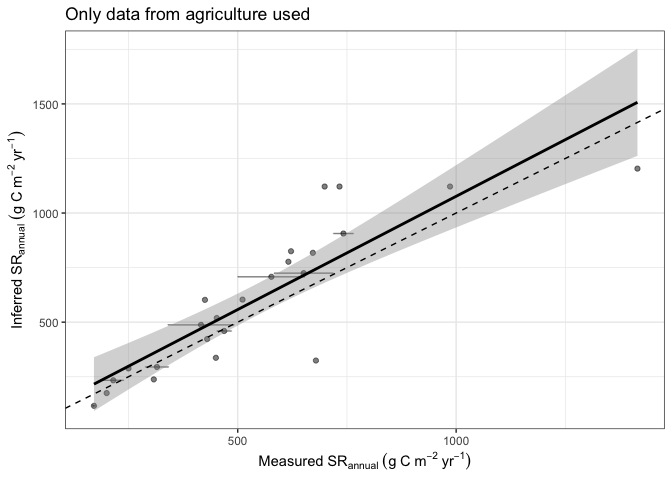
## [1] 0.7245201

## [1] 5.815127e-05

## Wed Apr 3 11:03:16 2019 -------------------  
## Wed Apr 3 11:03:16 2019 -------------------  
## Wed Apr 3 11:03:16 2019 Doing main figure comparing Rs\_annual and Rs\_annual\_bahn

## Wed Apr 3 11:03:17 2019 Saving outputs/4.2.1-Rs (Figure 2).pdf

## Saving 7 x 5 in image

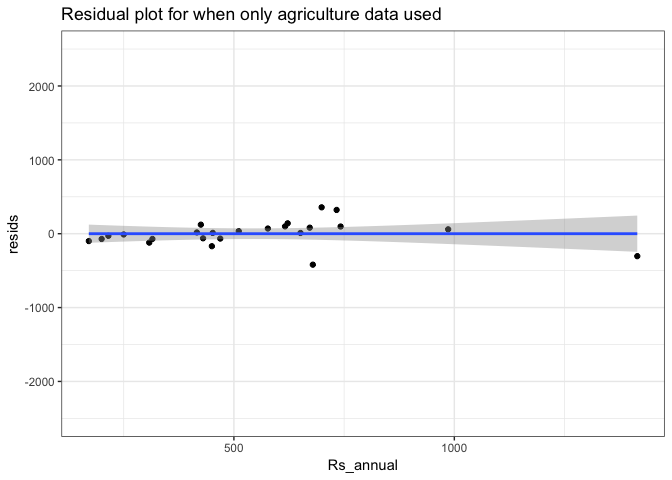


## Wed Apr 3 11:03:17 2019 -------------------  
## Wed Apr 3 11:03:17 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:17 2019 sdata rows = 24 cols = 35  
## Wed Apr 3 11:03:17 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -419.32 -71.05 10.60 85.48 357.17   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 38.7305 78.3951 0.494 0.626   
## Rs\_annual 1.0379 0.1296 8.010 5.78e-08 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 170.9 on 22 degrees of freedom  
## Multiple R-squared: 0.7447, Adjusted R-squared: 0.7331   
## F-statistic: 64.17 on 1 and 22 DF, p-value: 5.778e-08  
##   
## Wed Apr 3 11:03:17 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:17 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:17 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:17 2019 Test H0 of intercept=0: p-value = 0.6261729  
## Wed Apr 3 11:03:17 2019 Test H0 of slope=1: p-value = 0.7724564

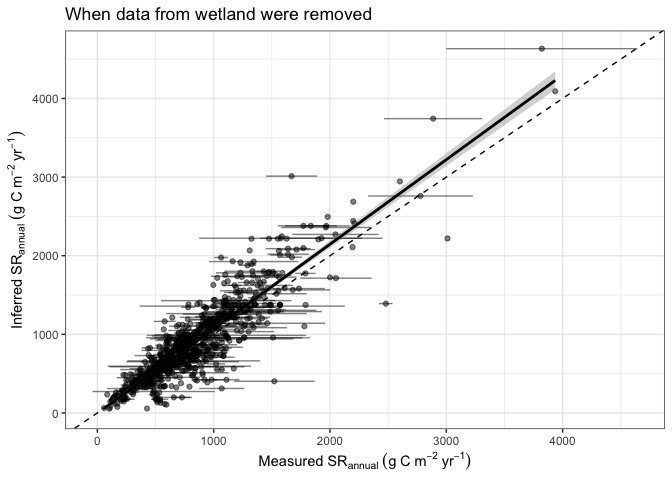
## [1] 0.6261729

## [1] "Agriculture alone, p value for slope = 0.77"

## Wed Apr 3 11:03:18 2019 -------------------  
## Wed Apr 3 11:03:18 2019 -------------------  
## Wed Apr 3 11:03:18 2019 Doing main figure comparing Rs\_annual and Rs\_annual\_bahn

## Wed Apr 3 11:03:19 2019 Saving outputs/4.2.1-Rs (Figure 2).pdf

## Saving 7 x 5 in image

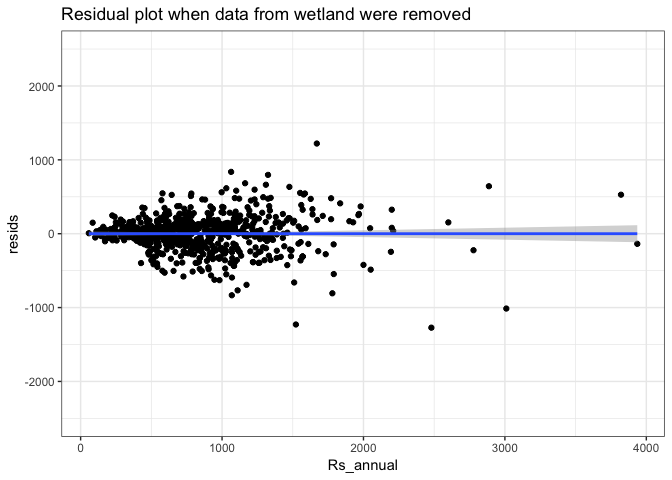


## Wed Apr 3 11:03:19 2019 -------------------  
## Wed Apr 3 11:03:19 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:19 2019 sdata rows = 812 cols = 35  
## Wed Apr 3 11:03:19 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1272.17 -106.27 18.95 118.95 1220.89   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -4.97330 17.51551 -0.284 0.777   
## Rs\_annual 1.07561 0.01869 57.540 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 234.4 on 810 degrees of freedom  
## Multiple R-squared: 0.8034, Adjusted R-squared: 0.8032   
## F-statistic: 3311 on 1 and 810 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:19 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:19 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:19 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:19 2019 Test H0 of intercept=0: p-value = 0.7765312  
## Wed Apr 3 11:03:19 2019 Test H0 of slope=1: p-value = 5.735639e-05

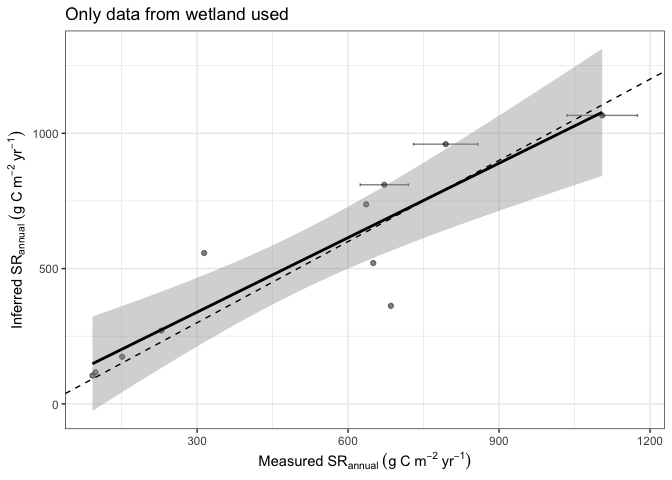
## [1] 0.7765312

## [1] 5.735639e-05

## Wed Apr 3 11:03:19 2019 -------------------  
## Wed Apr 3 11:03:19 2019 -------------------  
## Wed Apr 3 11:03:19 2019 Doing main figure comparing Rs\_annual and Rs\_annual\_bahn

## Wed Apr 3 11:03:20 2019 Saving outputs/4.2.1-Rs (Figure 2).pdf

## Saving 7 x 5 in image

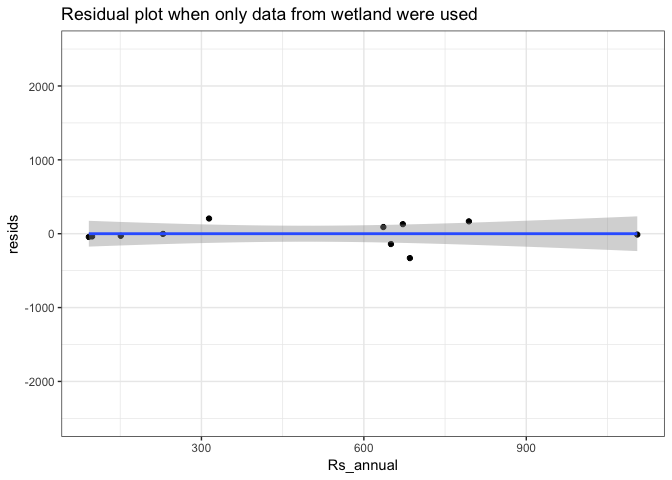


## Wed Apr 3 11:03:20 2019 -------------------  
## Wed Apr 3 11:03:20 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:20 2019 sdata rows = 11 cols = 35  
## Wed Apr 3 11:03:20 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -330.05 -40.34 -11.38 109.88 205.68   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 63.8791 88.4994 0.722 0.488743   
## Rs\_annual 0.9174 0.1507 6.086 0.000182 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 159.2 on 9 degrees of freedom  
## Multiple R-squared: 0.8045, Adjusted R-squared: 0.7828   
## F-statistic: 37.04 on 1 and 9 DF, p-value: 0.0001823  
##   
## Wed Apr 3 11:03:20 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:20 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:20 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:20 2019 Test H0 of intercept=0: p-value = 0.4887431  
## Wed Apr 3 11:03:20 2019 Test H0 of slope=1: p-value = 0.5972095

## [1] 0.4887431

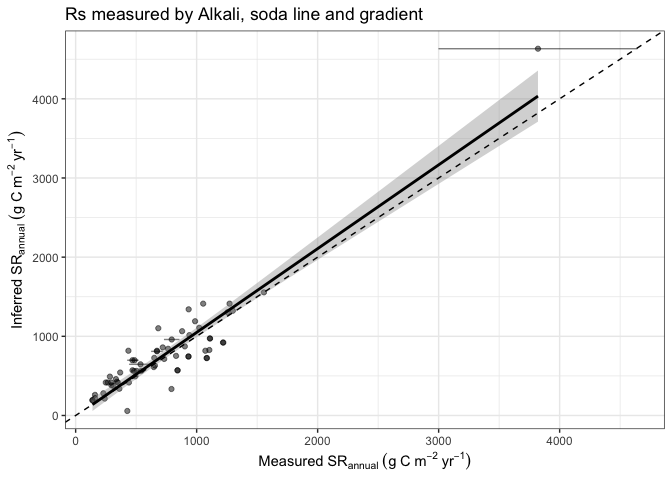
## [1] 0.5972095

## 4.2.3 Does Meas\_method affects the relationship

## Wed Apr 3 11:03:21 2019 -------------------  
## Wed Apr 3 11:03:21 2019 -------------------  
## Wed Apr 3 11:03:21 2019 Doing main figure comparing Rs\_annual and Rs\_annual\_bahn

## Wed Apr 3 11:03:21 2019 Saving outputs/4.2.1-Rs (Figure 2).pdf

## Saving 7 x 5 in image

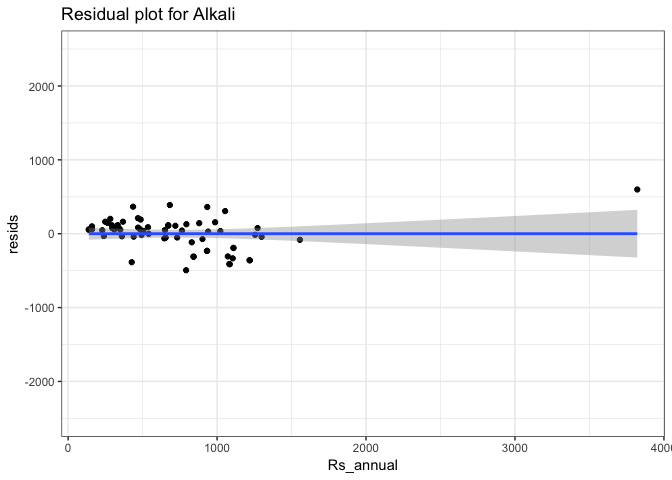


## Wed Apr 3 11:03:21 2019 -------------------  
## Wed Apr 3 11:03:21 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:21 2019 sdata rows = 64 cols = 35  
## Wed Apr 3 11:03:21 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -494.54 -74.91 48.01 114.80 598.56   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -9.05188 46.38773 -0.195 0.846   
## Rs\_annual 1.05818 0.05158 20.515 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 215.2 on 62 degrees of freedom  
## Multiple R-squared: 0.8716, Adjusted R-squared: 0.8695   
## F-statistic: 420.9 on 1 and 62 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:21 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:21 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:22 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:22 2019 Test H0 of intercept=0: p-value = 0.8459251  
## Wed Apr 3 11:03:22 2019 Test H0 of slope=1: p-value = 0.2636615

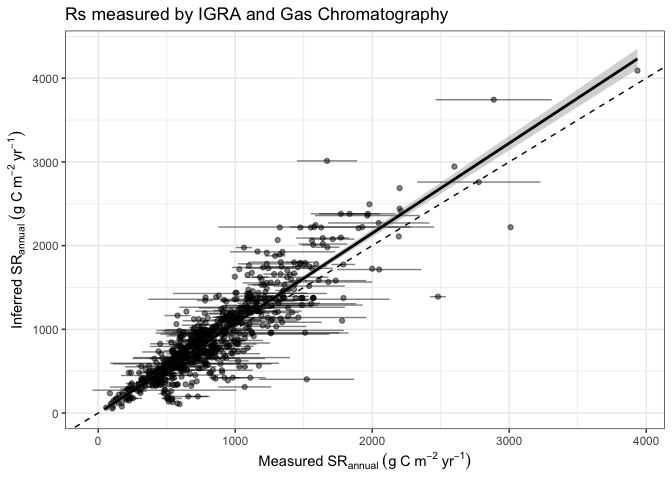
## [1] 0.8459251

## [1] 0.2636615

## Wed Apr 3 11:03:22 2019 -------------------  
## Wed Apr 3 11:03:22 2019 -------------------  
## Wed Apr 3 11:03:22 2019 Doing main figure comparing Rs\_annual and Rs\_annual\_bahn

## Wed Apr 3 11:03:22 2019 Saving outputs/4.2.1-Rs (Figure 2).pdf

## Saving 7 x 5 in image

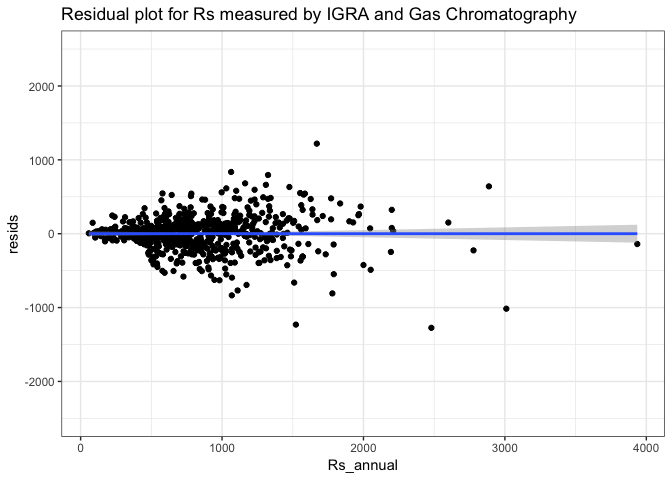


## Wed Apr 3 11:03:23 2019 -------------------  
## Wed Apr 3 11:03:23 2019 How are Rs\_annual and Rs\_annual\_bahn\_Temp related?  
## Wed Apr 3 11:03:23 2019 sdata rows = 759 cols = 35  
## Wed Apr 3 11:03:23 2019 Model summary:  
##   
## Call:  
## lm(formula = temp ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1274.11 -107.78 15.72 118.06 1219.27   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -4.01278 18.49850 -0.217 0.828   
## Rs\_annual 1.07601 0.01976 54.443 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 235.2 on 757 degrees of freedom  
## Multiple R-squared: 0.7966, Adjusted R-squared: 0.7963   
## F-statistic: 2964 on 1 and 757 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:23 2019 Plotting and saving model diagnostics...

## Wed Apr 3 11:03:23 2019 Plotting and saving model residuals...

## Wed Apr 3 11:03:23 2019 Saving outputs/3-modelresids.pdf

## Saving 7 x 5 in image



## Wed Apr 3 11:03:23 2019 Test H0 of intercept=0: p-value = 0.8283256  
## Wed Apr 3 11:03:23 2019 Test H0 of slope=1: p-value = 0.0001303059

## [1] 0.8283256

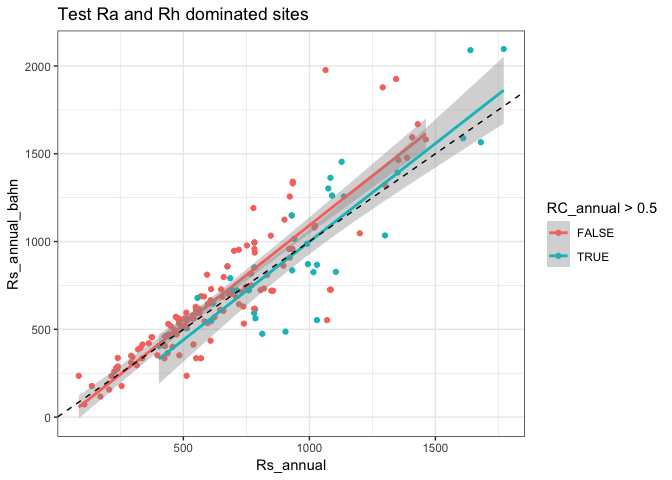
## [1] 0.0001303059

### 4.2.4 RA or RH dominated sites differ?

## Wed Apr 3 11:03:24 2019 -------------------  
## Wed Apr 3 11:03:24 2019 How does RC contribution affect this relationship?  
##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual \* (RC\_annual > 0.5),   
## data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -618.25 -88.18 8.28 74.49 812.62   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -39.21232 38.43903 -1.02 0.309   
## Rs\_annual 1.13078 0.05371 21.05 <2e-16 \*\*\*  
## RC\_annual > 0.5TRUE -80.77950 100.99778 -0.80 0.425   
## Rs\_annual:RC\_annual > 0.5TRUE -0.01172 0.10633 -0.11 0.912   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 180.9 on 156 degrees of freedom  
## (663 observations deleted due to missingness)  
## Multiple R-squared: 0.8073, Adjusted R-squared: 0.8036   
## F-statistic: 217.8 on 3 and 156 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:24 2019 -------------------  
## Wed Apr 3 11:03:24 2019 Model for RC>0.5 only:  
##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual, data = subset(sdata,   
## RC\_annual > 0.5))  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -480.17 -161.35 43.78 161.44 375.79   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -119.9918 109.8520 -1.092 0.282   
## Rs\_annual 1.1191 0.1079 10.369 3.26e-12 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 212.8 on 35 degrees of freedom  
## Multiple R-squared: 0.7544, Adjusted R-squared: 0.7474   
## F-statistic: 107.5 on 1 and 35 DF, p-value: 3.261e-12  
##   
## Wed Apr 3 11:03:24 2019 -------------------  
## Wed Apr 3 11:03:24 2019 Model for RC<=0.5 only:  
##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual, data = subset(sdata,   
## RC\_annual <= 0.5))  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -618.25 -76.67 8.04 65.10 812.62   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -39.21232 36.24490 -1.082 0.281   
## Rs\_annual 1.13078 0.05065 22.326 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 170.6 on 121 degrees of freedom  
## Multiple R-squared: 0.8047, Adjusted R-squared: 0.8031   
## F-statistic: 498.5 on 1 and 121 DF, p-value: < 2.2e-16

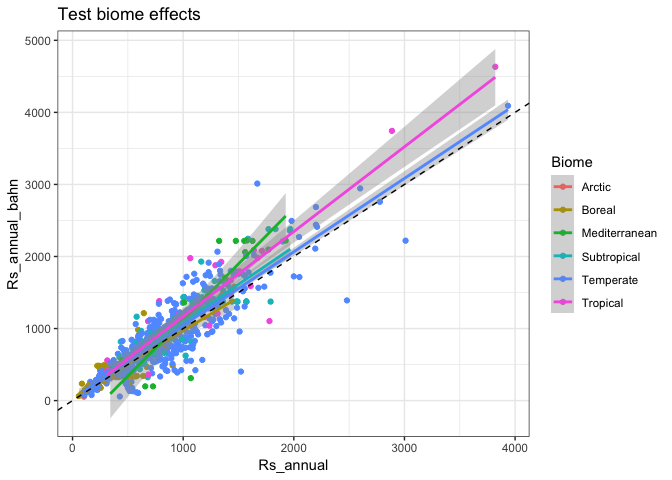
## Wed Apr 3 11:03:24 2019 Saving outputs/3-RC\_effect.pdf

## Saving 7 x 5 in image



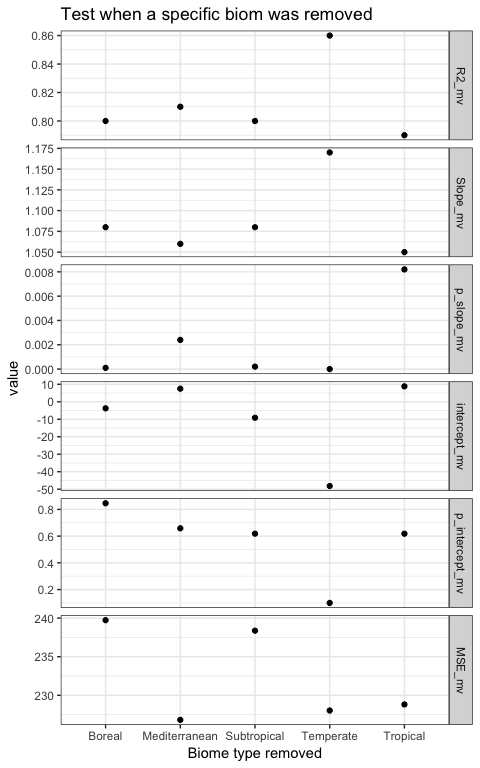
### 4.2.5 Biome effect

##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual \* Biome, data = srdb)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1174.64 -104.79 8.19 123.61 1283.73   
##   
## Coefficients: (1 not defined because of singularities)  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -66.80877 227.89726 -0.293 0.76948   
## Rs\_annual 1.17678 0.05508 21.366 < 2e-16 \*\*\*  
## BiomeBoreal 113.46654 234.16931 0.485 0.62813   
## BiomeMediterranean -369.22121 269.23223 -1.371 0.17063   
## BiomeSubtropical 120.80677 235.67500 0.513 0.60837   
## BiomeTemperate 93.10098 228.83632 0.407 0.68423   
## BiomeTropical 58.62423 237.83119 0.246 0.80536   
## Rs\_annual:BiomeBoreal -0.25204 0.11340 -2.223 0.02652 \*   
## Rs\_annual:BiomeMediterranean 0.37897 0.12742 2.974 0.00302 \*\*   
## Rs\_annual:BiomeSubtropical -0.13619 0.08153 -1.670 0.09522 .   
## Rs\_annual:BiomeTemperate -0.15752 0.05954 -2.646 0.00831 \*\*   
## Rs\_annual:BiomeTropical NA NA NA NA   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 227.8 on 812 degrees of freedom  
## Multiple R-squared: 0.816, Adjusted R-squared: 0.8137   
## F-statistic: 360.1 on 10 and 812 DF, p-value: < 2.2e-16



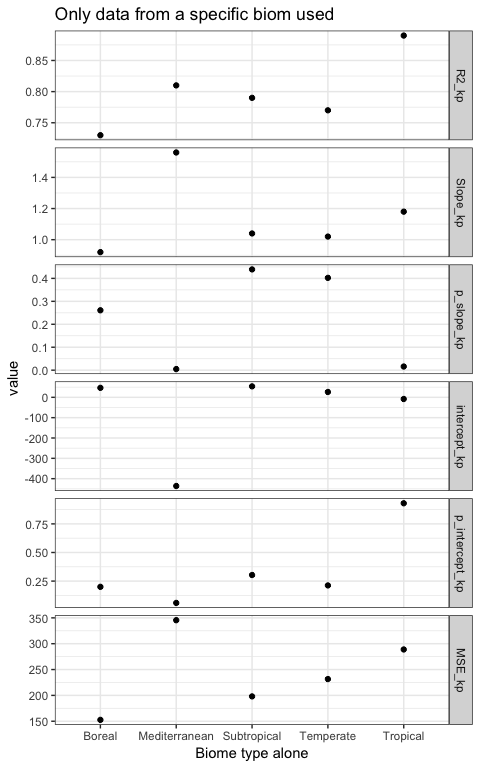
## Biome R2\_mv Slope\_mv p\_slope\_mv intercept\_mv  
## Rs\_annual Boreal 0.80 1.08 0.0001 -3.74  
## Rs\_annual1 Mediterranean 0.81 1.06 0.0024 7.49  
## Rs\_annual2 Subtropical 0.80 1.08 0.0002 -9.15  
## Rs\_annual3 Temperate 0.86 1.17 0.0000 -48.17  
## Rs\_annual4 Tropical 0.79 1.05 0.0082 8.83  
## p\_intercept\_mv MSE\_mv  
## Rs\_annual 0.8459 239.73  
## Rs\_annual1 0.6586 226.82  
## Rs\_annual2 0.6182 238.37  
## Rs\_annual3 0.0999 228.03  
## Rs\_annual4 0.6182 228.82

## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?



## Biome R2\_kp Slope\_kp p\_slope\_kp intercept\_kp  
## Rs\_annual Boreal 0.73 0.92 0.2610 46.66  
## Rs\_annual1 Mediterranean 0.81 1.56 0.0048 -436.03  
## Rs\_annual2 Subtropical 0.79 1.04 0.4391 54.00  
## Rs\_annual3 Temperate 0.77 1.02 0.4023 26.29  
## Rs\_annual4 Tropical 0.89 1.18 0.0159 -8.18  
## p\_intercept\_kp MSE\_kp  
## Rs\_annual 0.2000 152.67  
## Rs\_annual1 0.0593 345.48  
## Rs\_annual2 0.3033 198.07  
## Rs\_annual3 0.2122 231.59  
## Rs\_annual4 0.9301 288.84

## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
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## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?

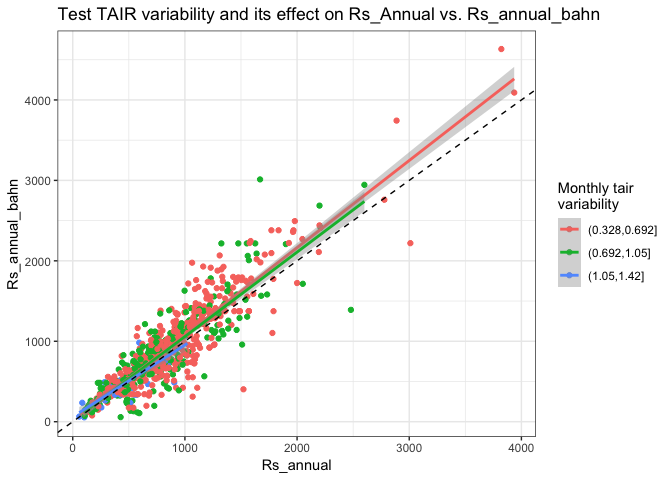


## 4.2.6 TAIR and precipitation variability affect?

## Wed Apr 3 11:03:27 2019 -------------------  
## Wed Apr 3 11:03:27 2019 How does climate variability affect this relationship?  
##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual \* TAIR\_SD2, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1241.54 -105.63 18.66 116.66 1250.75   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -5.99228 24.56567 -0.244 0.807   
## Rs\_annual 1.08443 0.02403 45.119 <2e-16 \*\*\*  
## TAIR\_SD2(0.692,1.05] 13.72567 37.30563 0.368 0.713   
## TAIR\_SD2(1.05,1.42] 66.74171 75.97634 0.878 0.380   
## Rs\_annual:TAIR\_SD2(0.692,1.05] -0.03431 0.04077 -0.841 0.400   
## Rs\_annual:TAIR\_SD2(1.05,1.42] -0.19145 0.13718 -1.396 0.163   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 233.5 on 817 degrees of freedom  
## Multiple R-squared: 0.8055, Adjusted R-squared: 0.8043   
## F-statistic: 676.5 on 5 and 817 DF, p-value: < 2.2e-16

## Wed Apr 3 11:03:27 2019 Saving outputs/4.2.6\_var\_effect\_tair.pdf

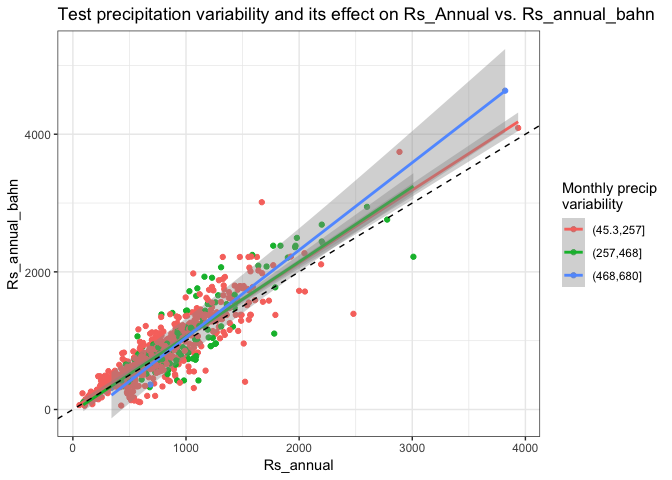
## Saving 7 x 5 in image



##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual \* PRECIP\_SD2, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1248.00 -106.68 15.86 116.29 1232.15   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 10.38548 19.46686 0.533 0.5938   
## Rs\_annual 1.05967 0.02232 47.467 <2e-16 \*\*\*  
## PRECIP\_SD2(257,468] -42.31196 48.89676 -0.865 0.3871   
## PRECIP\_SD2(468,680] -235.91911 147.04492 -1.604 0.1090   
## Rs\_annual:PRECIP\_SD2(257,468] 0.02917 0.04616 0.632 0.5277   
## Rs\_annual:PRECIP\_SD2(468,680] 0.21125 0.08361 2.527 0.0117 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 233 on 817 degrees of freedom  
## Multiple R-squared: 0.8063, Adjusted R-squared: 0.8051   
## F-statistic: 680.1 on 5 and 817 DF, p-value: < 2.2e-16

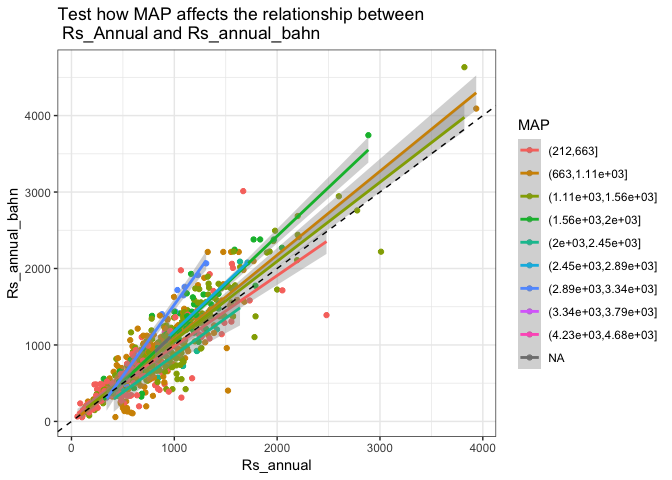
## Wed Apr 3 11:03:27 2019 Saving outputs/4.2.6\_var\_effect\_precip.pdf

## Saving 7 x 5 in image



## 4.2.7 Does drought affect?

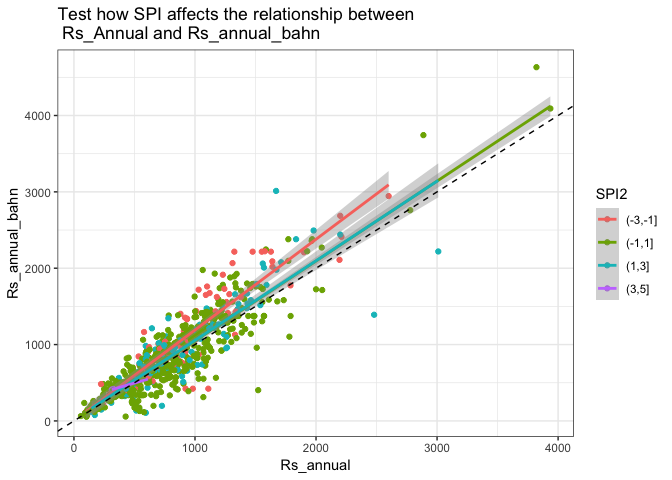
##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual \* MAP\_Del2, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1248.03 -100.96 7.75 108.18 1410.69   
##   
## Coefficients: (2 not defined because of singularities)  
## Estimate Std. Error t value  
## (Intercept) 52.44709 30.35569 1.728  
## Rs\_annual 0.92757 0.04122 22.501  
## MAP\_Del2(663,1.11e+03] -70.57991 43.05025 -1.639  
## MAP\_Del2(1.11e+03,1.56e+03] -28.46873 45.04854 -0.632  
## MAP\_Del2(1.56e+03,2e+03] -170.95538 65.15225 -2.624  
## MAP\_Del2(2e+03,2.45e+03] -155.69317 145.08651 -1.073  
## MAP\_Del2(2.45e+03,2.89e+03] -130.25623 568.49094 -0.229  
## MAP\_Del2(2.89e+03,3.34e+03] -388.18024 225.68816 -1.720  
## MAP\_Del2(3.34e+03,3.79e+03] 126.70434 223.43252 0.567  
## MAP\_Del2(4.23e+03,4.68e+03] 279.87080 223.21997 1.254  
## Rs\_annual:MAP\_Del2(663,1.11e+03] 0.16910 0.05484 3.084  
## Rs\_annual:MAP\_Del2(1.11e+03,1.56e+03] 0.10724 0.05090 2.107  
## Rs\_annual:MAP\_Del2(1.56e+03,2e+03] 0.34382 0.06932 4.960  
## Rs\_annual:MAP\_Del2(2e+03,2.45e+03] 0.04186 0.15178 0.276  
## Rs\_annual:MAP\_Del2(2.45e+03,2.89e+03] 0.33146 0.41251 0.804  
## Rs\_annual:MAP\_Del2(2.89e+03,3.34e+03] 0.93513 0.23613 3.960  
## Rs\_annual:MAP\_Del2(3.34e+03,3.79e+03] NA NA NA  
## Rs\_annual:MAP\_Del2(4.23e+03,4.68e+03] NA NA NA  
## Pr(>|t|)   
## (Intercept) 0.08442 .   
## Rs\_annual < 2e-16 \*\*\*  
## MAP\_Del2(663,1.11e+03] 0.10151   
## MAP\_Del2(1.11e+03,1.56e+03] 0.52759   
## MAP\_Del2(1.56e+03,2e+03] 0.00886 \*\*   
## MAP\_Del2(2e+03,2.45e+03] 0.28355   
## MAP\_Del2(2.45e+03,2.89e+03] 0.81883   
## MAP\_Del2(2.89e+03,3.34e+03] 0.08582 .   
## MAP\_Del2(3.34e+03,3.79e+03] 0.57082   
## MAP\_Del2(4.23e+03,4.68e+03] 0.21028   
## Rs\_annual:MAP\_Del2(663,1.11e+03] 0.00212 \*\*   
## Rs\_annual:MAP\_Del2(1.11e+03,1.56e+03] 0.03543 \*   
## Rs\_annual:MAP\_Del2(1.56e+03,2e+03] 8.60e-07 \*\*\*  
## Rs\_annual:MAP\_Del2(2e+03,2.45e+03] 0.78280   
## Rs\_annual:MAP\_Del2(2.45e+03,2.89e+03] 0.42191   
## Rs\_annual:MAP\_Del2(2.89e+03,3.34e+03] 8.15e-05 \*\*\*  
## Rs\_annual:MAP\_Del2(3.34e+03,3.79e+03] NA   
## Rs\_annual:MAP\_Del2(4.23e+03,4.68e+03] NA   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 222.3 on 804 degrees of freedom  
## (3 observations deleted due to missingness)  
## Multiple R-squared: 0.8265, Adjusted R-squared: 0.8232   
## F-statistic: 255.3 on 15 and 804 DF, p-value: < 2.2e-16



## Wed Apr 3 11:03:29 2019 -------------------  
## Wed Apr 3 11:03:29 2019 How does drought affect this relationship? (discrete)  
##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual \* SPI2, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1207.66 -111.58 15.77 116.48 1258.29   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 1.99947 48.51641 0.041 0.96714   
## Rs\_annual 1.18864 0.04748 25.035 < 2e-16 \*\*\*  
## SPI2(-1,1] -2.16527 52.46724 -0.041 0.96709   
## SPI2(1,3] 11.52099 65.92498 0.175 0.86131   
## SPI2(3,5] 265.23165 426.02081 0.623 0.53374   
## Rs\_annual:SPI2(-1,1] -0.14157 0.05242 -2.701 0.00706 \*\*   
## Rs\_annual:SPI2(1,3] -0.14650 0.06486 -2.259 0.02416 \*   
## Rs\_annual:SPI2(3,5] -0.73067 0.96525 -0.757 0.44928   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 229.3 on 815 degrees of freedom  
## Multiple R-squared: 0.813, Adjusted R-squared: 0.8114   
## F-statistic: 506.2 on 7 and 815 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:29 2019 How does drought affect this relationship? (continuous)  
##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual \* SPI, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1282.92 -108.20 13.79 122.33 1329.19   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.20168 17.14350 0.012 0.99062   
## Rs\_annual 1.06943 0.01840 58.135 < 2e-16 \*\*\*  
## SPI 14.56256 18.13361 0.803 0.42217   
## Rs\_annual:SPI -0.04974 0.01854 -2.683 0.00745 \*\*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 231.1 on 819 degrees of freedom  
## Multiple R-squared: 0.809, Adjusted R-squared: 0.8083   
## F-statistic: 1156 on 3 and 819 DF, p-value: < 2.2e-16

## Wed Apr 3 11:03:29 2019 Saving outputs/4.2.7\_SPI\_effect.pdf

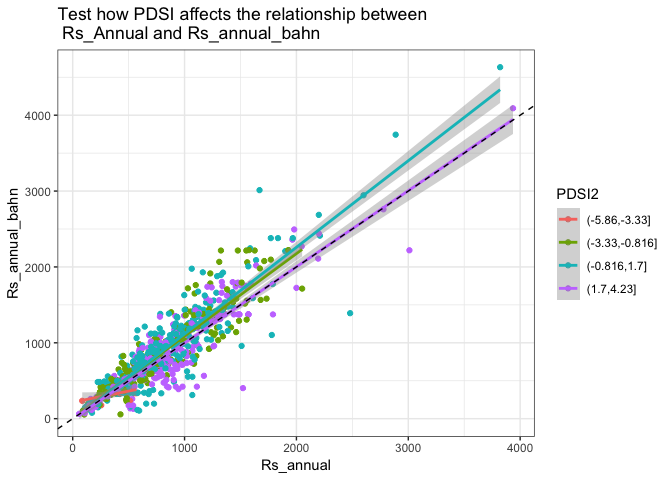
## Saving 7 x 5 in image



## Wed Apr 3 11:03:29 2019 -------------------  
## Wed Apr 3 11:03:29 2019 How does drought affect this relationship? (discrete)  
##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual \* PDSI2, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1416.23 -104.92 16.56 107.65 1129.58   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 216.7363 169.6390 1.278 0.2017   
## Rs\_annual 0.2935 0.4205 0.698 0.4853   
## PDSI2(-3.33,-0.816] -215.3118 173.1452 -1.244 0.2140   
## PDSI2(-0.816,1.7] -239.1508 171.6835 -1.393 0.1640   
## PDSI2(1.7,4.23] -223.4889 172.3152 -1.297 0.1950   
## Rs\_annual:PDSI2(-3.33,-0.816] 0.7939 0.4222 1.880 0.0604 .  
## Rs\_annual:PDSI2(-0.816,1.7] 0.8472 0.4214 2.010 0.0447 \*  
## Rs\_annual:PDSI2(1.7,4.23] 0.7104 0.4215 1.685 0.0923 .  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 228.2 on 815 degrees of freedom  
## Multiple R-squared: 0.8147, Adjusted R-squared: 0.8131   
## F-statistic: 511.7 on 7 and 815 DF, p-value: < 2.2e-16  
##   
## Wed Apr 3 11:03:29 2019 How does drought affect this relationship? (continuous)  
##   
## Call:  
## lm(formula = Rs\_annual\_bahn ~ Rs\_annual \* PDSI2, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1416.23 -104.92 16.56 107.65 1129.58   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 216.7363 169.6390 1.278 0.2017   
## Rs\_annual 0.2935 0.4205 0.698 0.4853   
## PDSI2(-3.33,-0.816] -215.3118 173.1452 -1.244 0.2140   
## PDSI2(-0.816,1.7] -239.1508 171.6835 -1.393 0.1640   
## PDSI2(1.7,4.23] -223.4889 172.3152 -1.297 0.1950   
## Rs\_annual:PDSI2(-3.33,-0.816] 0.7939 0.4222 1.880 0.0604 .  
## Rs\_annual:PDSI2(-0.816,1.7] 0.8472 0.4214 2.010 0.0447 \*  
## Rs\_annual:PDSI2(1.7,4.23] 0.7104 0.4215 1.685 0.0923 .  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 228.2 on 815 degrees of freedom  
## Multiple R-squared: 0.8147, Adjusted R-squared: 0.8131   
## F-statistic: 511.7 on 7 and 815 DF, p-value: < 2.2e-16

## Wed Apr 3 11:03:30 2019 Saving outputs/4.2.7\_PDSI\_effect.pdf

## Saving 7 x 5 in image



# 5. Discussion & questions

# 6. More analysis in the future

* 1 Using SD information with boosting?
* 2 Use Rs\_mat predict Rh?
* 3 Use this approach estimate global Rs
* 4 Think about application
* 5 Update bahn model with more predictors or using regression tree method?