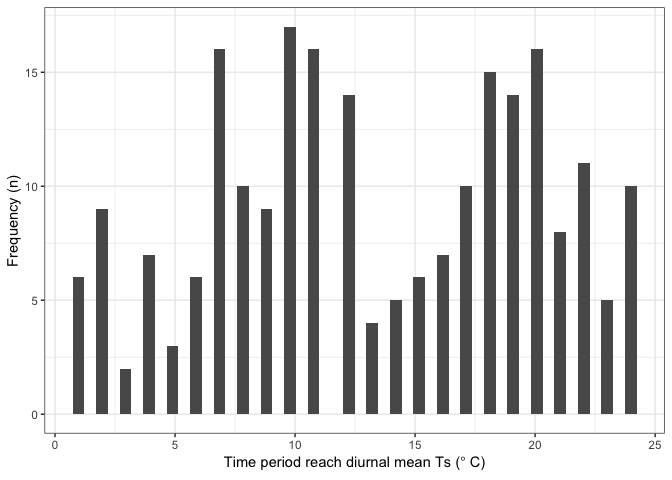
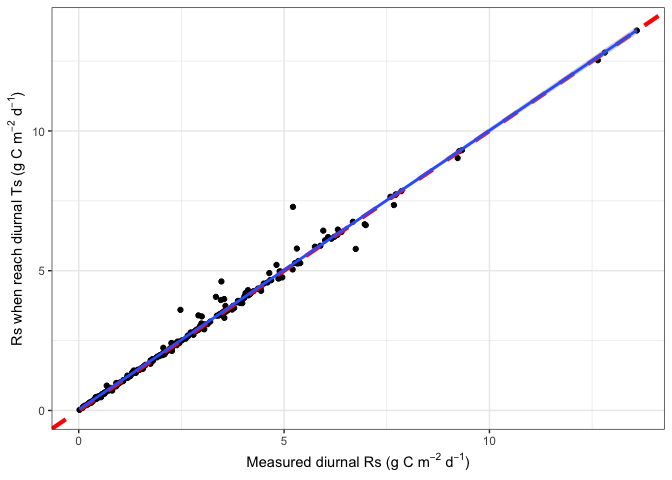
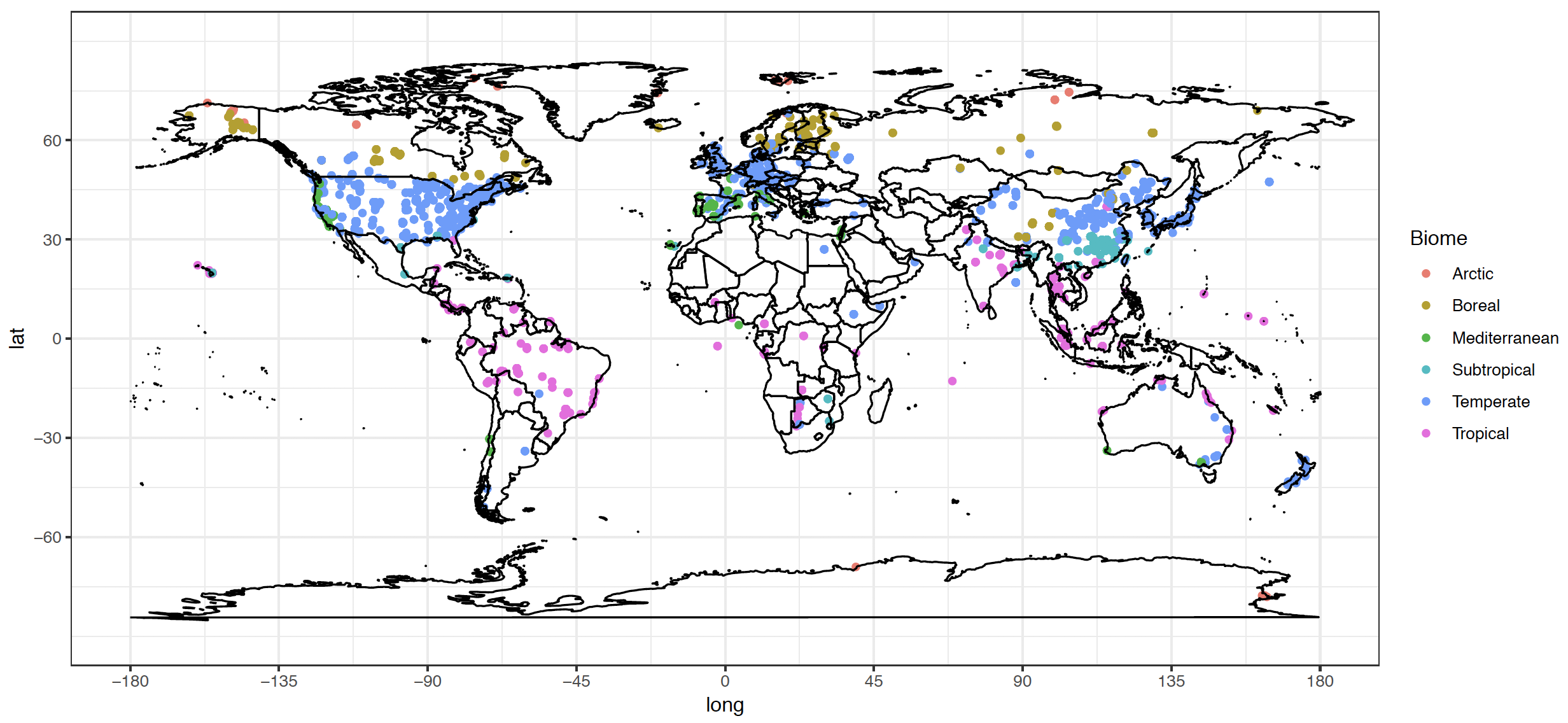
Can soil respiration measured at MAT represent annual soil respiration?

Jinshi

March 26, 2019

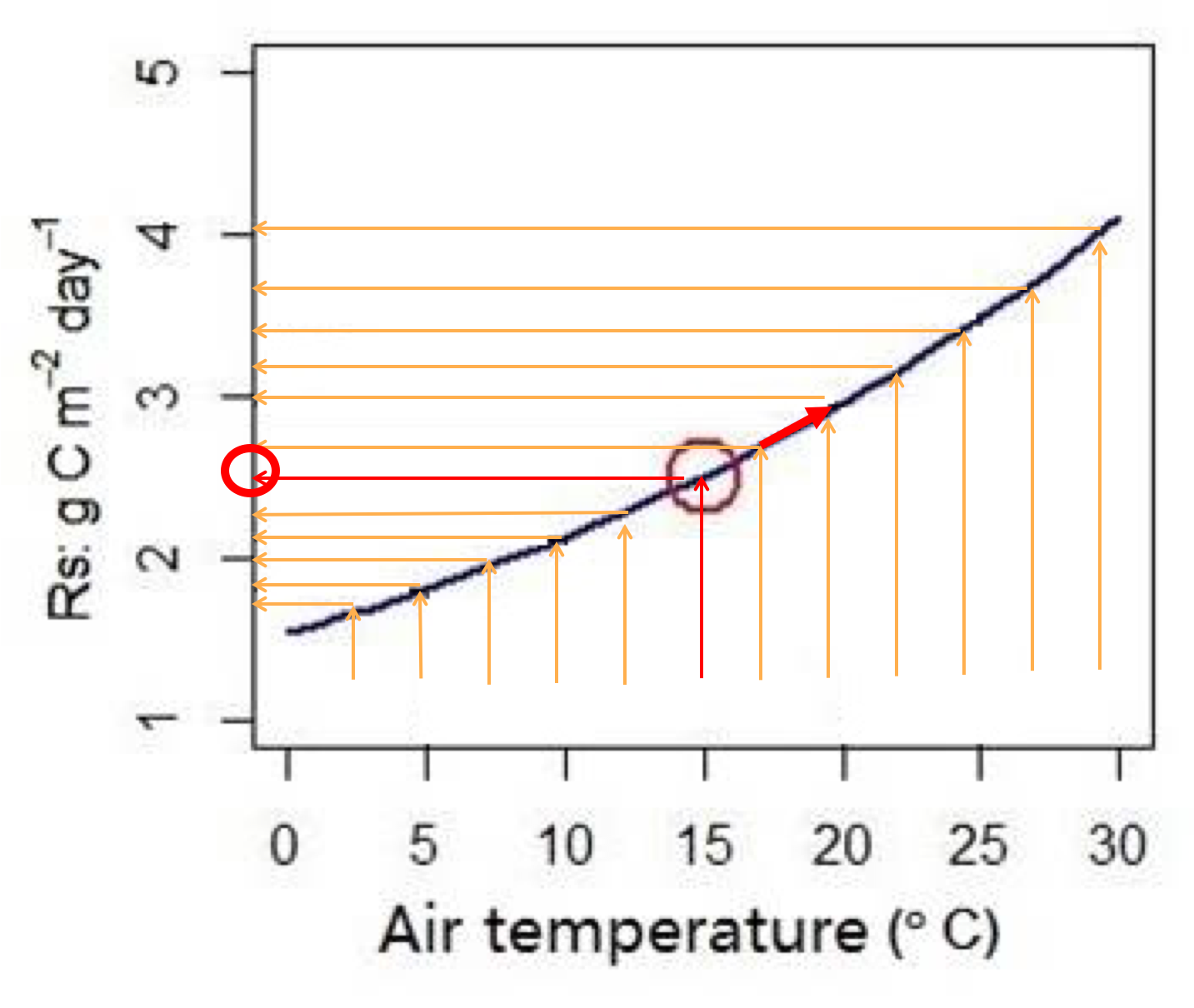
# 1. The spatial distribution of global Rs sites

* In daily and monthly time scale, we used this approach a lot Rs\_mat\_Rs\_diurnal () 
* We have much more measurements Rs in mid-latitude regions, where developed countries are mostly located
* It is difficult to measure soil respiration all year around in cold regions, but critical because of high rates of climate change and large soil C stocks
* Less-developed countries are constrained by lack of resources, and thus we do not have enough measurements from tropical regions [(Xu and Shang 2016)](http://dx.doi.org/10.1016/j.jplph.2016.08.007)



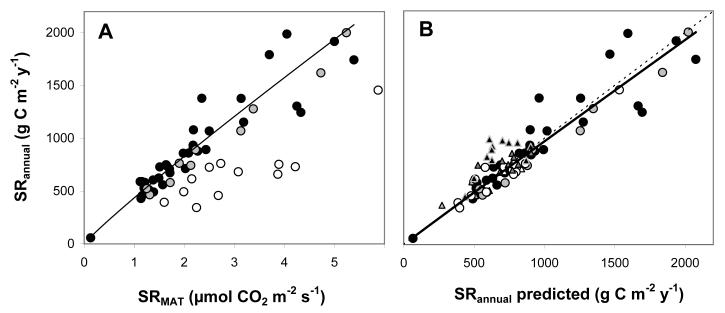
Global spatial distribution of soil respiration sites

Rs data from cold regions are more important, but how to increase the number of measurements? \* Make equipment work normally in very cold and remote conditions \* Increase resources devoted to Rs measurements \* Methodological improvements: for instance, measuring once per day to get daily mean



Rs measured at diurnal soil temperature

* Measure once per year to get annual Rs mean? This is **Bahn’s approach** [Bahn et al. (2004) Biogeosciences](http://dx.doi.org/10.5194/bg-7-2147-2010)



Rs measured at mean annual soil temperature

* Rs measured at annual mean temperature is ~~linearly~~ related with annual Rs rate
* Rs at mean temperature: soil respiration measured at annual mean temperature, monthly mean temperature, and/or daily mean temperature
* Rs\_annual ~ Rs\_mat (“Rs\_bahn”)
* Rs\_annual = 455.8 \* Rs\_mat^1.0054 (R2 = 0.94, p<0.001)

# 2. The objects of this analysis are

* Examine whether Rs measured at annual mean soil temperature can represent annual Rs rate? (We now have an order of magnitude more data than Bahn et al.)
* Annual 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?

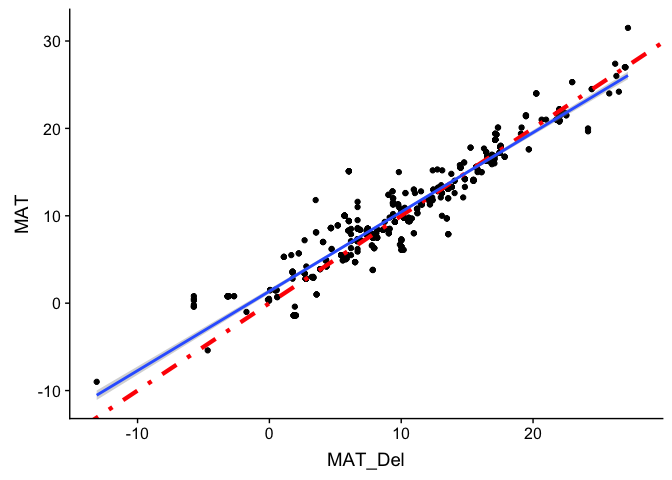
# 3. Methods

**Data**

* Use SRDB\_V4 – Rs\_Annual
* Annual mean soil temperature (reported in the papers or can be calculated with simple assumptions)
* 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

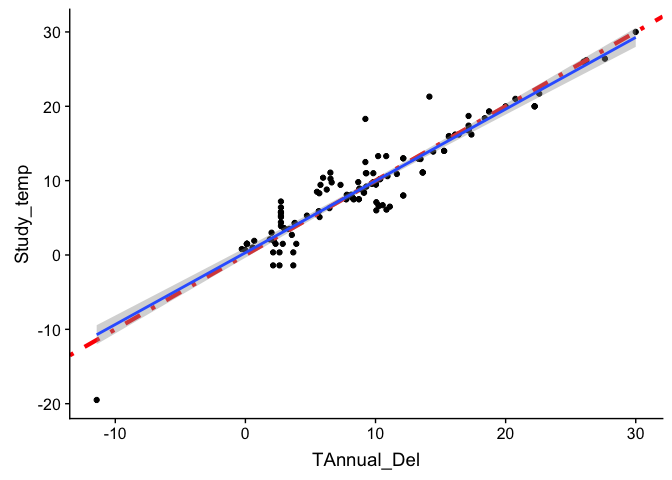
## Warning: Removed 147 rows containing non-finite values (stat\_smooth).

## Warning: Removed 147 rows containing missing values (geom\_point).



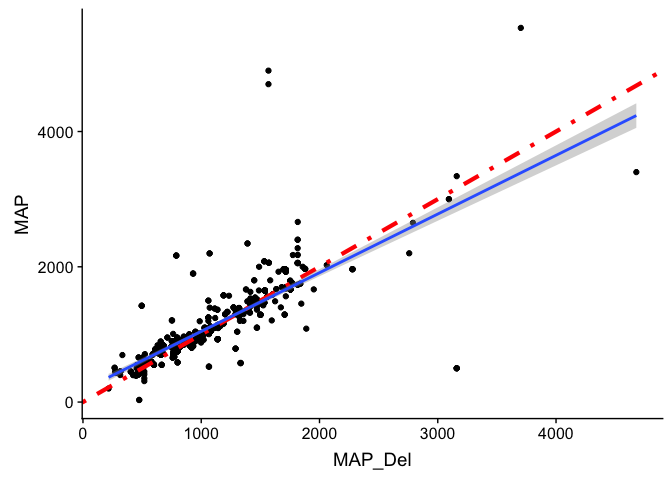
## Warning: Removed 687 rows containing non-finite values (stat\_smooth).

## Warning: Removed 687 rows containing missing values (geom\_point).



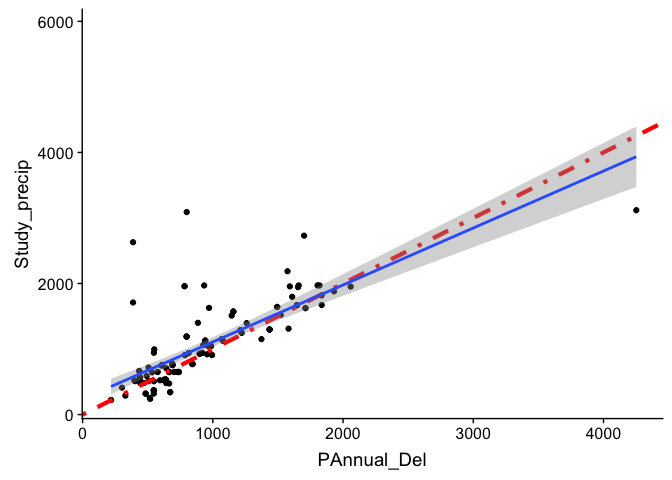
## Warning: Removed 125 rows containing non-finite values (stat\_smooth).

## Warning: Removed 125 rows containing missing values (geom\_point).



## Warning: Removed 696 rows containing non-finite values (stat\_smooth).

## Warning: Removed 696 rows containing missing values (geom\_point).

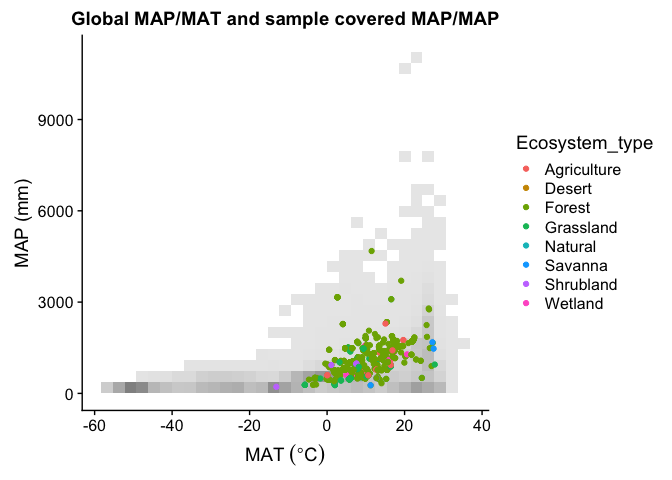


**Statistics**

* According the the relationship between Rs and Ts, we can estimate Rs\_mat based on the annual mean soil temperature, T\_Annual, and/or MAT
* Use the Bahn 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

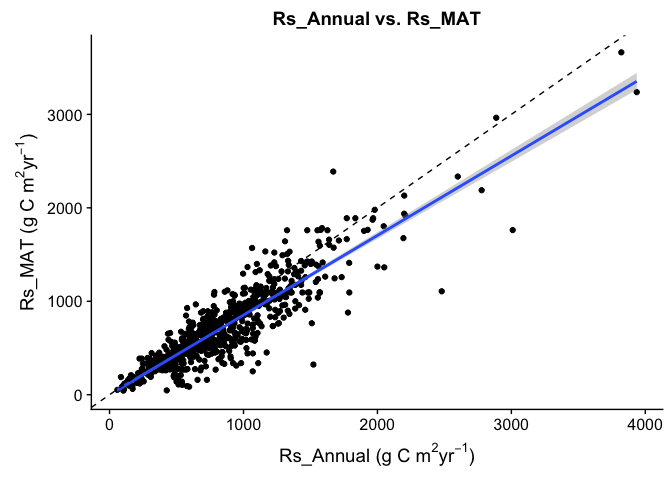
**Update Bahn’s model**

* 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

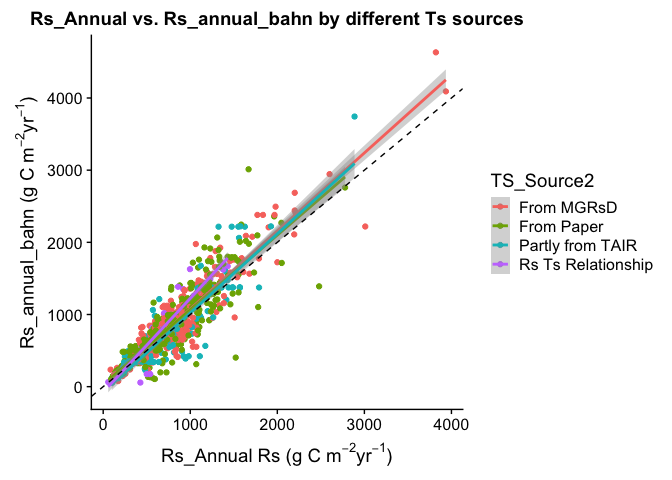
## Wed Apr 3 17:46:50 2019 -------------------+++++-------------------  
## Wed Apr 3 17:46:50 2019 Bahn relationship for these data:  
##   
## Call:  
## lm(formula = Rs\_TAIR ~ Rs\_annual, data = sdata)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1006.45 -84.72 14.90 93.38 964.58   
##   
## 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"

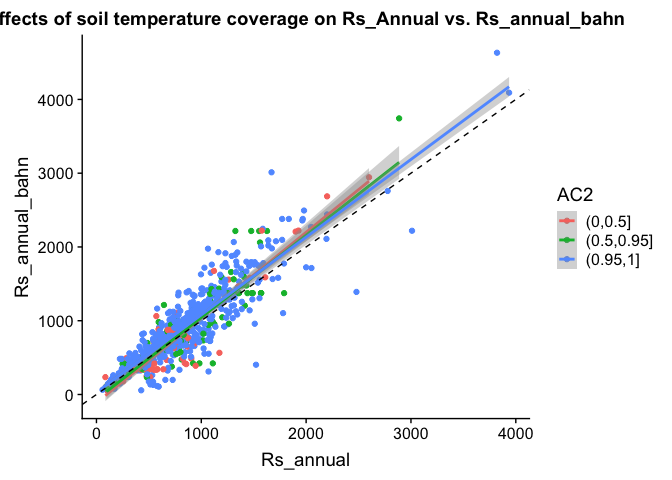
## 3.3 Ts sources (MGRsD, MGRsD\_TAIR, From paper, Rs\_Ts\_relationship)

## Saving 7 x 5 in image

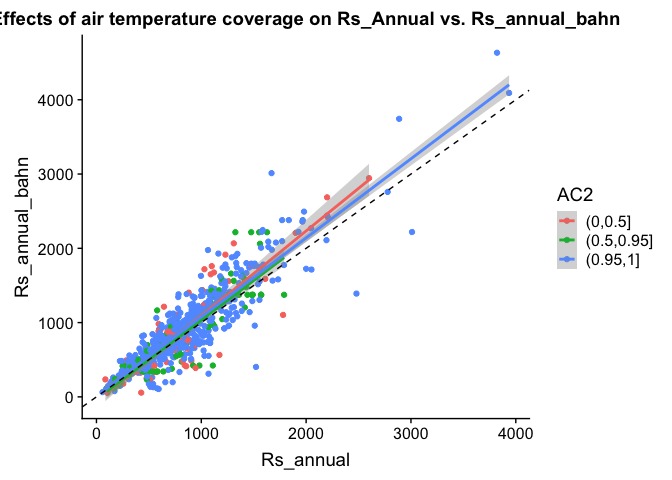


## 3.4 Annual Rs or Ts coverage effect

## Saving 7 x 5 in image



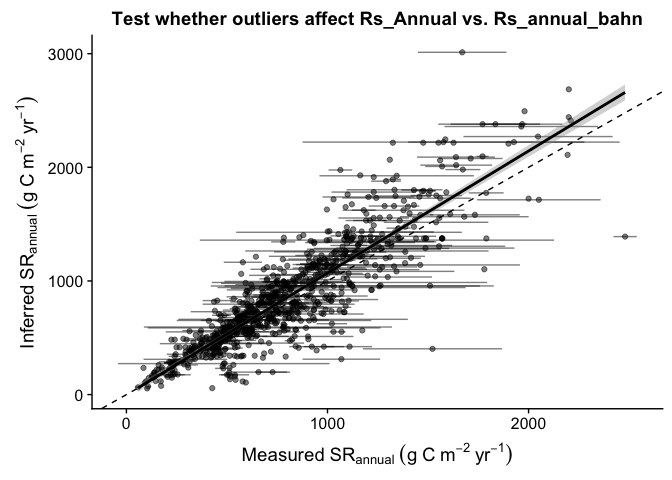
## Saving 7 x 5 in image



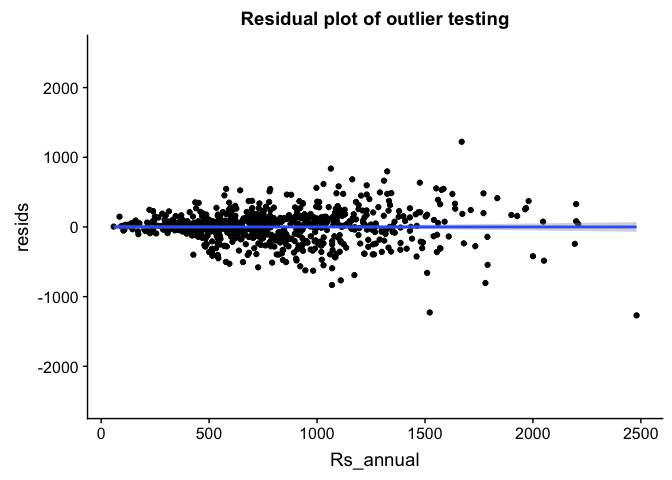
## 3.4.1 Test whether outliers affect the regression (need update)

* Conclusion: need to update the code and results

## Saving 7 x 5 in image

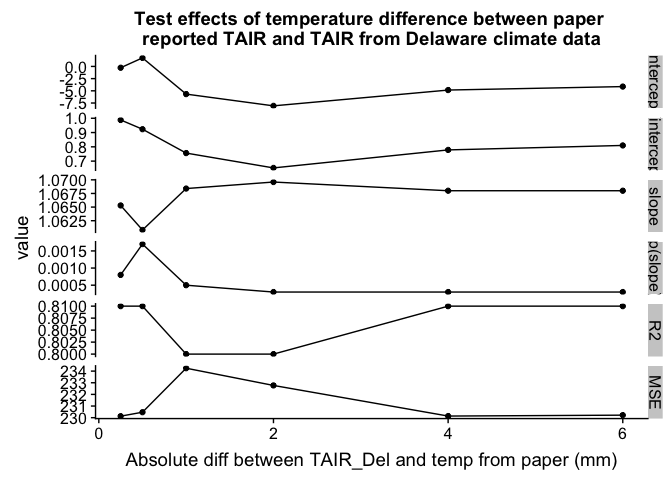


## Saving 7 x 5 in image

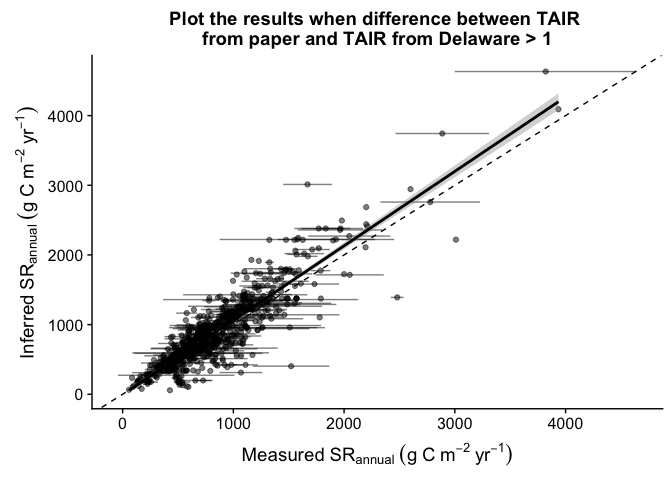


## 3.4.2 Effect of maximum allowed divergence between global climate data set and site-specific air temperature

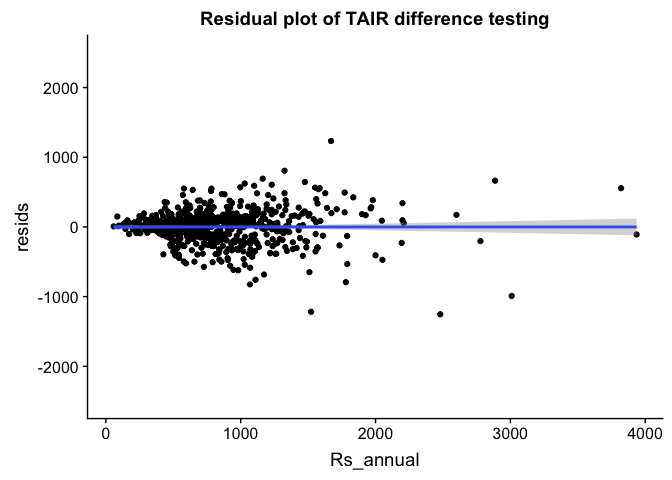
* Does TAIR\_dev and TAIR\_LT<\_dev affect the relationship – YES!!!!!
* TAIR\_LTM\_dev = with( srdb, abs( MAT\_Del - MAT ) )
* Does TAIR\_LTM\_dev () pull the slope off 1? – YES!!!!!
* TAIR\_dev <- with( srdb, abs( TAnnual\_Del - Study\_temp ) )
* Figure E. Effect of maximum allowed divergence between 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).



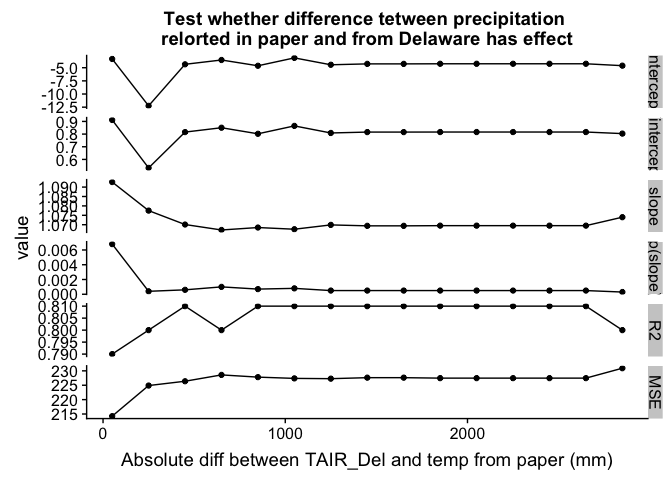
## Saving 7 x 5 in image



## Saving 7 x 5 in image



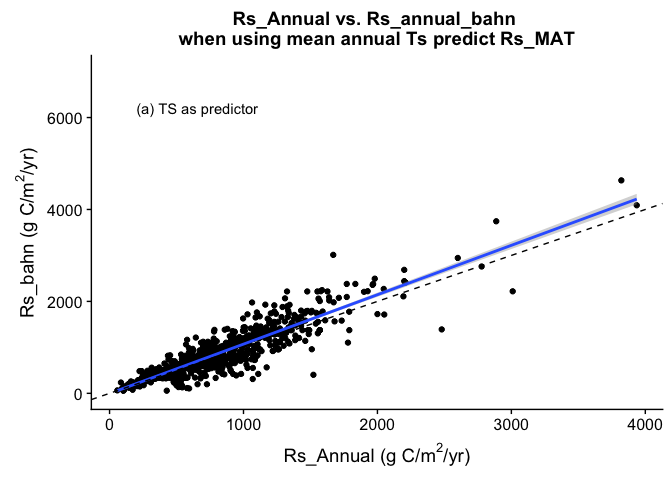
## 3.4.3 Effect of maximum allowed divergence between annual precipitation from paper and Del



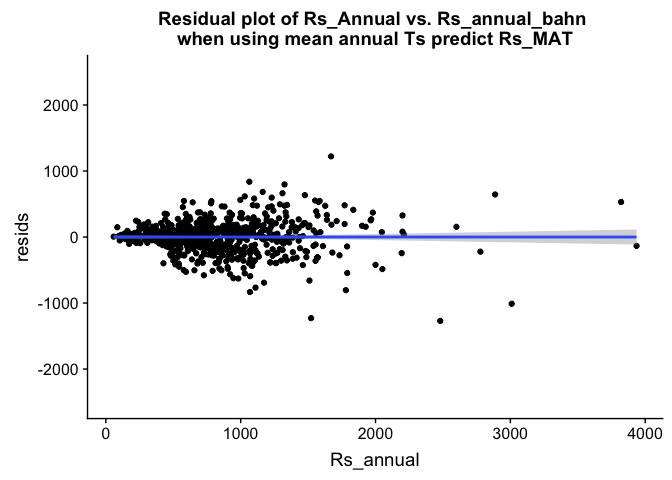
# 4. Results

## 4.1 Using Ts, TAnnual or MAT

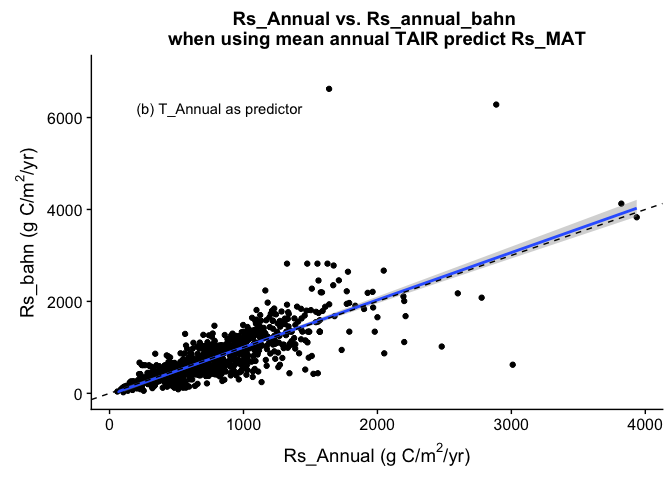
### 4.1.1 Using soil temperature



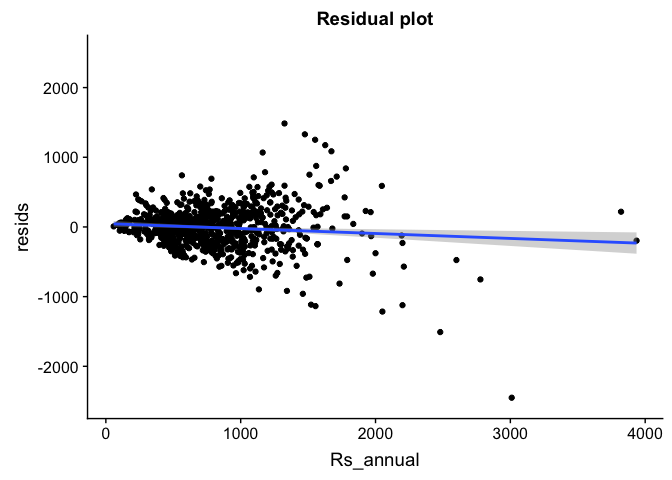
## Saving 7 x 5 in image



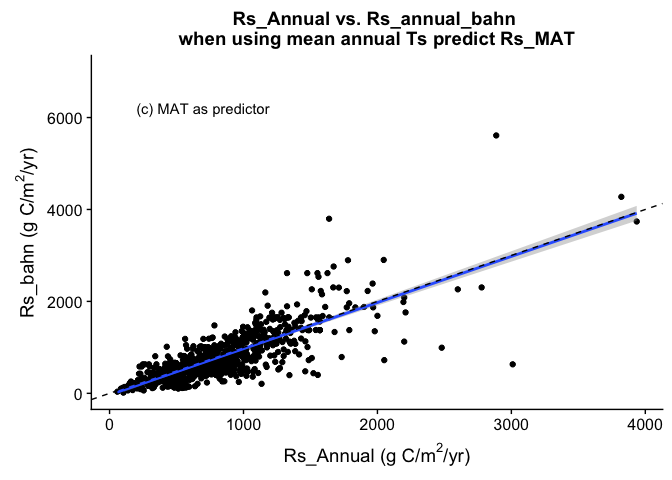
### 4.1.2 Using T\_Annual



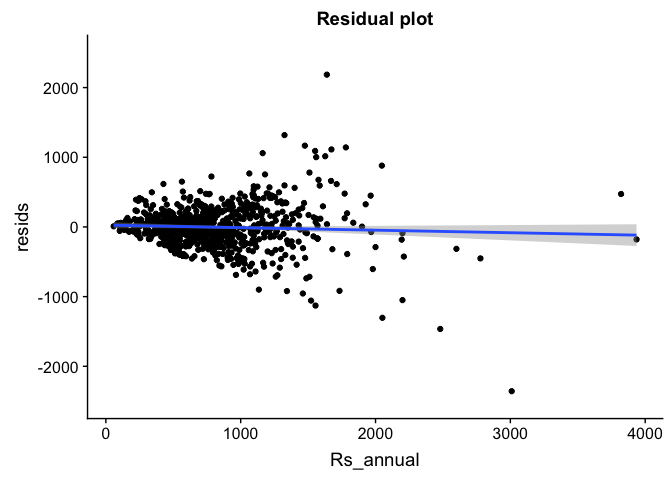
## Saving 7 x 5 in image



### 4.1.3 Using MAT



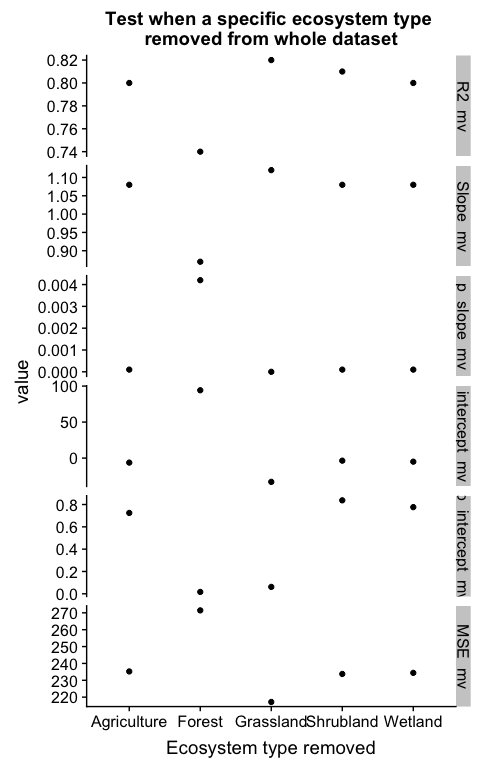
## Saving 7 x 5 in image



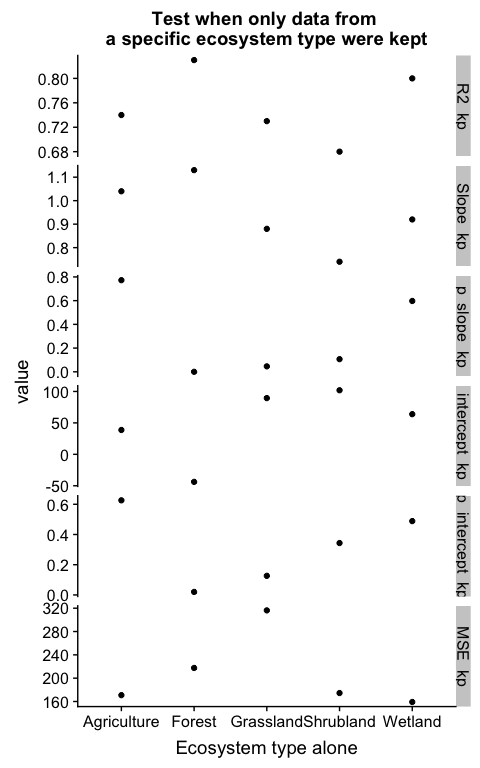
## 4.2 Analysis when Rs\_mat cannot represent Rs\_annual

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

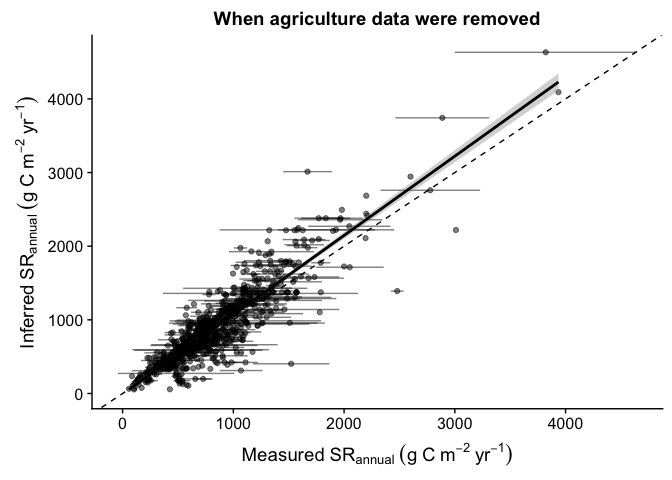
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust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



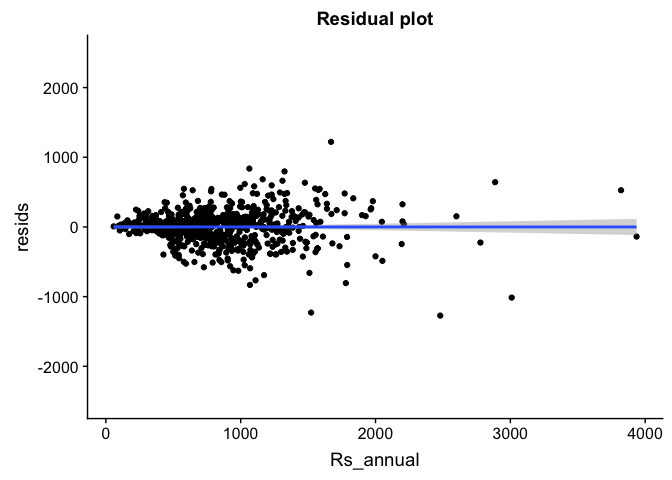
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust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



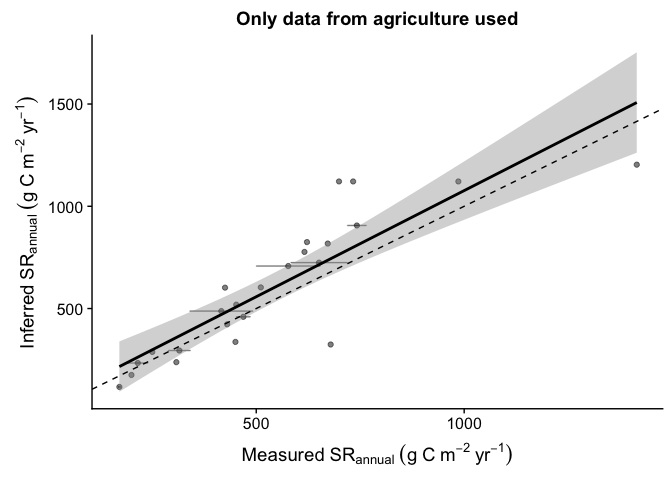
## Saving 7 x 5 in image



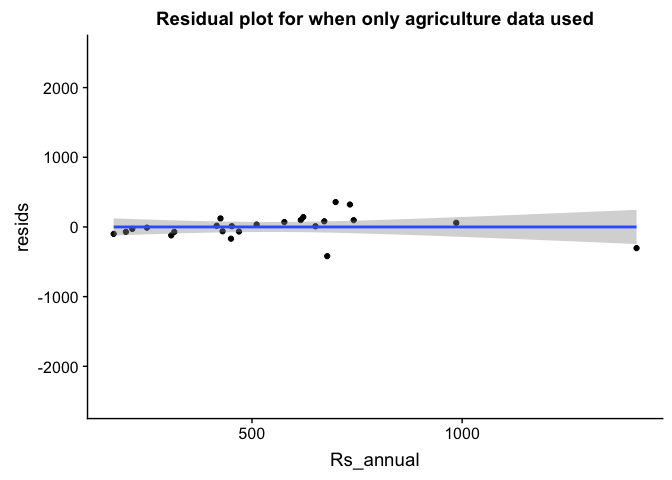
## Saving 7 x 5 in image



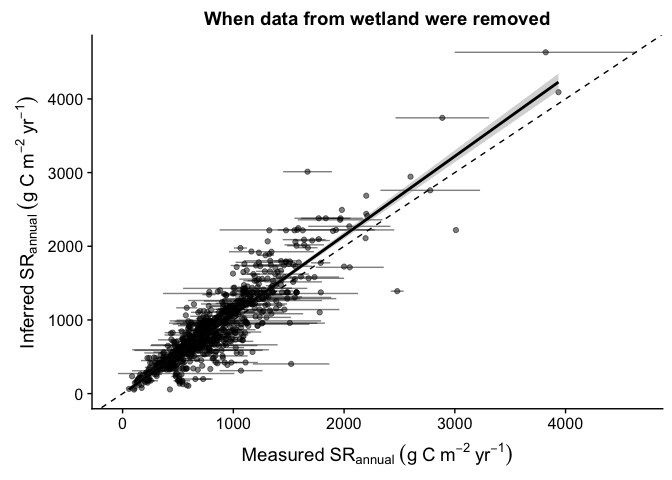
## Saving 7 x 5 in image



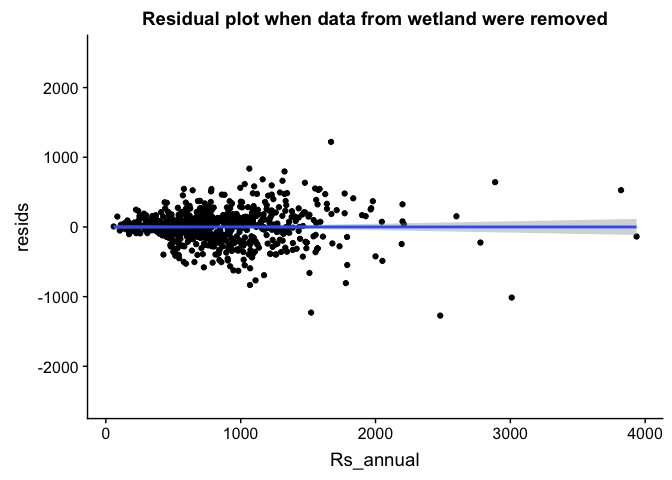
## Saving 7 x 5 in image



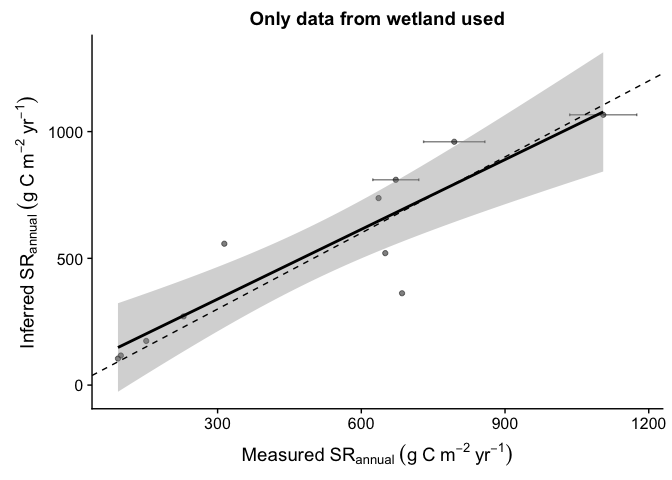
## Saving 7 x 5 in image



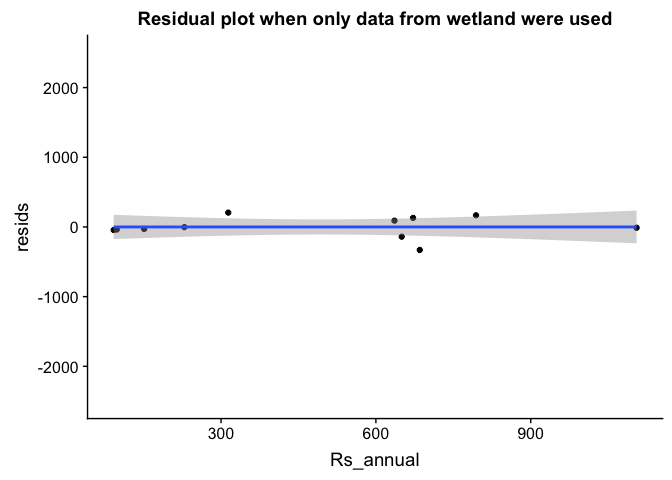
## Saving 7 x 5 in image



## Saving 7 x 5 in image

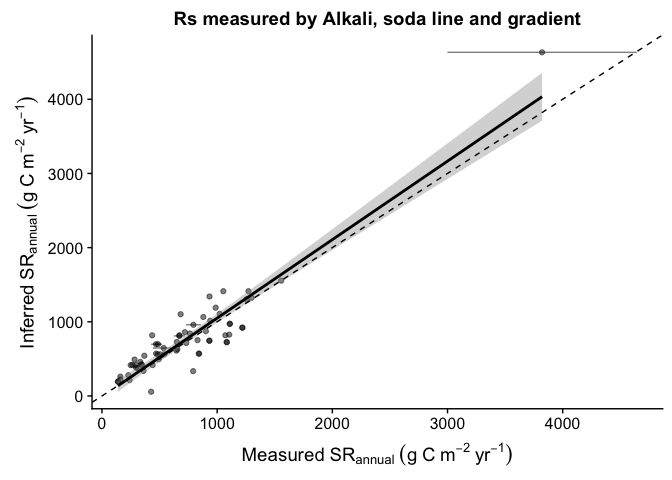


## Saving 7 x 5 in image

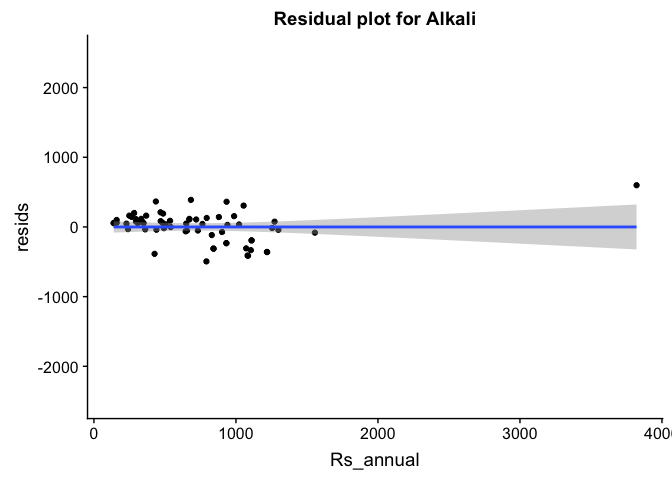


## 4.2.3 Does Meas\_method affect the relationship?

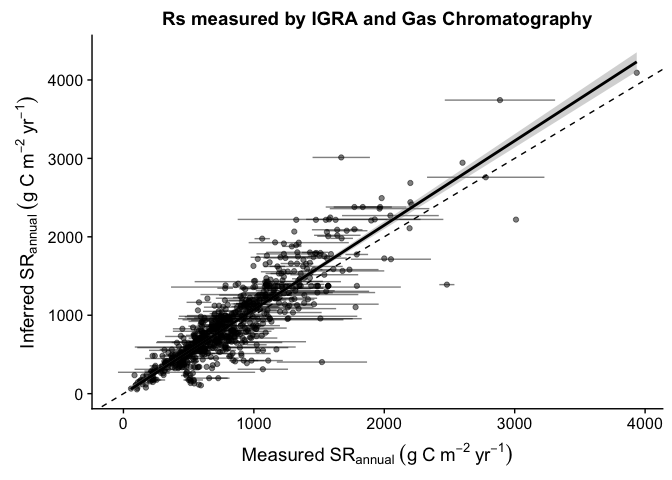
## Saving 7 x 5 in image



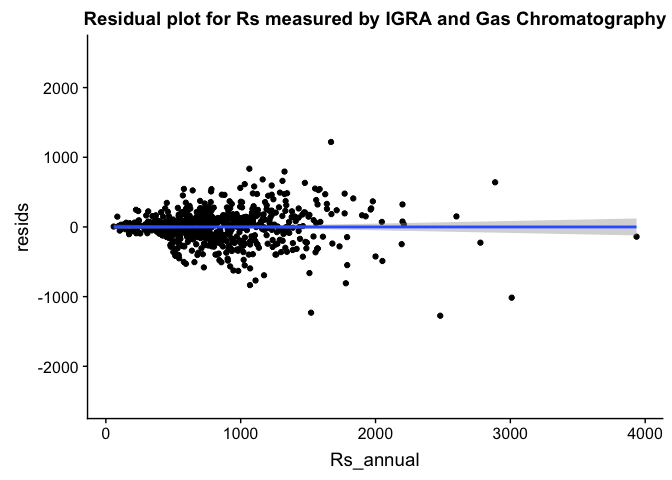
## Saving 7 x 5 in image



## Saving 7 x 5 in image

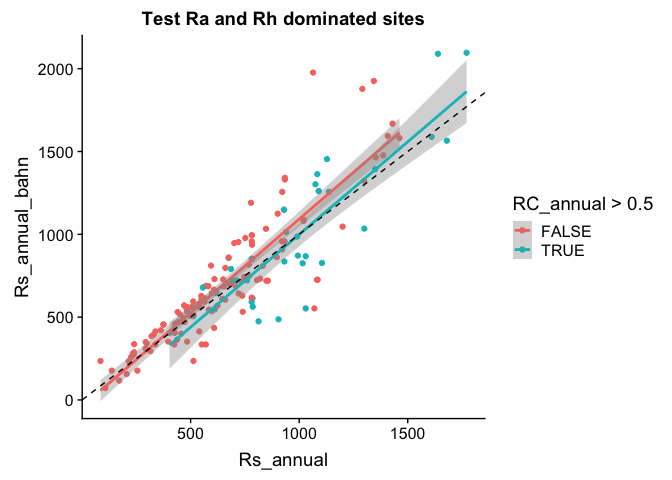


## Saving 7 x 5 in image

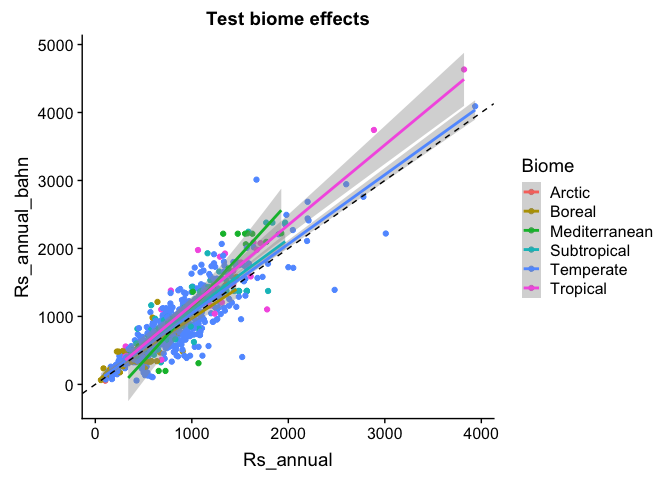


### 4.2.4 RA- or RH-dominated effect?

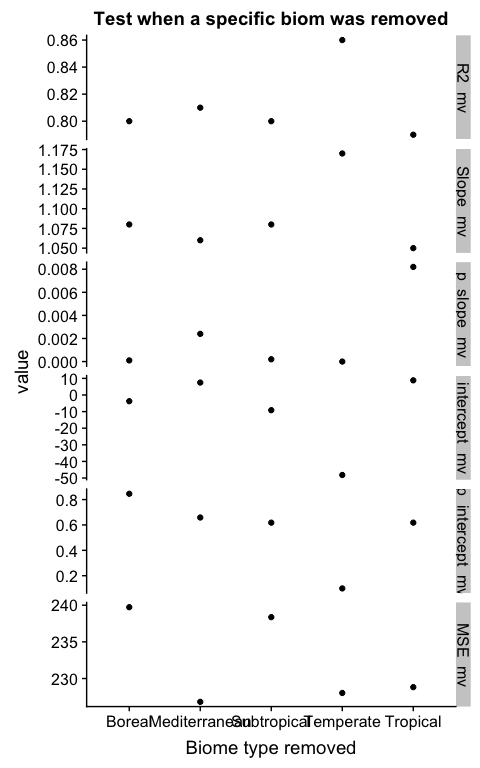
## Saving 7 x 5 in image



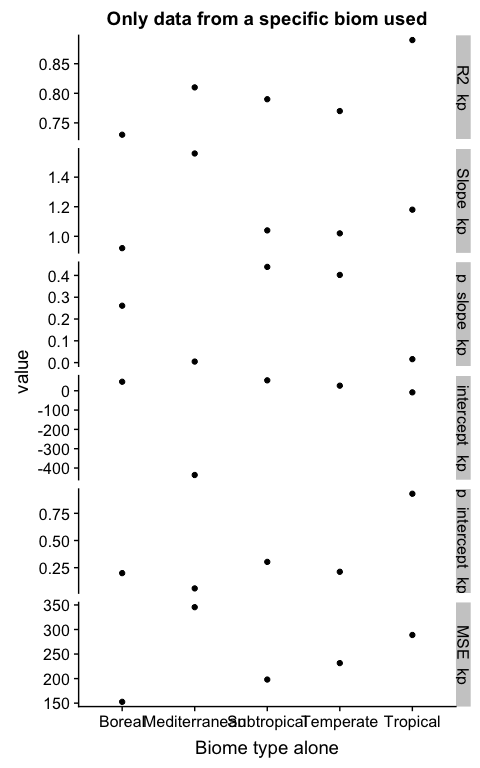
### 4.2.5 Biome effect?



## 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?

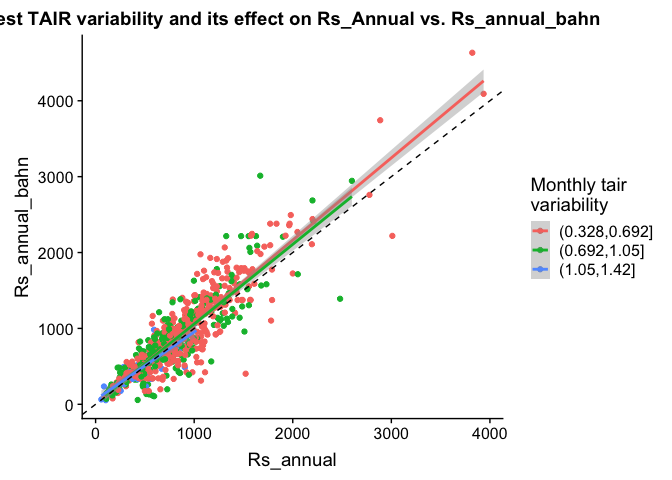


## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust the group aesthetic?  
## geom\_path: Each group consists of only one observation. Do you need to  
## adjust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

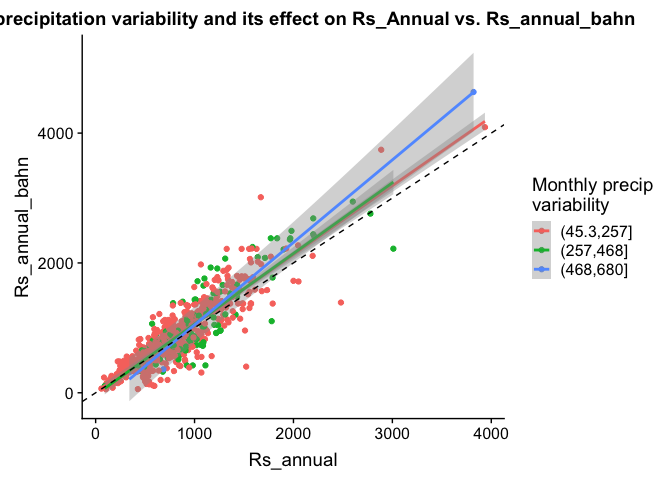


## 4.2.6 TAIR and precipitation variability effect?

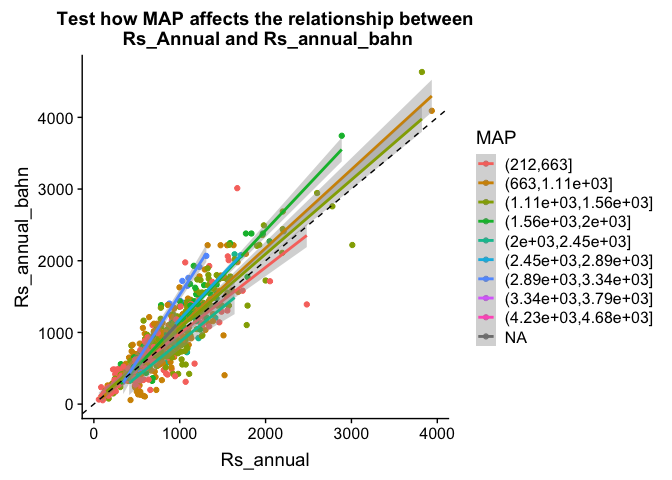
## Saving 7 x 5 in image



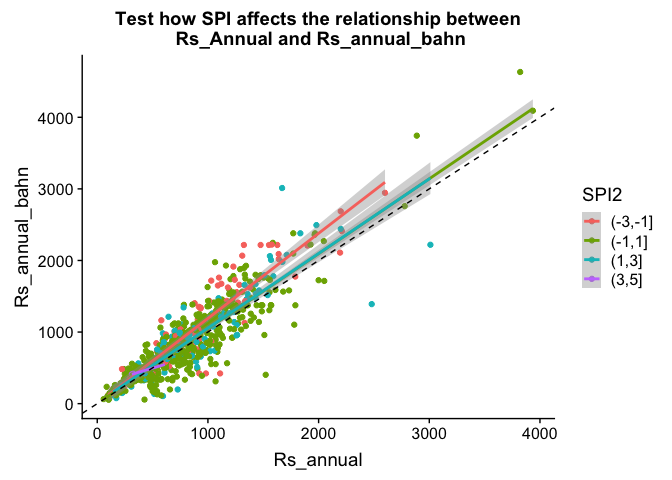
## Saving 7 x 5 in image



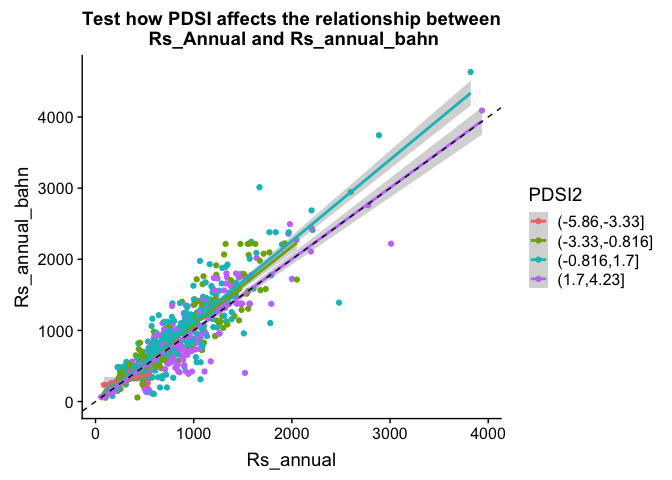
## 4.2.7 Drought effect?



## Saving 7 x 5 in image



## 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?