

# Maladaptive plastic responses of flowering time to geothermal heating (Cerastium 2)

Analyses with logger data

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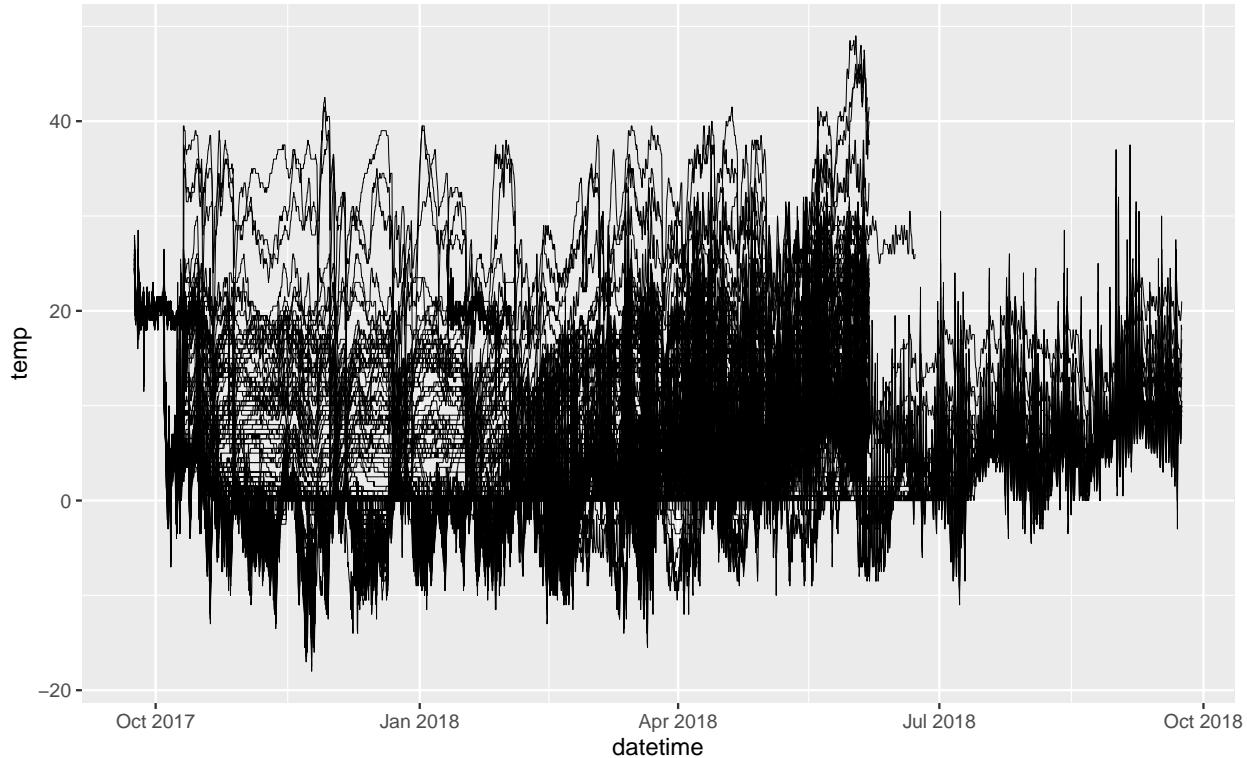
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## Read data

**Plot with all logger data, one line per logger id**

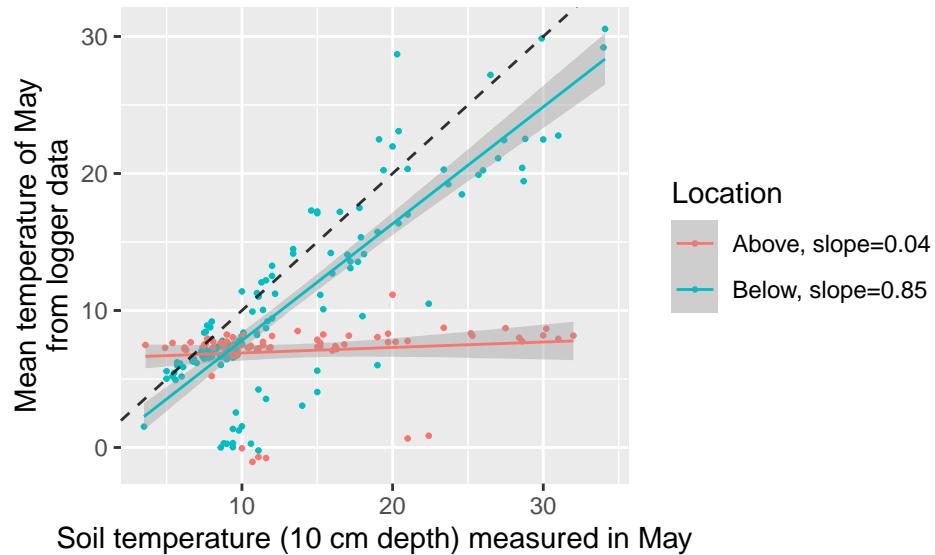


**Q1: Are instantaneous measures of soil temperature representative for the conditions during the entire spring/growing season?**

Correlations logger temperature - instant temperature

## May

For each logger\_nr, get mean temperature during May 2017 and compare with temp\_term (which was measured with a thermometer at 10 cm depth on May 2017):



Observations	78
Dependent variable	meanmay_logger
Type	OLS linear regression

F(1,76)	1.233
R <sup>2</sup>	0.016
Adj. R <sup>2</sup>	0.003

	Est.	S.E.	t val.	p
(Intercept)	6.507	0.547	11.900	0.000
temp_term	0.040	0.036	1.111	0.270

Standard errors: OLS

Observations	141
Dependent variable	meanmay_logger
Type	OLS linear regression

F(1,139)	399.799
R <sup>2</sup>	0.742
Adj. R <sup>2</sup>	0.740

Correlation mean temperature of may from logger data and soil temperature measured in may with thermometer:

```
## [1] 0.6446784
```

	Est.	S.E.	t val.	p
(Intercept)	-0.727	0.625	-1.163	0.247
temp_term	0.853	0.043	19.995	0.000

Standard errors: OLS

Correlation mean temperature of may from logger data (only belowground loggers) and soil temperature measured in may with thermometer:

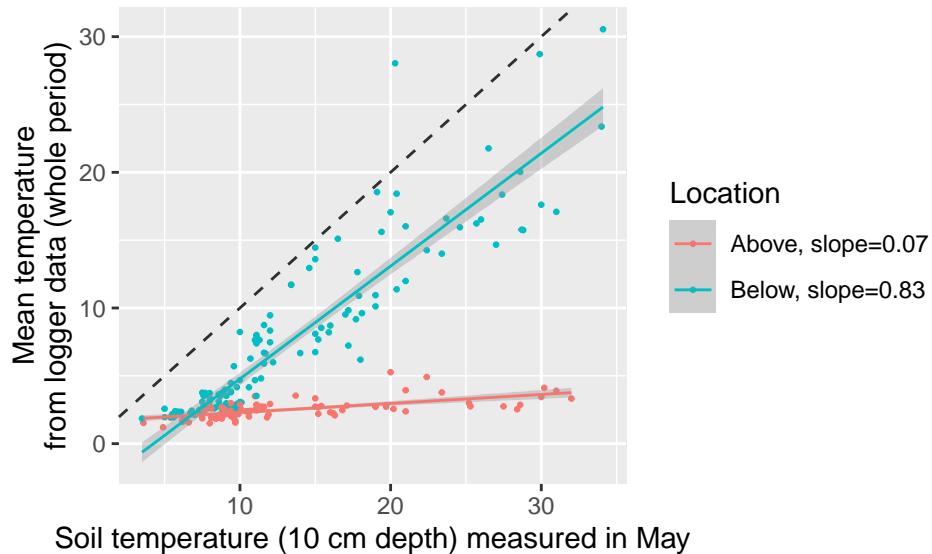
```
## [1] 0.8614051
```

Correlation mean temperature of may from logger data (only aboveground loggers) and soil temperature measured in may with thermometer:

```
## [1] 0.1263677
```

## Whole period

For each logger\_nr, get mean temperature during the whole period available and compare with temp\_term (which was measured with a thermometer at 10 cm depth on May 2017):



Observations	78
Dependent variable	mean_logger
Type	OLS linear regression

F(1,76)	54.027
R <sup>2</sup>	0.416
Adj. R <sup>2</sup>	0.408

Correlation mean temperature from logger data and soil temperature measured in may with thermometer:

```
## [1] 0.6700633
```

	Est.	S.E.	t val.	p
(Intercept)	1.633	0.138	11.819	0.000
temp_term	0.066	0.009	7.350	0.000

Standard errors: OLS

Observations	141
Dependent variable	mean_logger
Type	OLS linear regression

F(1,139)	686.807
R <sup>2</sup>	0.832
Adj. R <sup>2</sup>	0.830

	Est.	S.E.	t val.	p
(Intercept)	-3.547	0.465	-7.623	0.000
temp_term	0.832	0.032	26.207	0.000

Standard errors: OLS

Correlation mean temperature from logger data (only belowground loggers) and soil temperature measured in may with thermometer:

```
## [1] 0.9119648
```

Correlation mean temperature from logger data (only aboveground loggers) and soil temperature measured in may with thermometer:

```
## [1] 0.6445959
```

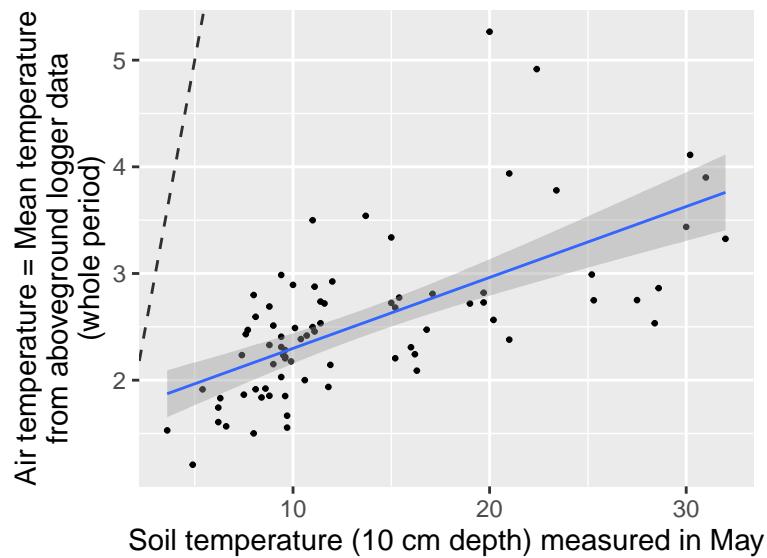
The correlation values seem to indicate that the temperature measured with a thermometer represents quite well longer-term conditions

## Q2: Do differences between soil and air temperatures change with soil temperature?

For the plants with aboveground loggers, we have air temperature and soil temperature measured at the same exact location (air temperature measured by the aboveground logger and soil temperature measured with the thermometer). We use these plants to test for correlations between air and soil temperature.

## All temperature values

Logger data for the whole period:



Observations	78
Dependent variable	mean_logger
Type	OLS linear regression
<hr/>	
F(1,76)	54.027
R <sup>2</sup>	0.416
Adj. R <sup>2</sup>	0.408

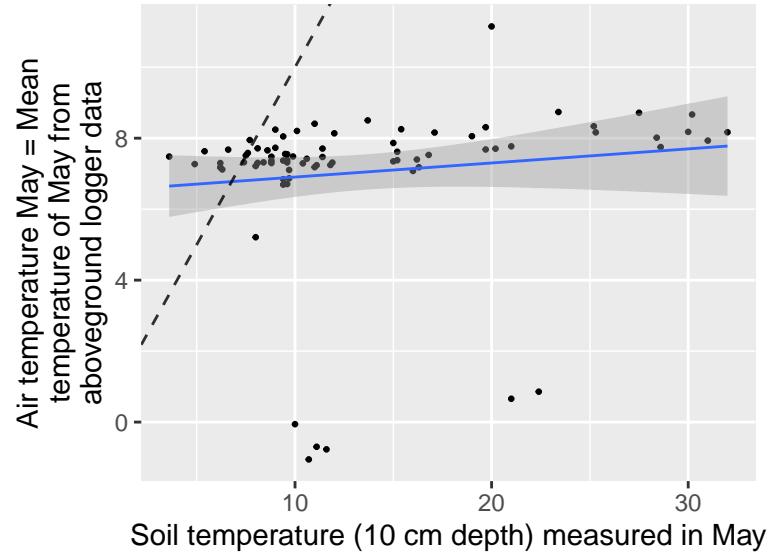
	Est.	S.E.	t val.	p
(Intercept)	1.633	0.138	11.819	0.000
temp_term	0.066	0.009	7.350	0.000

Standard errors: OLS

```
## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
## Model 2: mean_logger ~ temp_term
##
##   Res.Df   RSS Df Sum of Sq    F    Pr(>F)
## 1     77 3339.5
## 2     76 23.6  1   3315.9 10658 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ',' 1
```

The slope is significantly different from 1: differences between soil and air temperature change with soil temperature, being larger at higher soil temperatures.

### Logger data for May:



Observations	78
Dependent variable	meanmay_logger
Type	OLS linear regression

F(1,76)	1.233
R <sup>2</sup>	0.016
Adj. R <sup>2</sup>	0.003

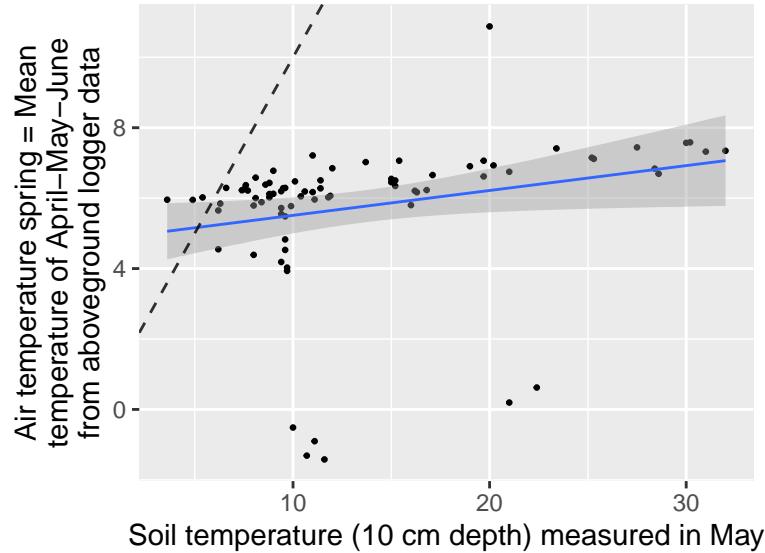
	Est.	S.E.	t val.	p
(Intercept)	6.507	0.547	11.900	0.000
temp_term	0.040	0.036	1.111	0.270

Standard errors: OLS

```
## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
## Model 2: meanmay_logger ~ temp_term
##
##   Res.Df   RSS Df Sum of Sq    F    Pr(>F)
## 1     77 3878.6
## 2     76 370.1  1    3508.5 720.54 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ',' 1
```

When looking only at air temperature in May, the slope is also significantly different from 1: differences between soil and air temperature change with soil temperature, being larger at higher soil temperatures.

#### Logger data for April-May-June:



Observations	78
Dependent variable	meanspring_logger
Type	OLS linear regression

F(1,76)	4.642
R <sup>2</sup>	0.058
Adj. R <sup>2</sup>	0.045

	Est.	S.E.	t val.	p
(Intercept)	4.805	0.501	9.592	0.000
temp_term	0.071	0.033	2.154	0.034

Standard errors: OLS

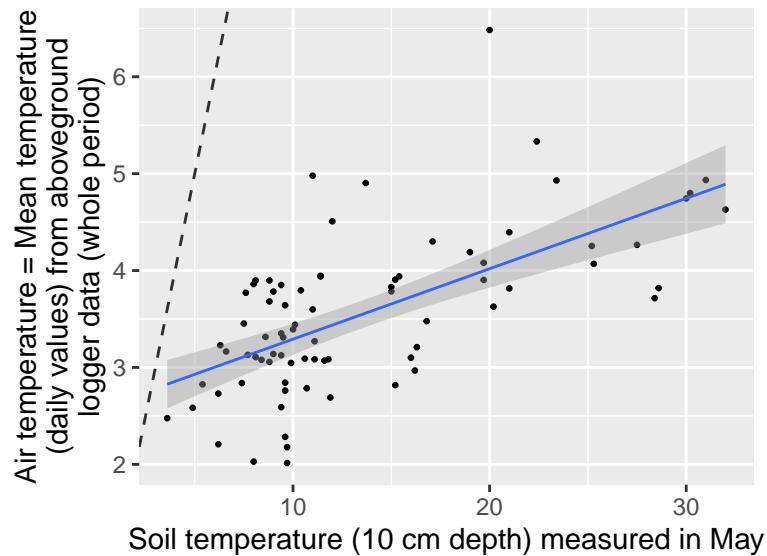
```
## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
## Model 2: meanspring_logger ~ temp_term
##
##   Res.Df   RSS Df Sum of Sq      F    Pr(>F)
## 1     77 3597.1
## 2     76 310.6  1    3286.5 804.06 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

When looking at air temperature in the period April-May-June, the slope is also significantly different from 1: differences between soil and air temperature change with soil temperature, being larger at higher soil temperatures.

## Daily temperature values

Repeat what was done above using only daily values of air temperature (after 8 am and before or equal to 8 pm).

**Logger data for the whole period:**



Observations	78
Dependent variable	mean_logger
Type	OLS linear regression

F(1,76)	50.038
R <sup>2</sup>	0.397
Adj. R <sup>2</sup>	0.389

	Est.	S.E.	t val.	p
(Intercept)	2.566	0.157	16.343	0.000
temp_term	0.073	0.010	7.074	0.000

Standard errors: OLS

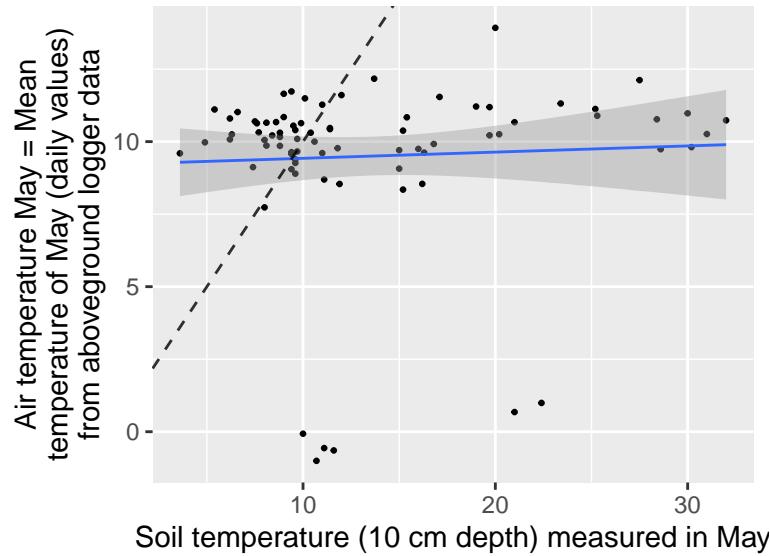
```
## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
```

```

## Model 2: mean_logger ~ temp_term
##
##   Res.Df     RSS Df Sum of Sq    F    Pr(>F)
## 1      77 3302.6
## 2      76   30.5  1     3272.1 8152 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Logger data for May:



Observations	78
Dependent variable	meanmay_logger
Type	OLS linear regression

F(1,76)	0.196
R <sup>2</sup>	0.003
Adj. R <sup>2</sup>	-0.011

	Est.	S.E.	t val.	p
(Intercept)	9.212	0.736	12.516	0.000
temp_term	0.021	0.048	0.443	0.659

Standard errors: OLS

```

## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
## Model 2: meanmay_logger ~ temp_term
##

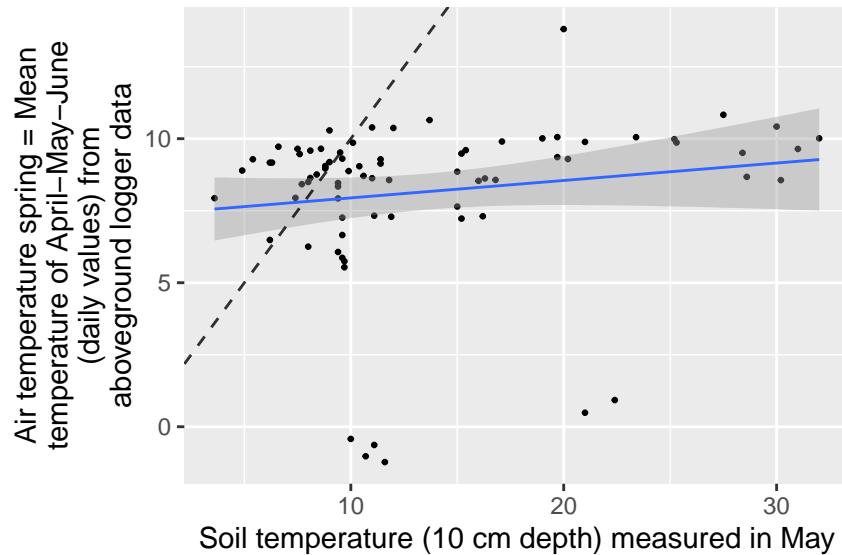
```

```

##   Res.Df      RSS Df Sum of Sq      F    Pr(>F)
## 1      77 4314.9
## 2      76  670.6  1     3644.3 413.04 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ',' 1

```

### Logger data for April-May-June:



Observations	78
Dependent variable	meanspring_logger
Type	OLS linear regression

F(1,76)	1.799
R <sup>2</sup>	0.023
Adj. R <sup>2</sup>	0.010

	Est.	S.E.	t val.	p
(Intercept)	7.340	0.689	10.651	0.000
temp_term	0.060	0.045	1.341	0.184

Standard errors: OLS

```

## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
## Model 2: meanspring_logger ~ temp_term
##
##   Res.Df      RSS Df Sum of Sq      F    Pr(>F)
## 1      77 3946.4

```

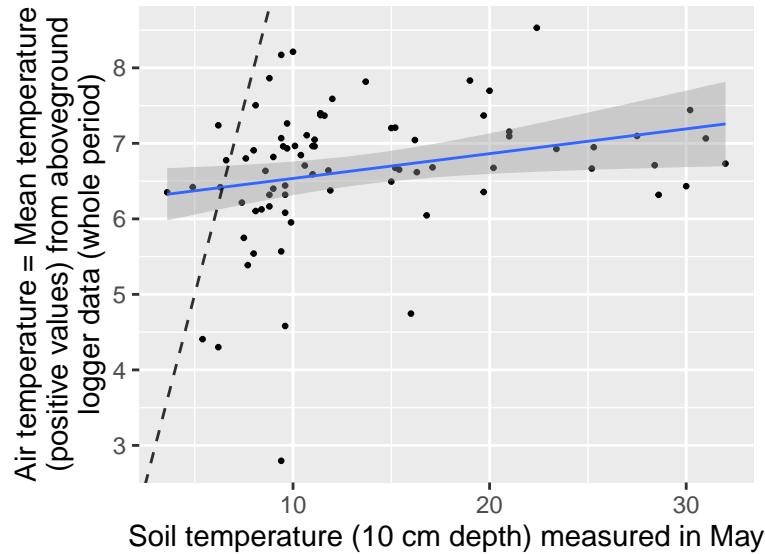
```

## 2      76  587.9  1    3358.5 434.13 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

## Positive temperature values

Logger data for the whole period:



Observations	78
Dependent variable	mean_logger
Type	OLS linear regression

F(1,76)	5.296
R <sup>2</sup>	0.065
Adj. R <sup>2</sup>	0.053

	Est.	S.E.	t val.	p
(Intercept)	6.208	0.218	28.499	0.000
temp_term	0.033	0.014	2.301	0.024

Standard errors: OLS

```

## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
## Model 2: mean_logger ~ temp_term
##
##   Res.Df   RSS Df Sum of Sq   F   Pr(>F)

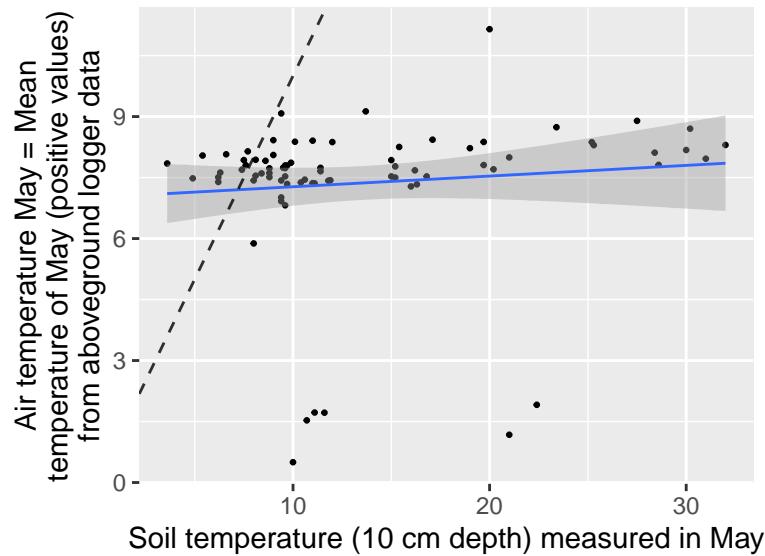
```

```

## 1      77 3618.1
## 2      76   58.7  1     3559.4 4606 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Logger data for May:



Observations	78
Dependent variable	meanmay_logger
Type	OLS linear regression

F(1,76)	0.773
R <sup>2</sup>	0.010
Adj. R <sup>2</sup>	-0.003

	Est.	S.E.	t val.	p
(Intercept)	7.011	0.457	15.342	0.000
temp_term	0.026	0.030	0.879	0.382

Standard errors: OLS

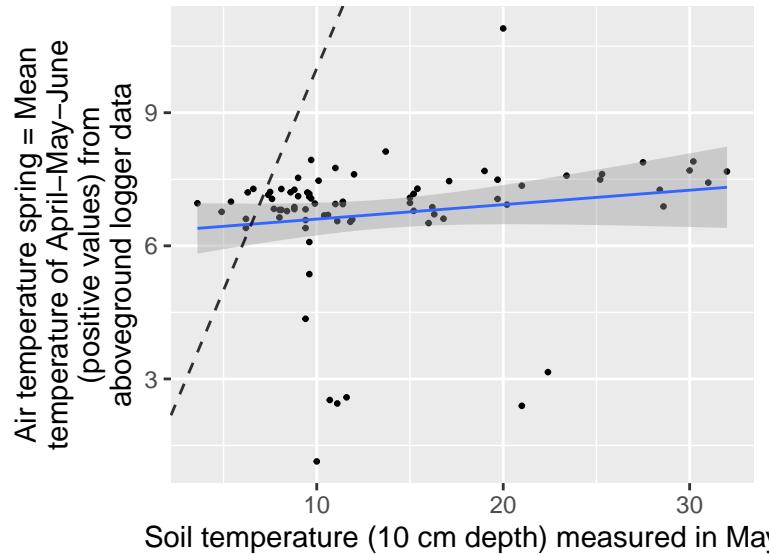
```

## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
## Model 2: meanmay_logger ~ temp_term
##
## Res.Df    RSS Df Sum of Sq      F    Pr(>F)
## 1      77 3866.0
## 2      76 258.5  1     3607.5 1060.6 < 2.2e-16 ***

```

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

### Logger data for April-May-June:



Observations	78
Dependent variable	meanspring_logger
Type	OLS linear regression

F(1,76)	1.944
R <sup>2</sup>	0.025
Adj. R <sup>2</sup>	0.012

	Est.	S.E.	t val.	p
(Intercept)	6.277	0.357	17.573	0.000
temp_term	0.033	0.023	1.394	0.167

Standard errors: OLS

```
## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
## Model 2: meanspring_logger ~ temp_term
##
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1     77 3718.9
## 2     76 157.9  1    3560.9 1713.6 < 2.2e-16 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Similar results when using daily or positive temperature values.

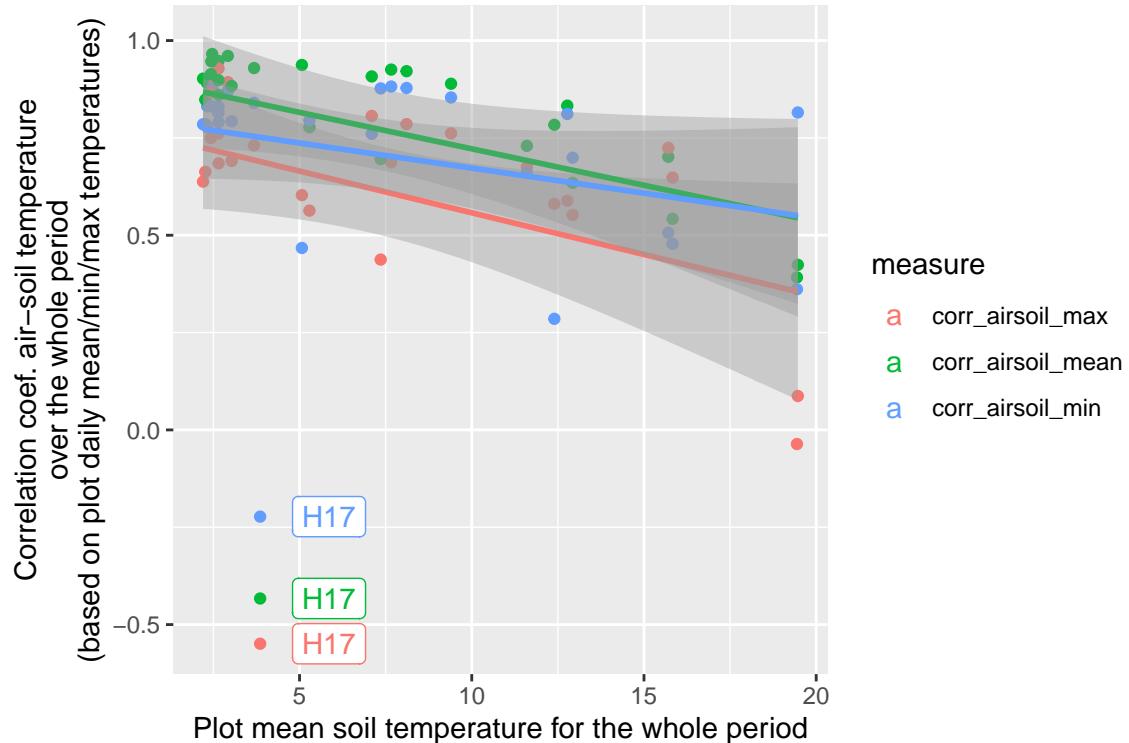
### Q3: Do correlations between soil and air temperature vary with soil temperature?

Or: How useful soil temperature is as a cue for air temperature, i.e., as a cue for spring advancement?

**Option 1:** use plots to calculate correlations between soil and air logger temperatures

Correlations soil-air temperature over the whole period

For each date and plot, calculate mean, max and min of air and soil temperature (from, respectively, above and belowground loggers). Then, calculate the correlation coefficient for air and soil temperatures over the whole period (based on the number of dates where both air and soil temperatures are available). Finally, regress these correlation coefficients on mean soil temperature for each plot for the whole period.



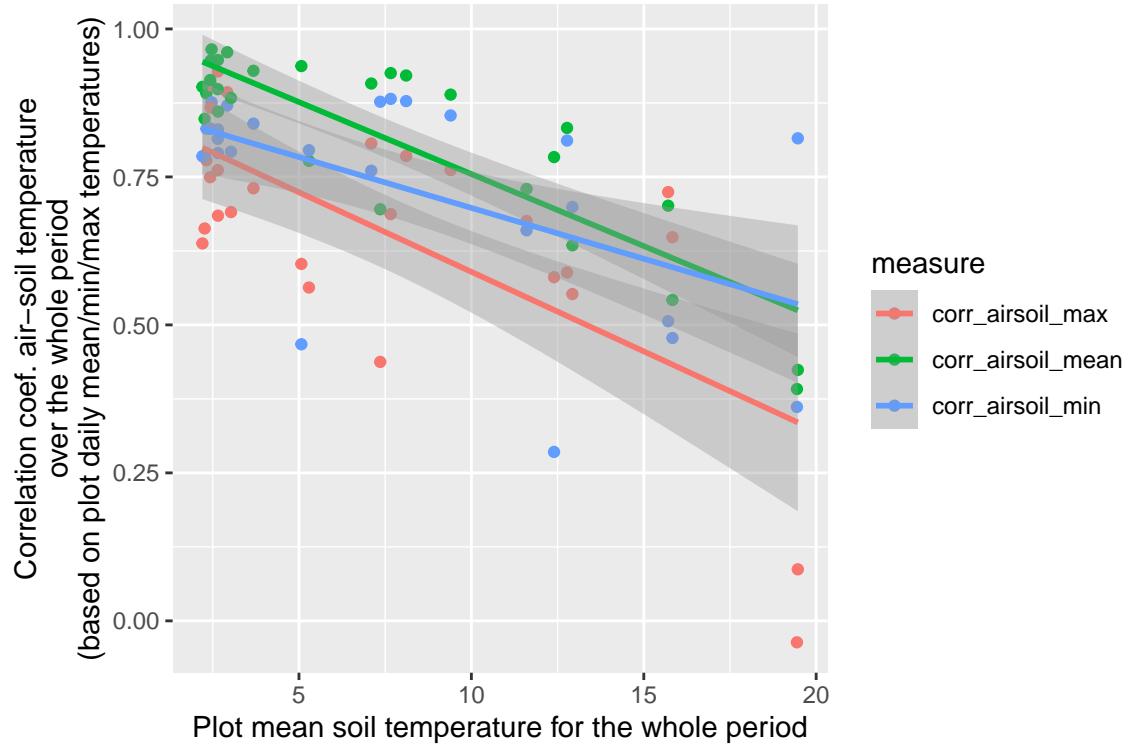
For plot H17, the correlation values are negative. This is strange, and I thought that it could be due to an error in one of the loggers, but after removing all loggers in that particular plot one by one, and redoing the analysis, the results were similar.

Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.7717260	0.0930390	8.294653	0.0000000
corr_airsoil_max	meansoilttemp	-0.0214152	0.0101682	-2.106090	0.0450041
corr_airsoil_mean	(Intercept)	0.9092314	0.0850159	10.694841	0.0000000
corr_airsoil_mean	meansoilttemp	-0.0187304	0.0092914	-2.015890	0.0542547
corr_airsoil_min	(Intercept)	0.8013020	0.0759185	10.554771	0.0000000
corr_airsoil_min	meansoilttemp	-0.0128874	0.0082971	-1.553246	0.1324536

Only significant for correlations based on max daily temperatures ( $p=0.04$ ).

Graph with plot H17 removed:

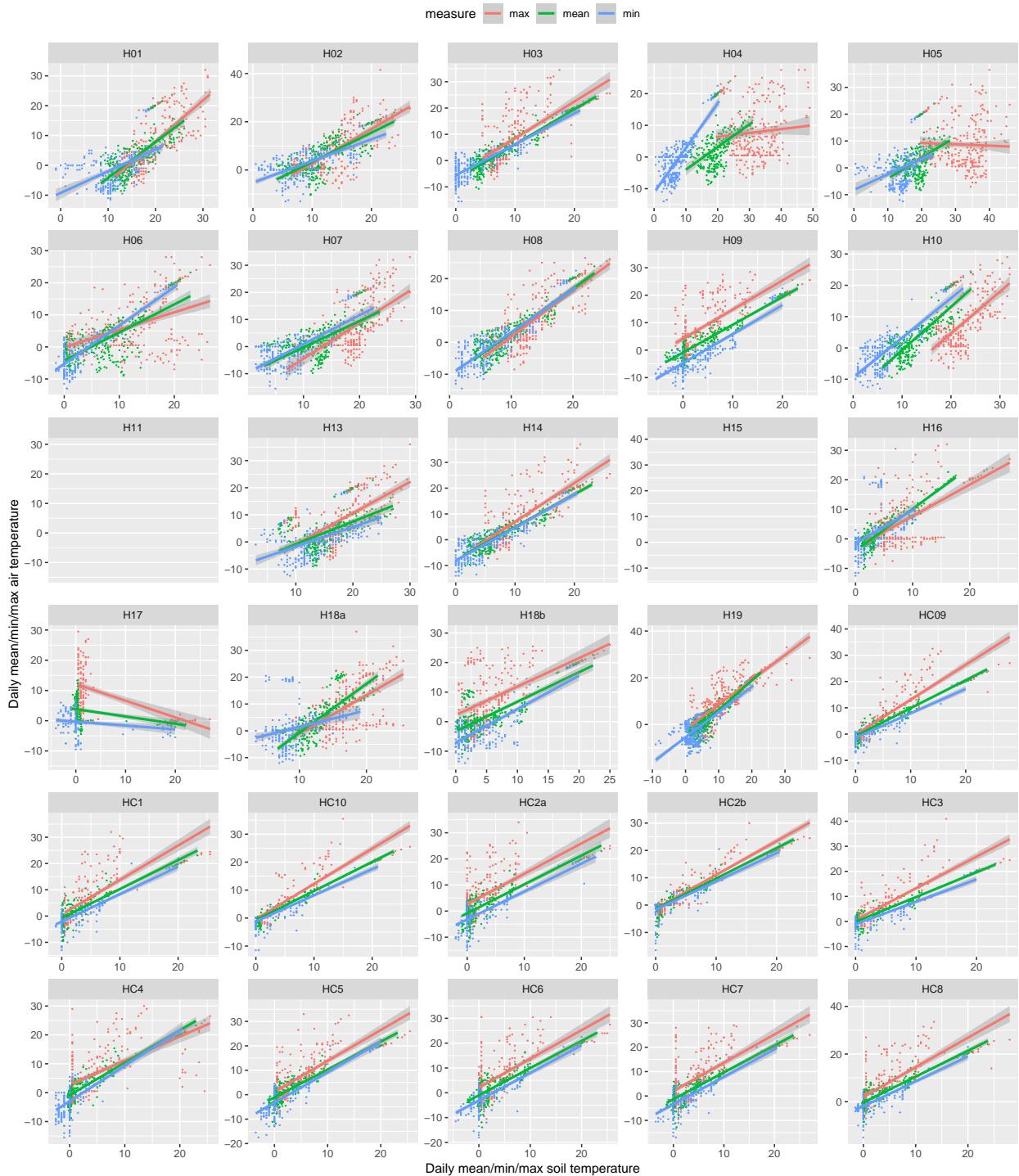


The same models with plot H17 removed:

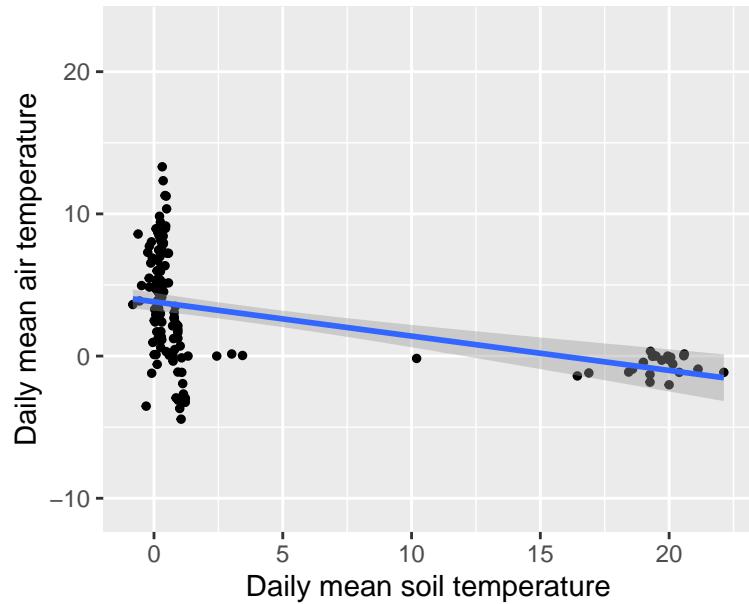
measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.8583782	0.0513025	16.731715	0.0000000
corr_airsoil_max	meansoilttemp	-0.0268723	0.0055234	-4.865216	0.0000528
corr_airsoil_mean	(Intercept)	0.9980987	0.0269446	37.042570	0.0000000
corr_airsoil_mean	meansoilttemp	-0.0243270	0.0029009	-8.385946	0.0000000
corr_airsoil_min	(Intercept)	0.8694813	0.0454946	19.111732	0.0000000
corr_airsoil_min	meansoilttemp	-0.0171812	0.0048981	-3.507755	0.0017315

Higly significant for all correlations (either based on max, mean or min daily temperatures). This indicates that correlations between soil and air temperature over the whole period vary with soil temperature, being weaker when soil temperature is warmer. Soil temperature is less useful as a cue for air temperature (i.e. for spring advancement) in warmer (heated) areas.

Is it OK to remove plot H17? What could cause the negative correlations in this plot? See below for scatterplots of air vs. soil temperature for each of the plots (plots H11 and H15 missing because they do not have any belowground loggers), and for H17, which is the only one with a negative correlation:

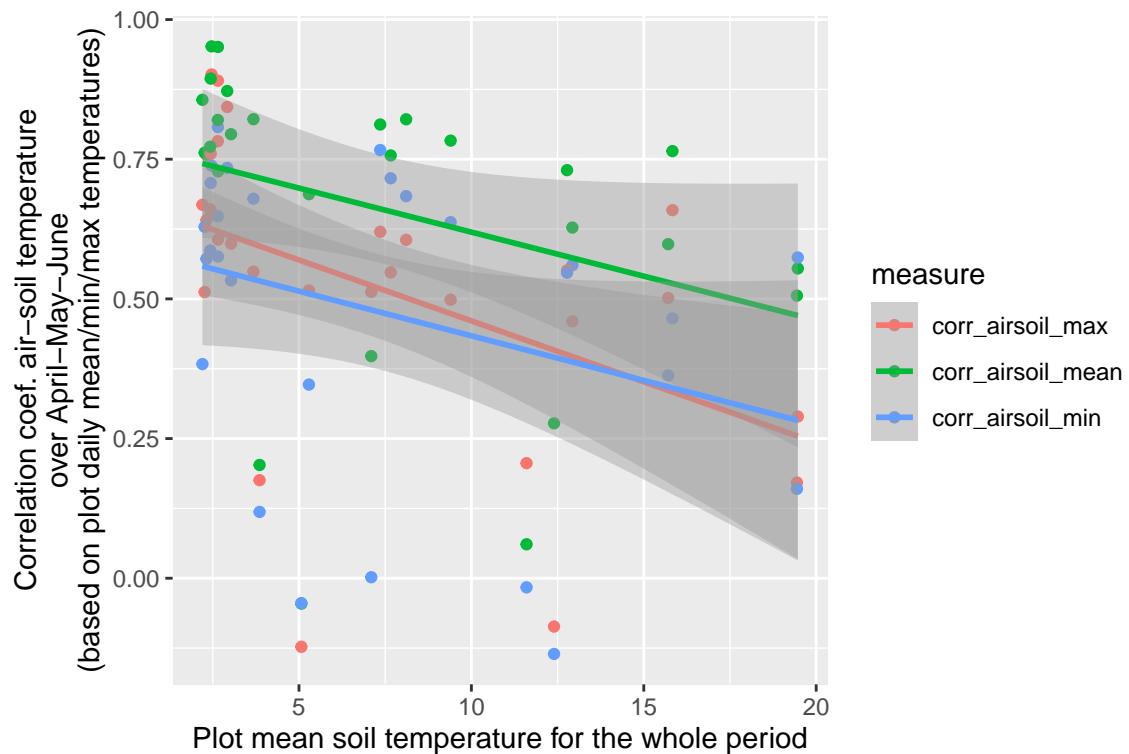


Plot H17



#### Correlations soil-air temperature over the period April-May-June

For each date and plot, calculate mean, max and min of air and soil temperature (from, respectively, above and belowground loggers). Then, calculate the correlation coefficient for air and soil temperatures over the period April-May-June. Finally, regress these correlation coefficients on mean soil temperature for each plot for the whole period.



Several plots with negative correlations!

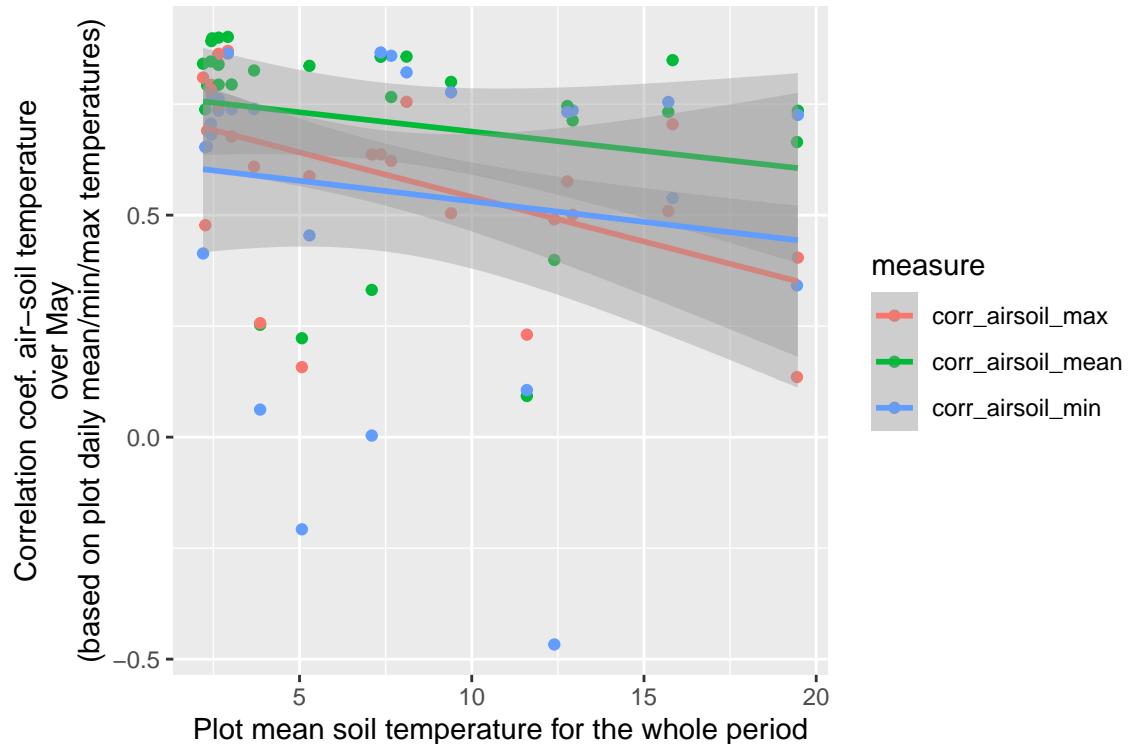
Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.6785493	0.0736613	9.211747	0.0000000
corr_airsoil_max	meansoiltemp	-0.0217924	0.0080504	-2.706986	0.0118359
corr_airsoil_mean	(Intercept)	0.7771129	0.0790988	9.824584	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0157616	0.0086447	-1.823267	0.0797812
corr_airsoil_min	(Intercept)	0.5938172	0.0839783	7.071082	0.0000002
corr_airsoil_min	meansoiltemp	-0.0159886	0.0091780	-1.742063	0.0933173

Only significant for correlations based on max daily temperatures ( $p=0.01$ ).

### Correlations soil-air temperature for May only

For each date and plot, calculate mean, max and min of air and soil temperature (from, respectively, above and belowground loggers). Then, calculate the correlation coefficient for air and soil temperatures over the month of May. Finally, regress these correlation coefficients on mean soil temperature for each plot for the whole period.

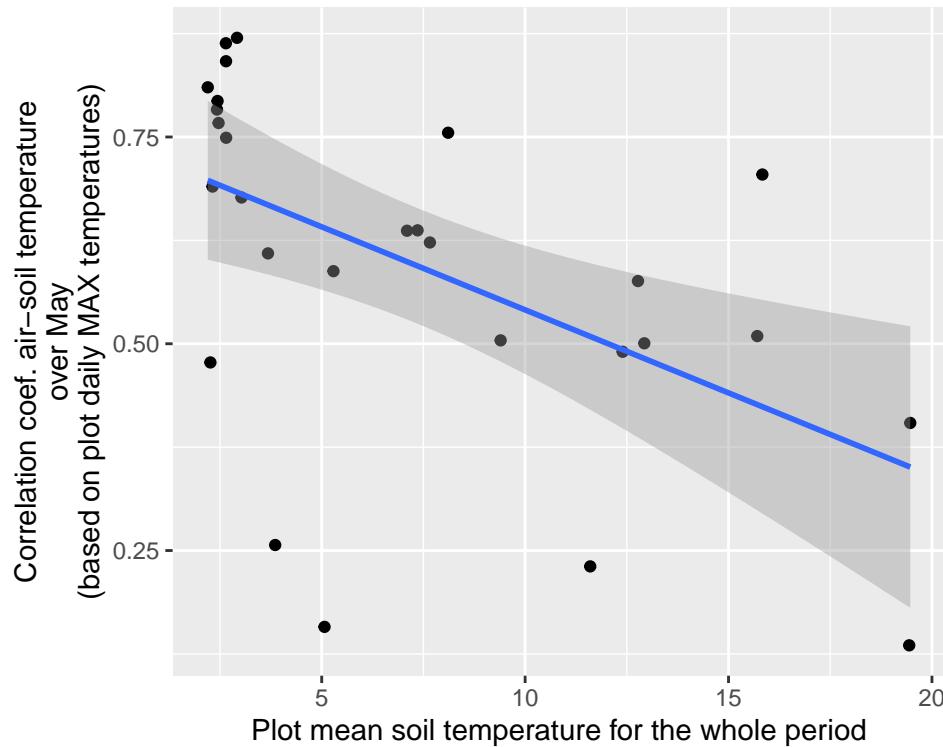


Several plots with negative correlations!

Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.7417553	0.0569785	13.018162	0.0000000
corr_airsoil_max	meansoiltemp	-0.0200765	0.0062272	-3.224012	0.0033943
corr_airsoil_mean	(Intercept)	0.7752010	0.0715949	10.827609	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0086922	0.0078246	-1.110879	0.2767886
corr_airsoil_min	(Intercept)	0.6238954	0.1111621	5.612483	0.0000067
corr_airsoil_min	meansoiltemp	-0.0092723	0.0121489	-0.763220	0.4522022

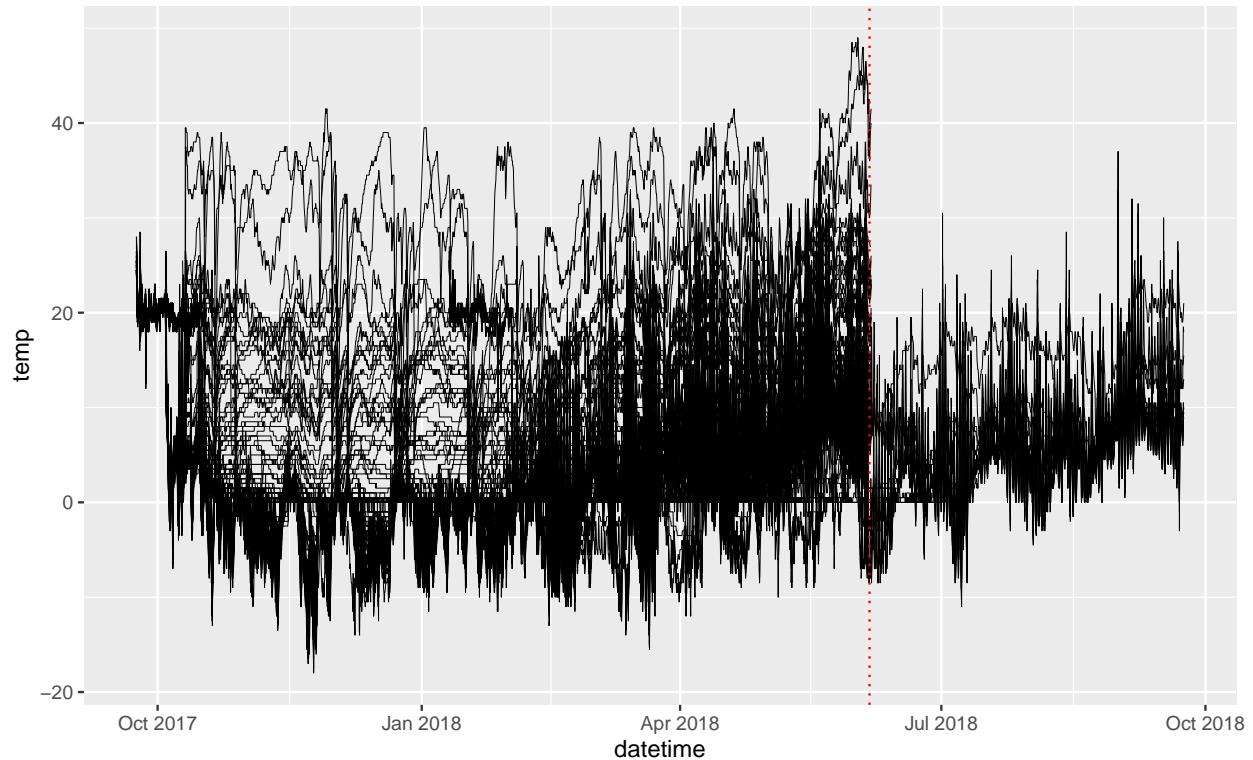
Only significant for correlations based on max daily temperatures ( $p < 0.01$ ). See graph below:



## Option 2: try to pair

### Paired logger data

Plot with all paired logger data, one line per logger id



```
## # A tibble: 145 x 3
##   logger_nr  pair last_date
##       <dbl>  <dbl> <dttm>
## 1       103     1 2018-06-06 12:11:00
## 2       105     1 2018-06-06 13:44:00
## 3       101     2 2018-06-06 11:34:00
## 4       104     2 2018-06-06 13:16:00
## 5       108     3 2018-06-06 12:52:00
## 6       113     3 2018-06-06 11:02:00
## 7       111     4 2018-06-06 12:59:00
## 8       115     4 2018-06-06 12:04:00
## 9       117     5 2018-06-06 10:43:00
## 10      122     5 2018-06-06 13:36:00
## # ... with 135 more rows
```

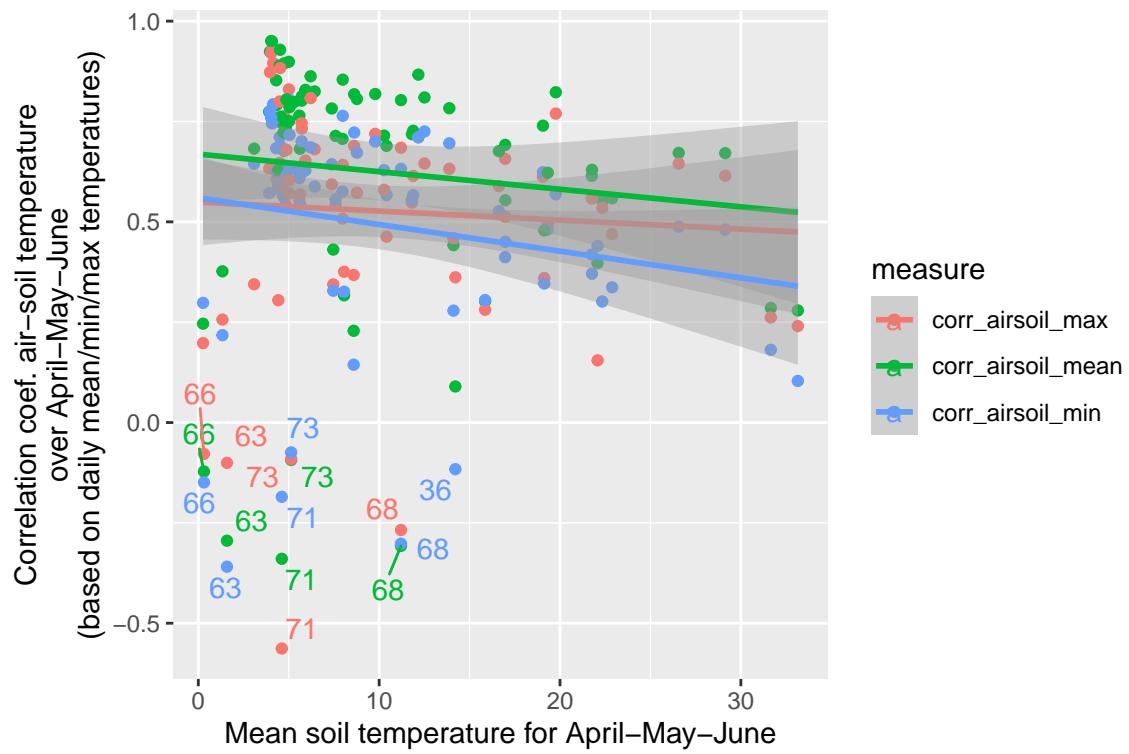
Most loggers (131 out of 145) end up on June 6th. So probably using May is OK.

### Analyses using all pairs

#### Correlations soil-air temperature over the period April-May-June

**Based on 24-h values** For each date and logger pair, calculate mean, max and min of air and soil temperature (from, respectively, the above and belowground logger). Then, calculate the correlation coefficient for air and soil temperatures over the period April-May-June. Finally, regress these correlation coefficients on mean soil temperature (from the aboveground logger) **for the same period (April-May-June)**.

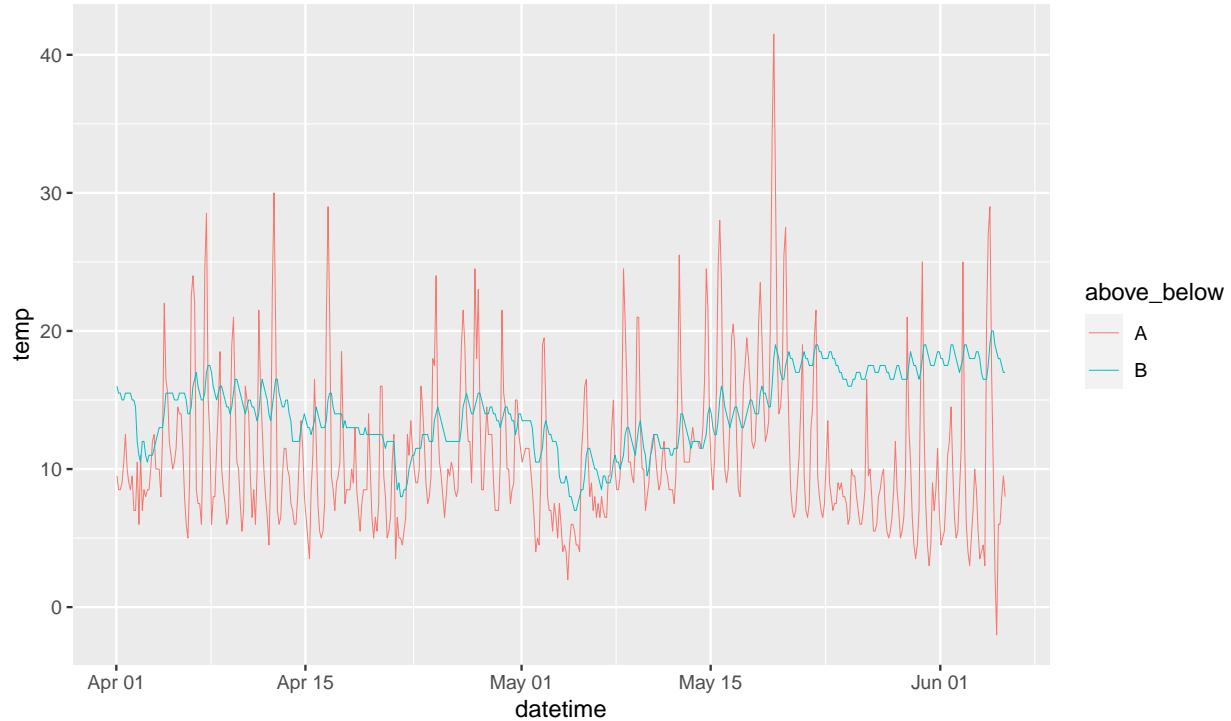
Using only data till June 5th, included (as most loggers stop on June 6th).



Look at the pairs with negative correlations in detail

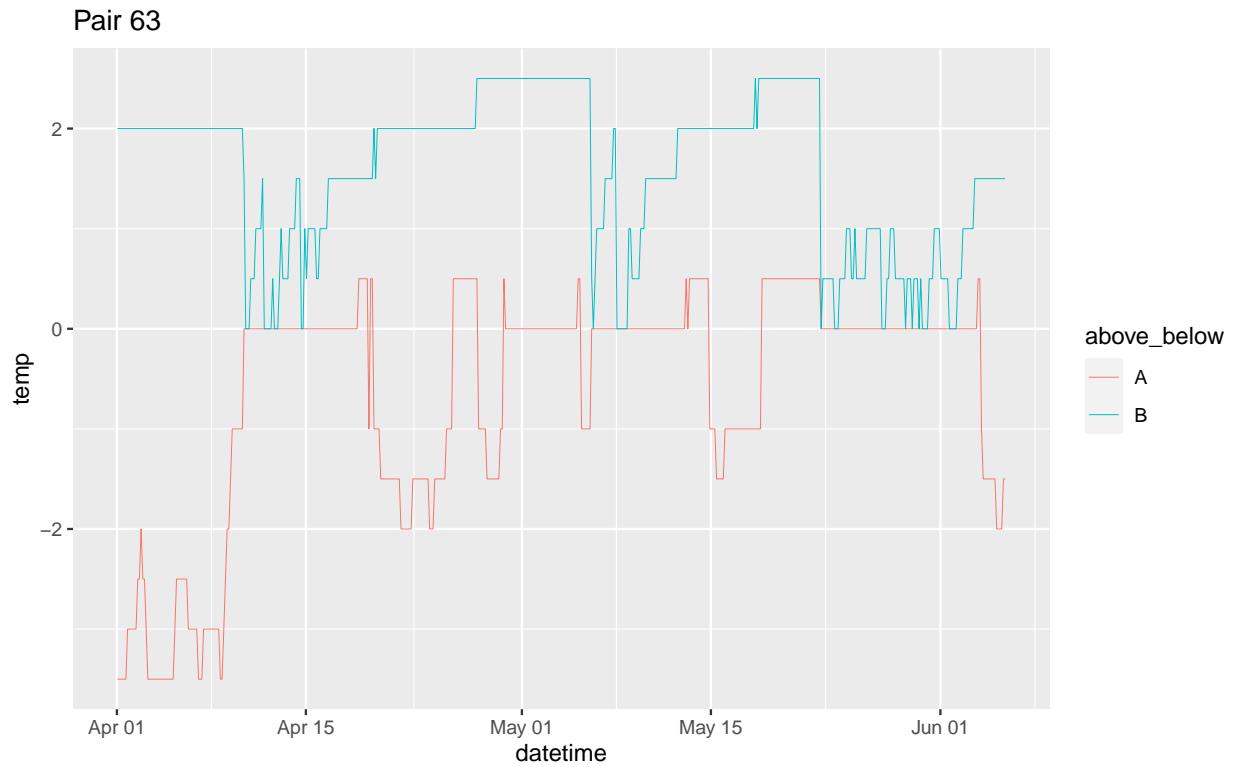
Pairs with negative correlations: 36 (only for min), 63, 66, 68, 71, 73.

### Pair 36



I cannot see anything worrying in the graph. As the negative correlation is only for the min temperature,

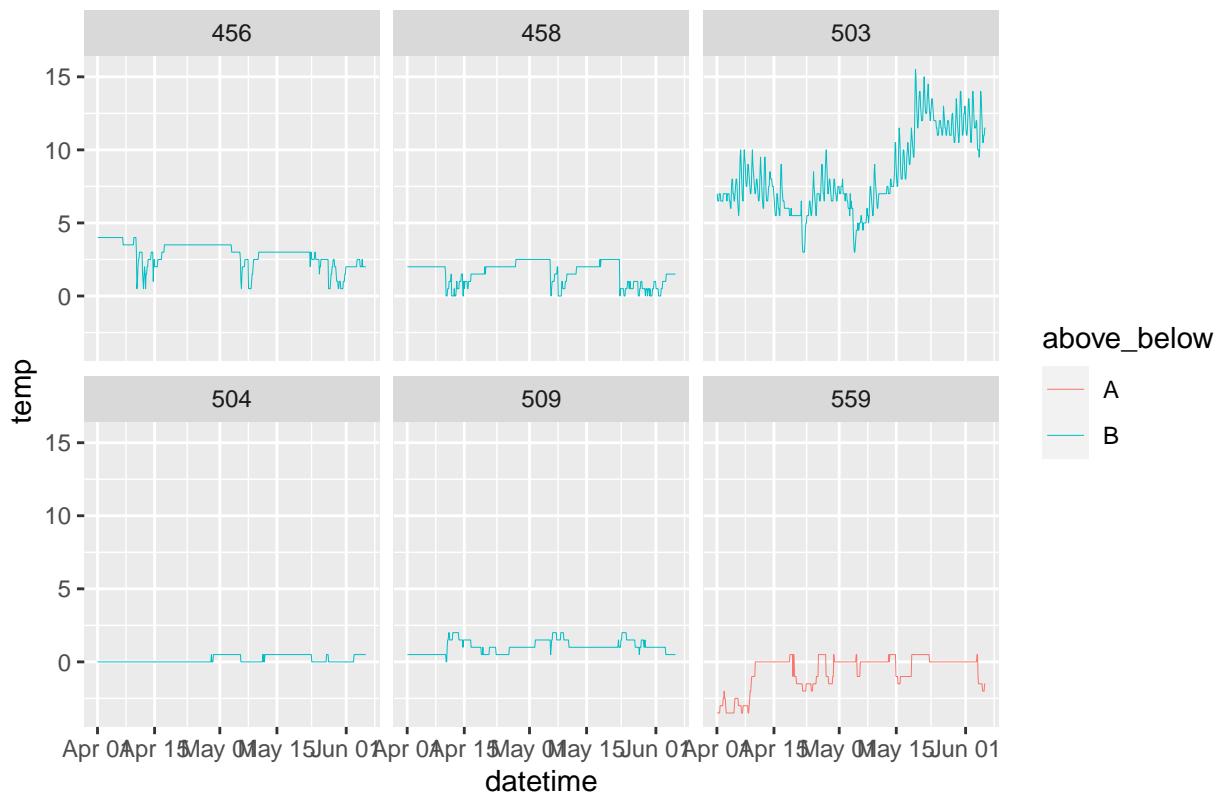
and it is also not very negative, maybe there is nothing strange here?



Here, both loggers have constant values of temperature for several periods of time.

The next graph shows all loggers in the same plot as pair 63:

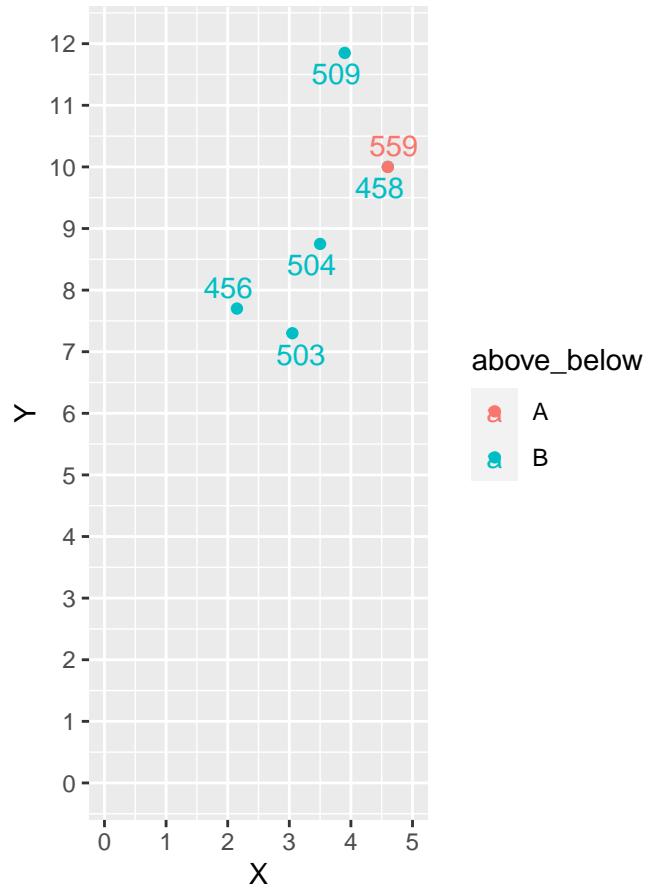
Plot H16



All but one have similar patterns, with constant values for some time periods.

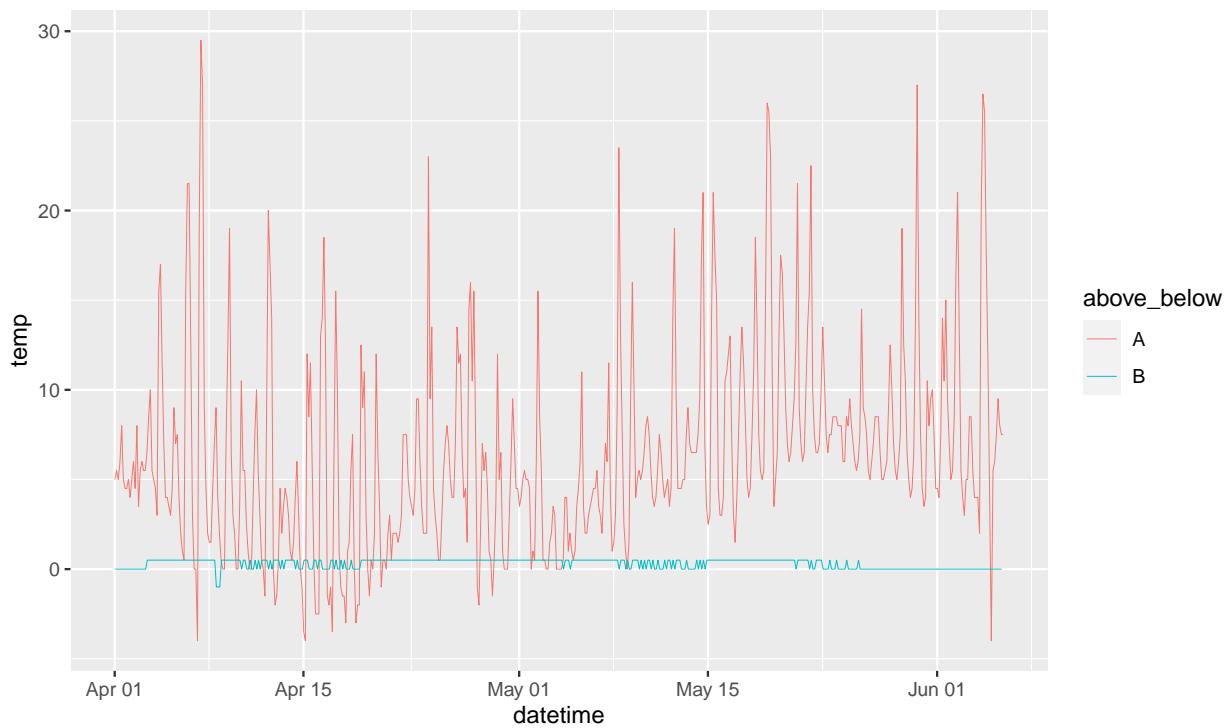
Here is the spatial distribution of the loggers in the plot:

Plot H16



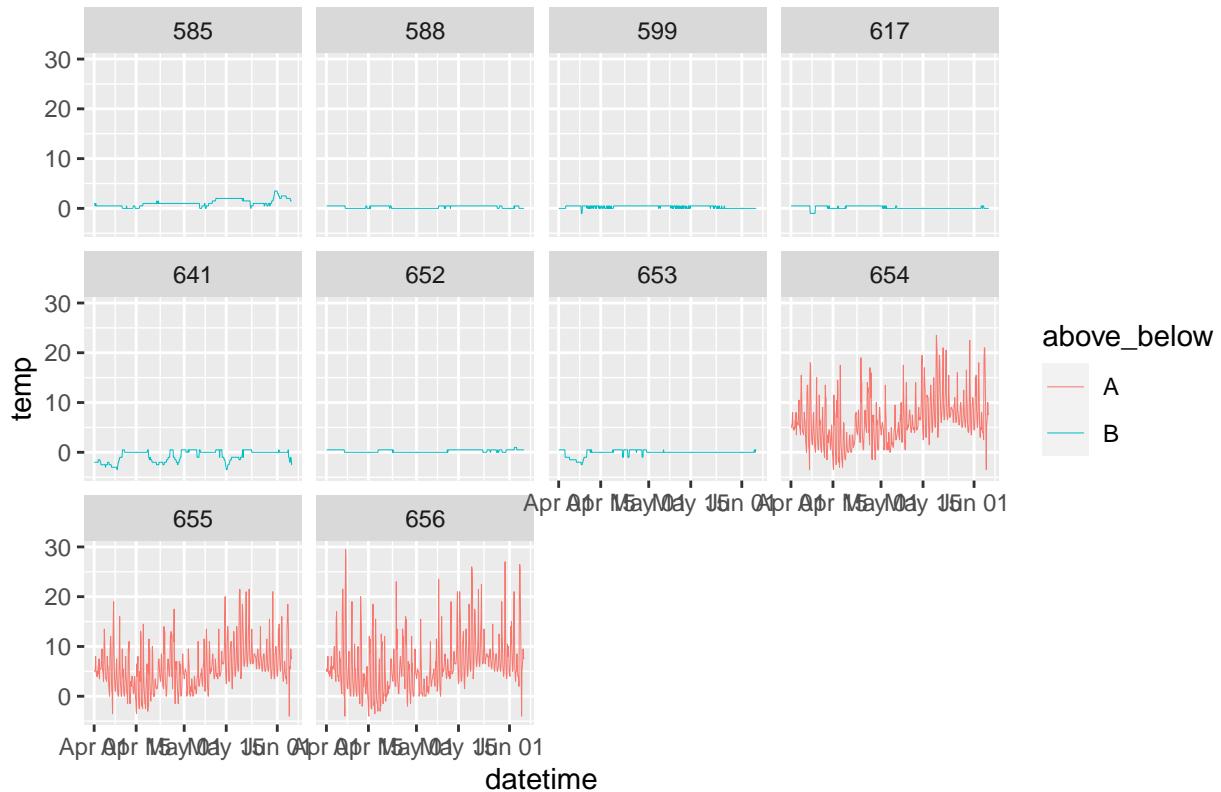
Maybe part of the plot was covered by snow, causing this low variation, and logger 503 was not?

Pair 66



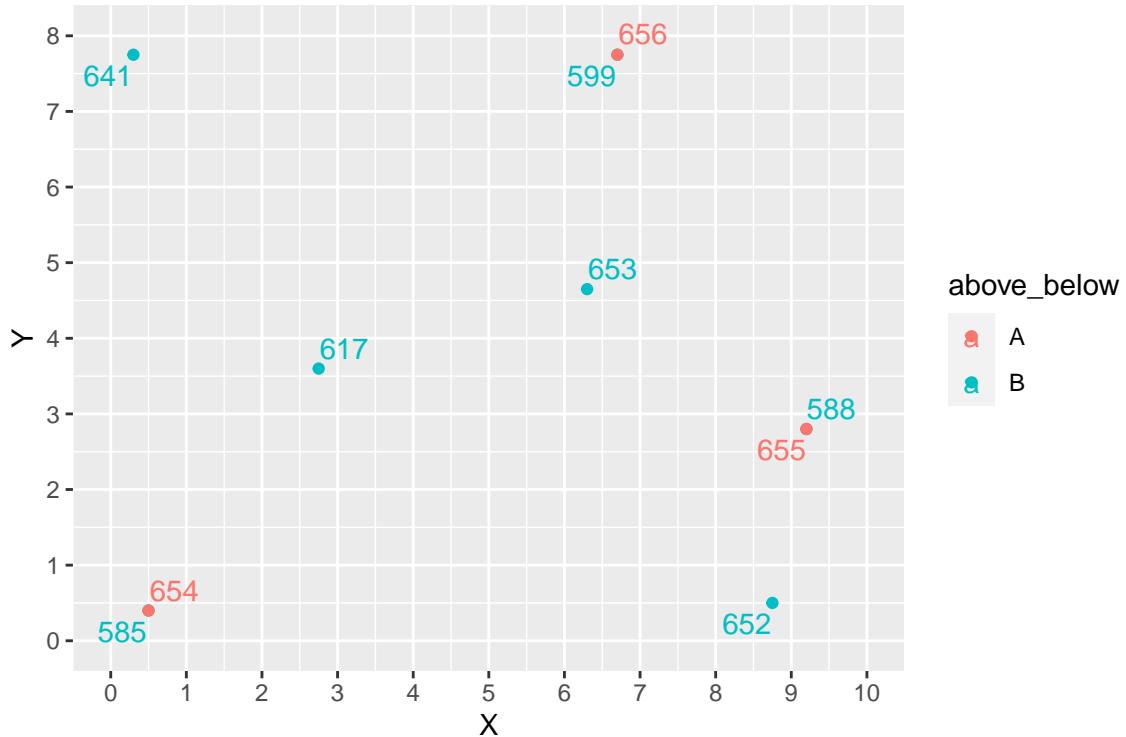
The next graph shows all loggers in the same plot as pair 66:

Plot H17

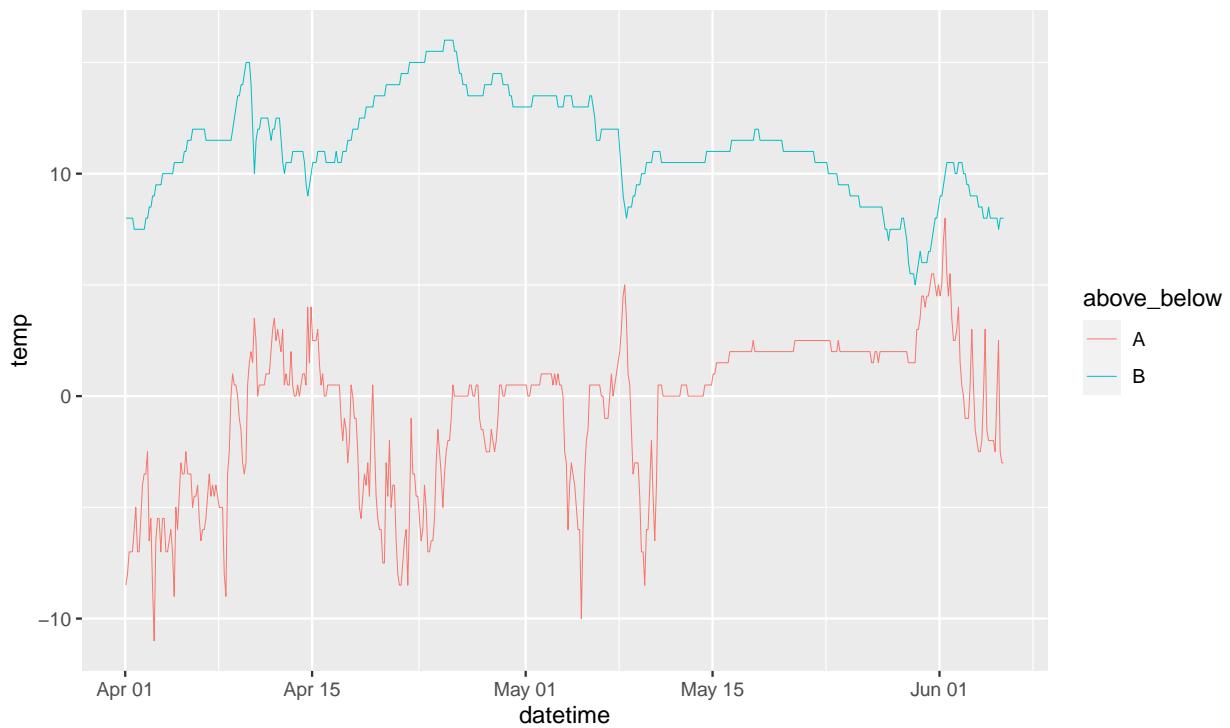


All the belowground loggers show similar patterns, with very low variation. However, the aboveground loggers look fine, even if they are located at the same plant that a belowground logger (see locations in the graph below). So this is probably not due to effects of snow? Or could it be that the aboveground loggers are out of the snow but the belowground ones are covered by snow?

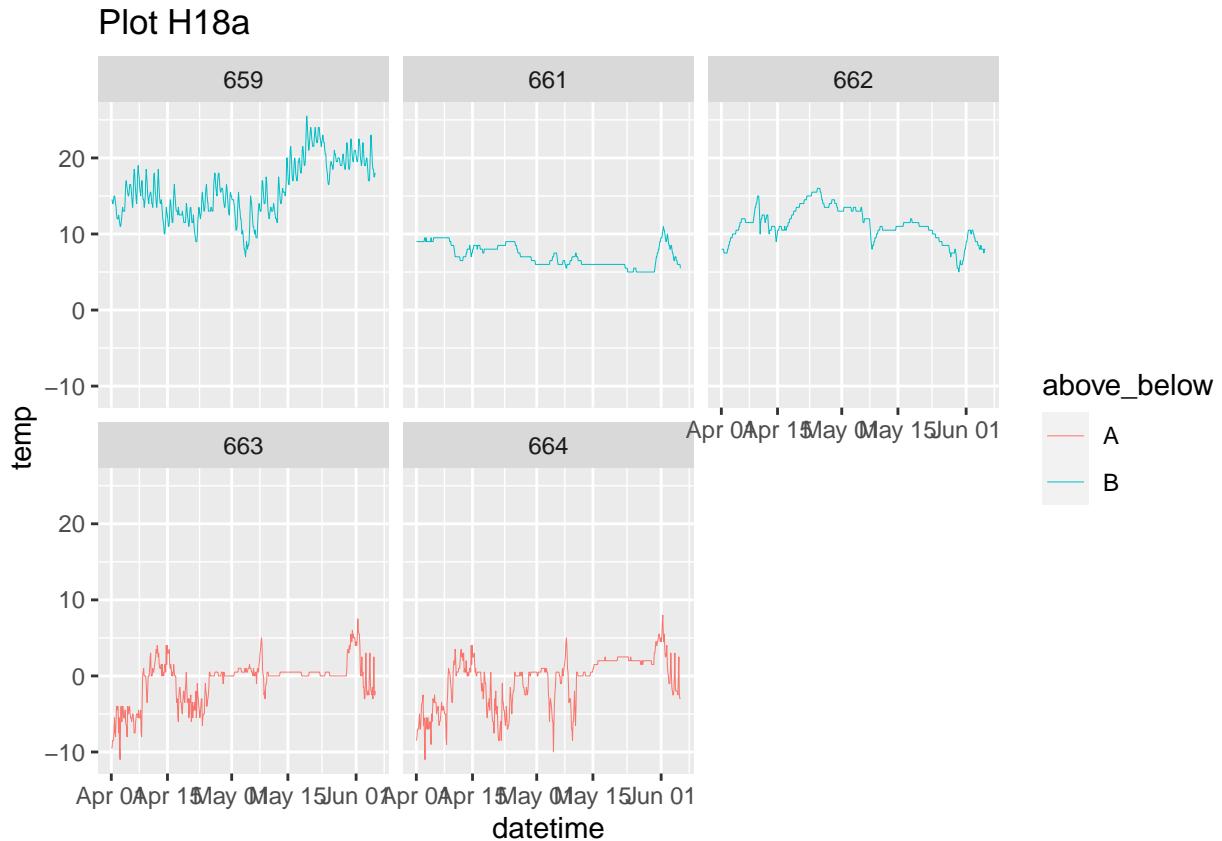
Plot H17



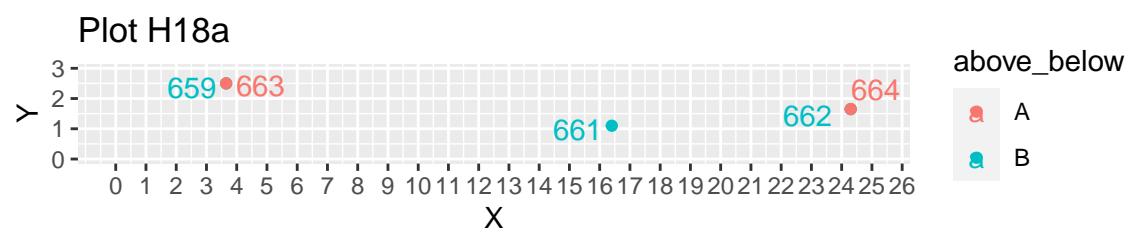
Pair 68



The next graph shows all loggers in the same plot as pair 68:

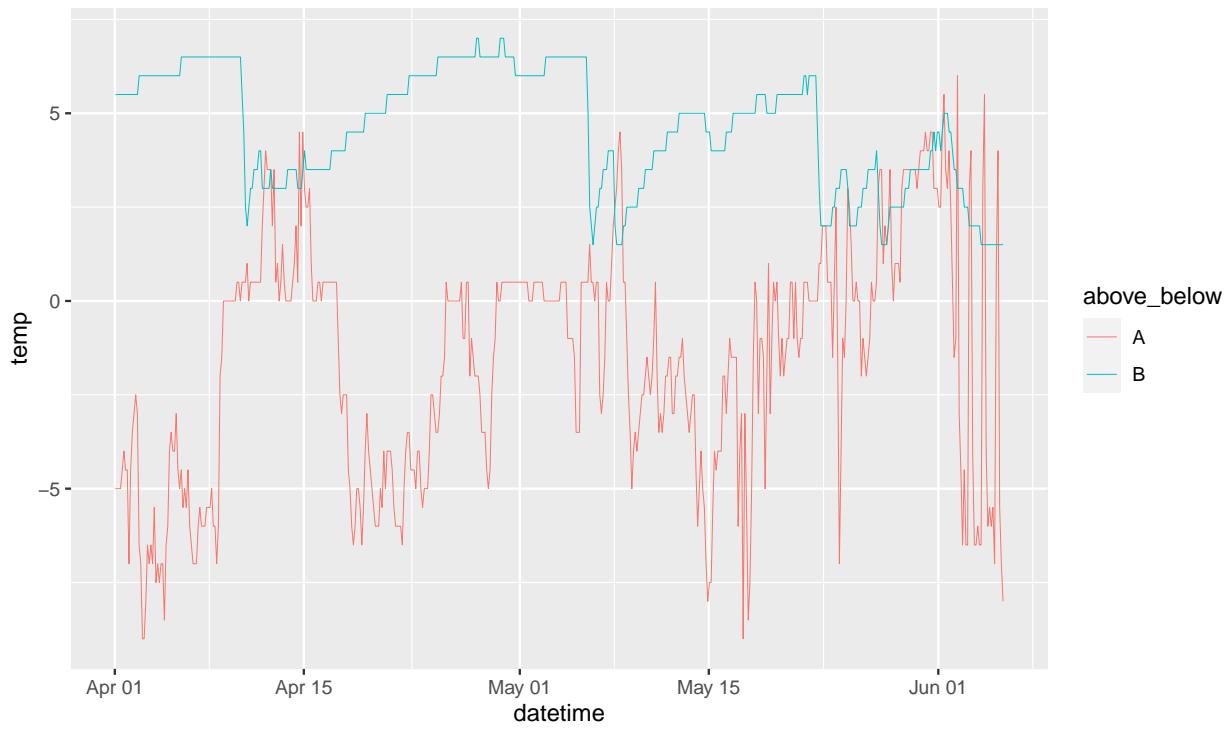


And the locations in the plot:



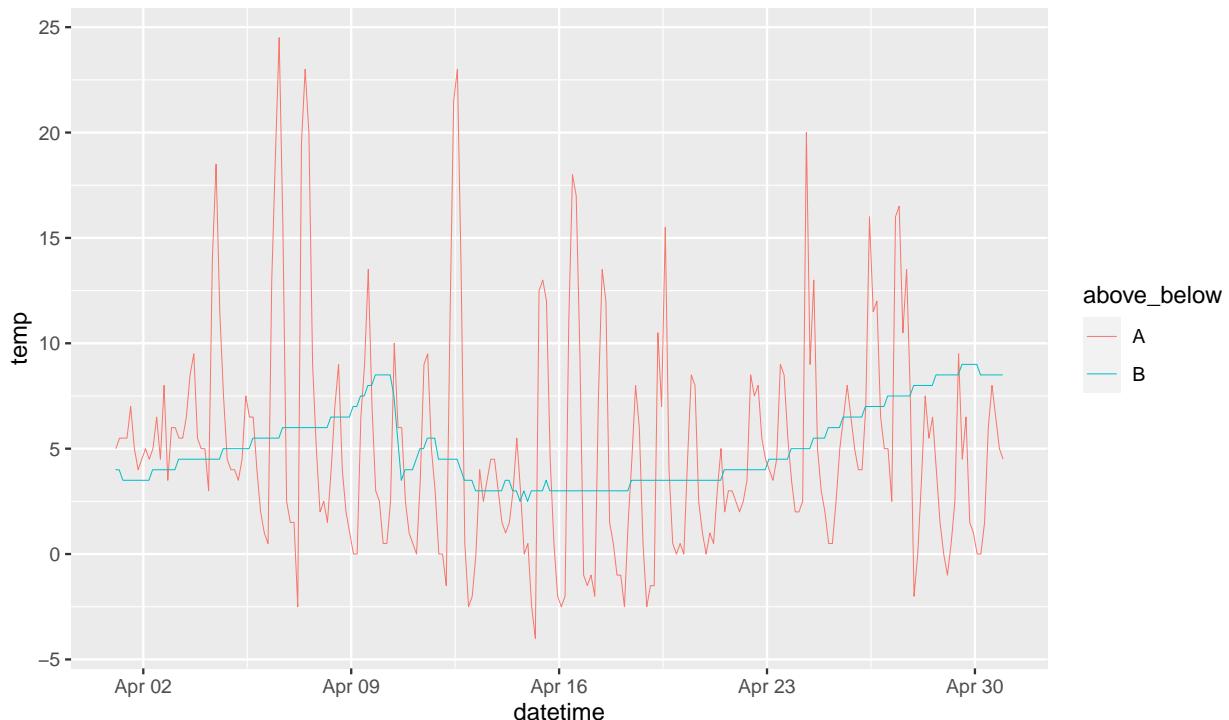
And the locations in the plot:

Pair 71



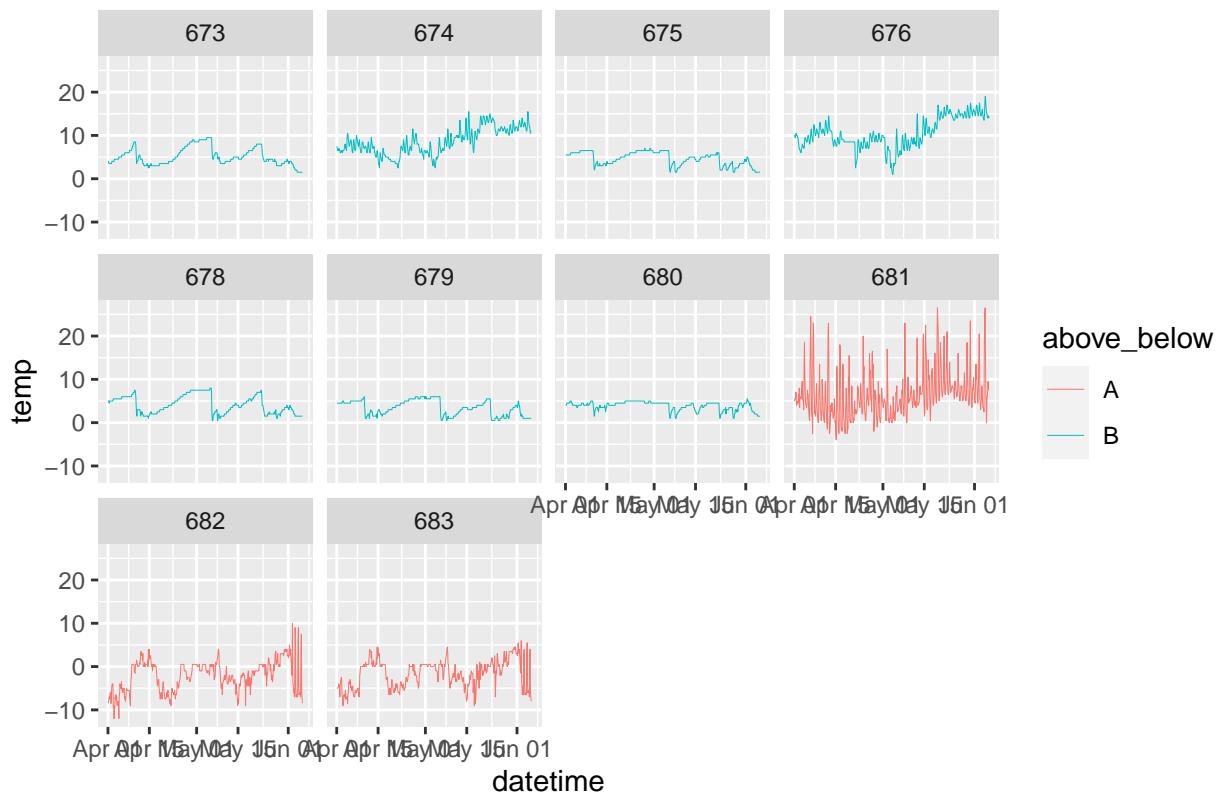
One can really see the negative correlation in this pair! The “peaks” for the aboveground logger coincide with the “valleys” for the belowground one.

Pair 73

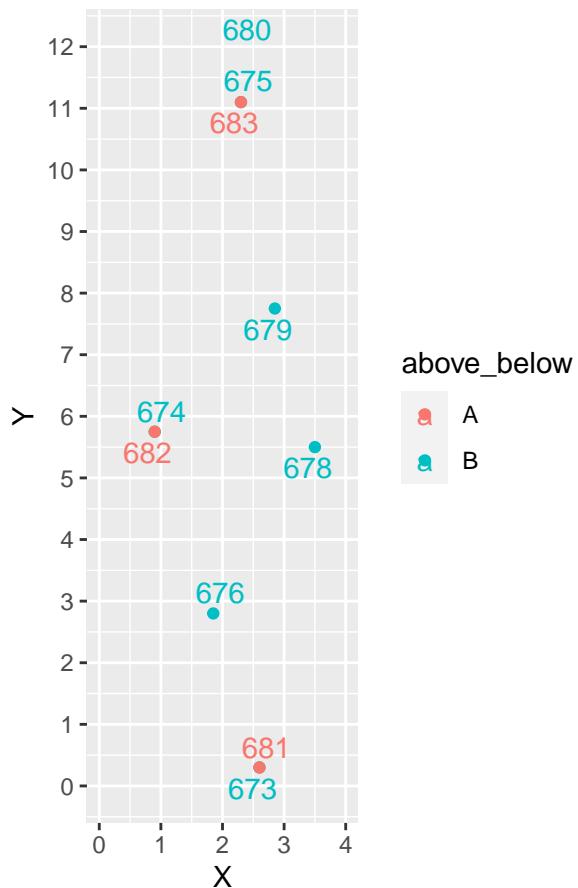


The next graph shows all loggers in the same plot as pair 71 and 73:

Plot H19



Plot H19

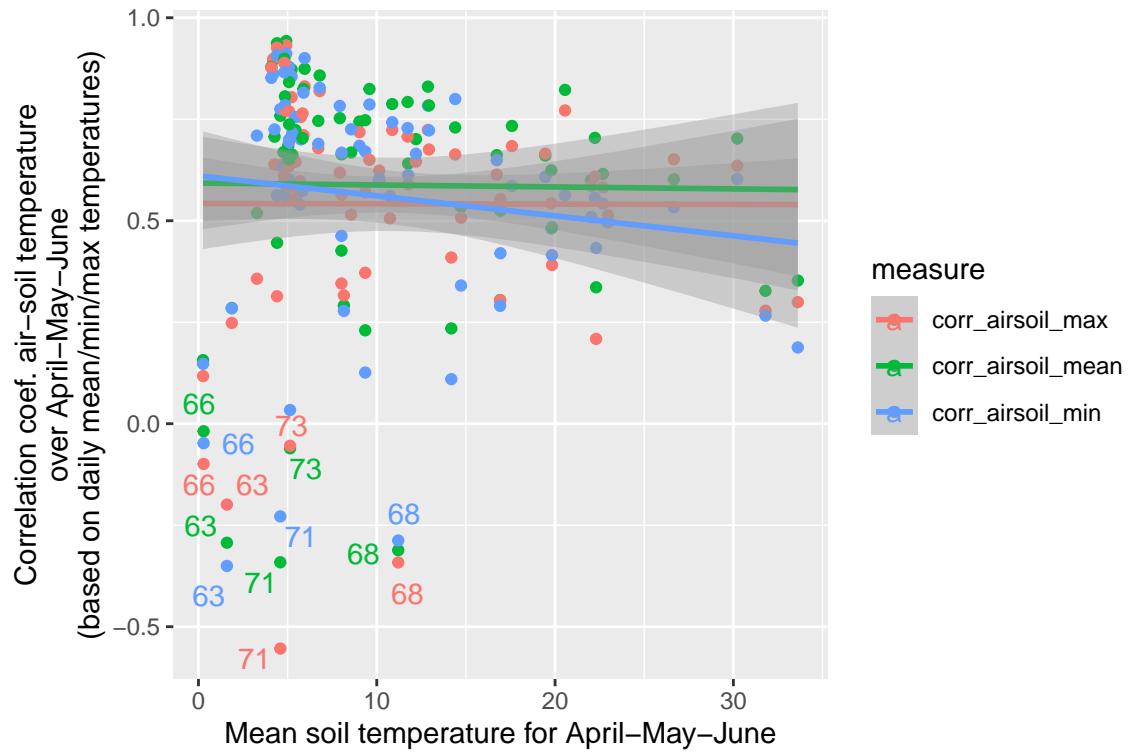


Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5493497	0.0543163	10.1139045	0.0000000
corr_airsoil_max	meansoiltemp	-0.0022523	0.0042507	-0.5298716	0.5978776
corr_airsoil_mean	(Intercept)	0.6687704	0.0604304	11.0667784	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0043788	0.0047292	-0.9258983	0.3576800
corr_airsoil_min	(Intercept)	0.5598539	0.0520408	10.7579765	0.0000000
corr_airsoil_min	meansoiltemp	-0.0066426	0.0040726	-1.6310399	0.1073734

Non-significant in all cases.

**Based on 12-h (day) values** Using only daily values of temperature (after 8 am and before or equal to 8 pm).

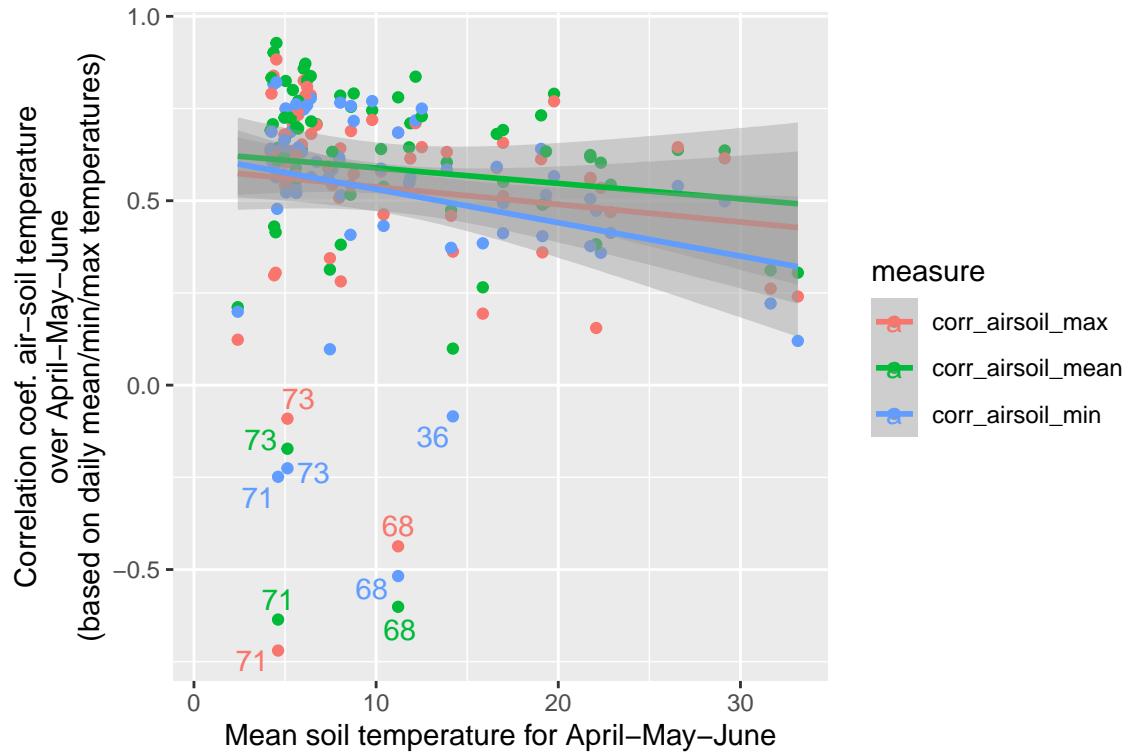


Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5440633	0.0569189	9.5585653	0.0000000
corr_airsoil_max	meansoiltemp	-0.0002213	0.0043831	-0.0504984	0.9598691
corr_airsoil_mean	(Intercept)	0.5946572	0.0575608	10.3309454	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0006487	0.0044325	-0.1463577	0.8840597
corr_airsoil_min	(Intercept)	0.6119754	0.0561293	10.9029545	0.0000000
corr_airsoil_min	meansoiltemp	-0.0051026	0.0043223	-1.1805265	0.2417868

Non-significant in all cases.

**Based on positive values** Using only positive values of temperature (>0).



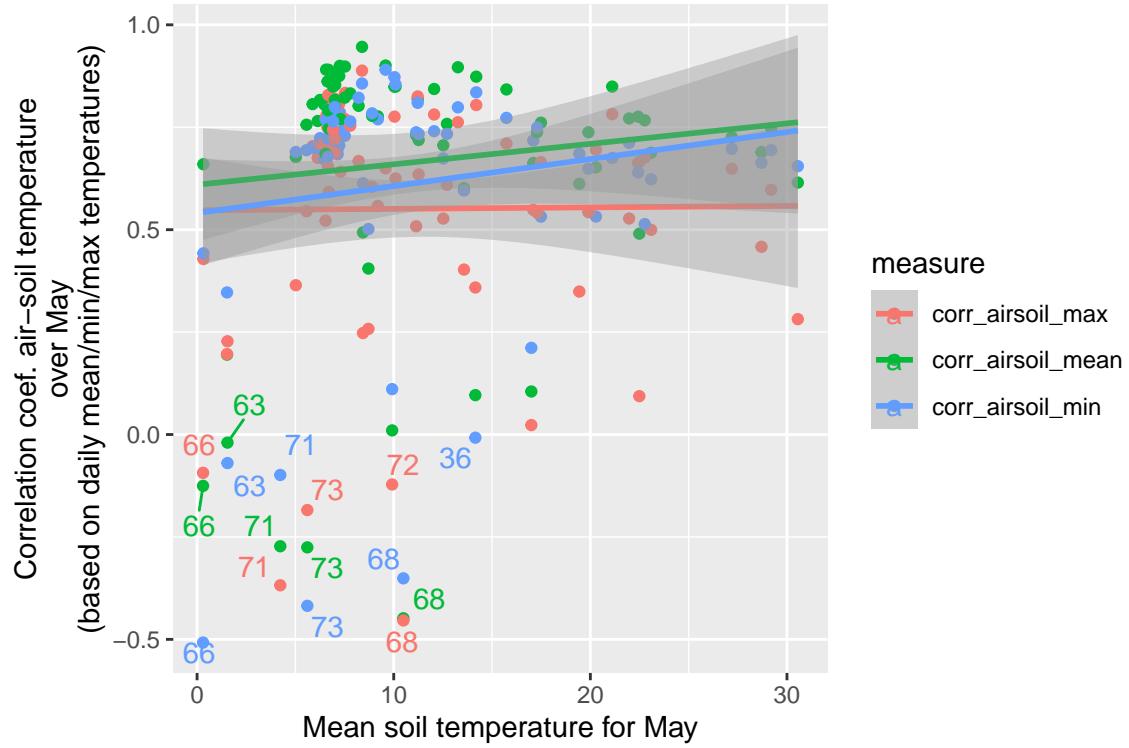
Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5852549	0.0577992	10.1256652	0.0000000
corr_airsoil_max	meansoiltemp	-0.0047639	0.0044043	-1.0816344	0.2832928
corr_airsoil_mean	(Intercept)	0.6308959	0.0616521	10.2331701	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0041979	0.0046979	-0.8935643	0.3747536
corr_airsoil_min	(Intercept)	0.6217876	0.0533706	11.6503867	0.0000000
corr_airsoil_min	meansoiltemp	-0.0090644	0.0040669	-2.2288434	0.0291830

Significant for min only.

### Correlations soil-air temperature for May only

**Based on 24-h values** For each date and logger pair, calculate mean, max and min of air and soil temperature (from, respectively, the above and belowground logger). Then, calculate the correlation coefficient for air and soil temperatures over the month of May. Finally, regress these correlation coefficients on mean soil temperature (from the aboveground logger) **for the same period (May)**.

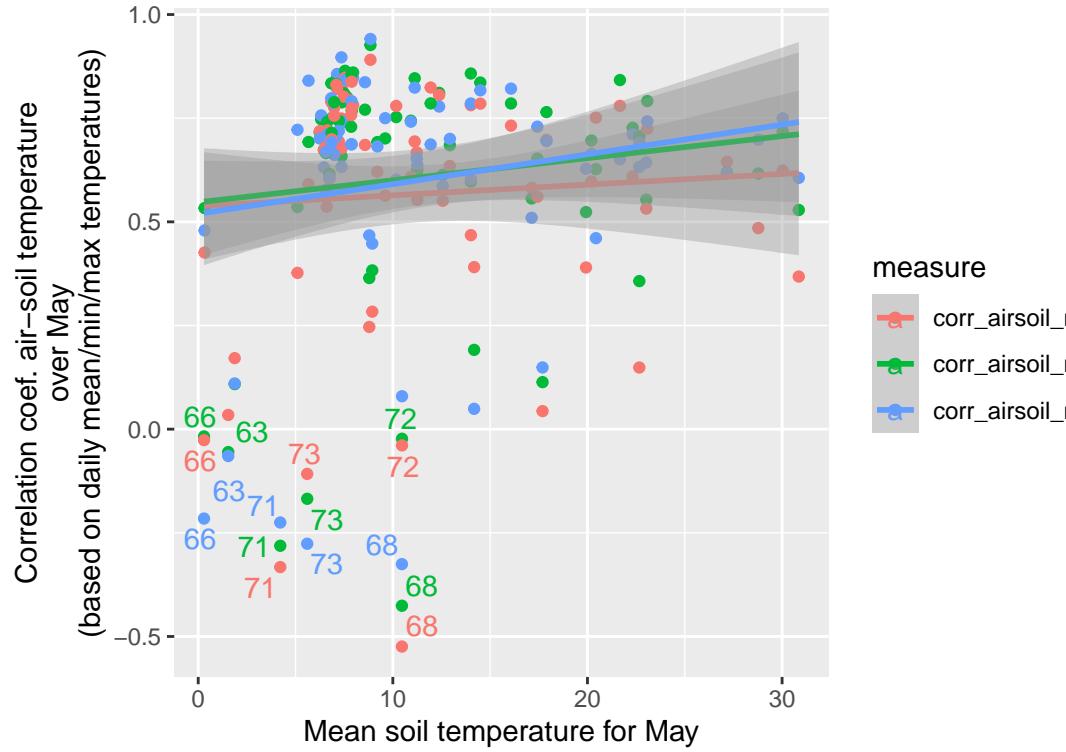


Pairs with negative correlations: 63 (not for max), 66, 68, 71, 72 (not for min), 73.

Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5472640	0.0656883	8.3312216	0.0000000
corr_airsoil_max	meansoiltemp	0.0003561	0.0049249	0.0722991	0.9425701
corr_airsoil_mean	(Intercept)	0.6096518	0.0697446	8.7412084	0.0000000
corr_airsoil_mean	meansoiltemp	0.0049926	0.0052290	0.9548016	0.3429638
corr_airsoil_min	(Intercept)	0.5405448	0.0663033	8.1526130	0.0000000
corr_airsoil_min	meansoiltemp	0.0065897	0.0049710	1.3256301	0.1892723

Non-significant in all cases.

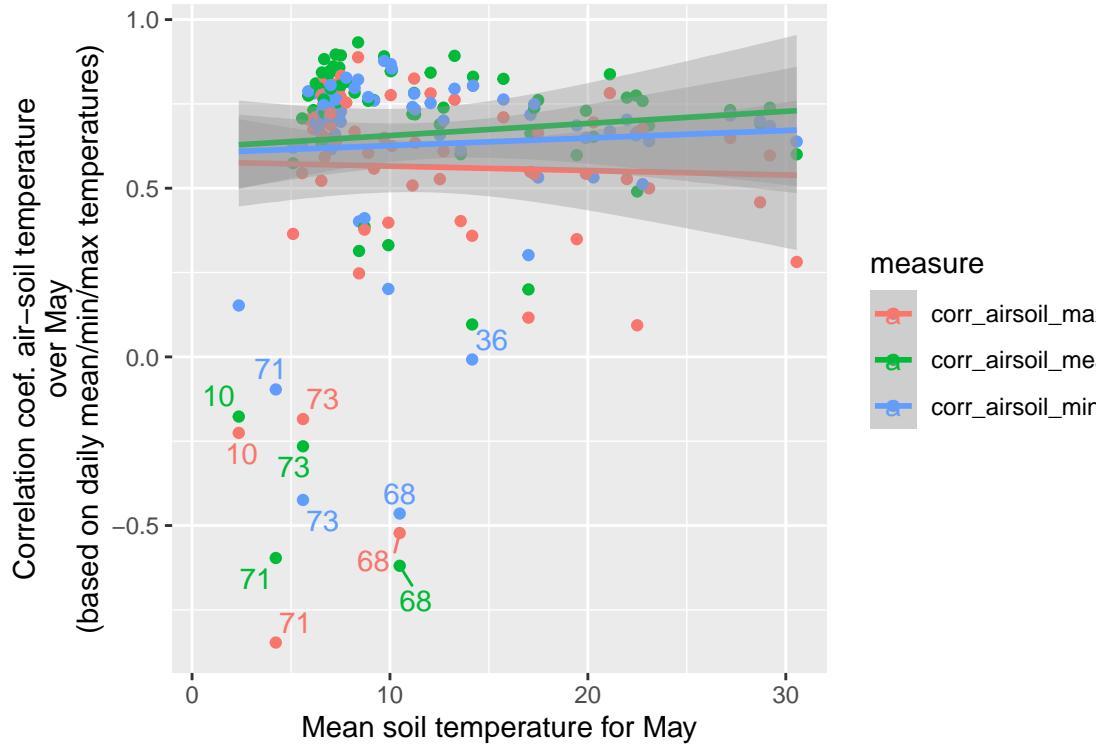


Based on 12-h (day) values

Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5380173	0.0661380	8.1347702	0.0000000
corr_airsoil_max	meansoiltemp	0.0025902	0.0048650	0.5324127	0.5961262
corr_airsoil_mean	(Intercept)	0.5472074	0.0656852	8.3307547	0.0000000
corr_airsoil_mean	meansoiltemp	0.0053163	0.0048317	1.1003040	0.2749692
corr_airsoil_min	(Intercept)	0.5192960	0.0643179	8.0738987	0.0000000
corr_airsoil_min	meansoiltemp	0.0071707	0.0047311	1.5156481	0.1341113

Non-significant in all cases.



Based on positive values

Linear models testing the effect of soil temperature on correlations between soil and air temperature:

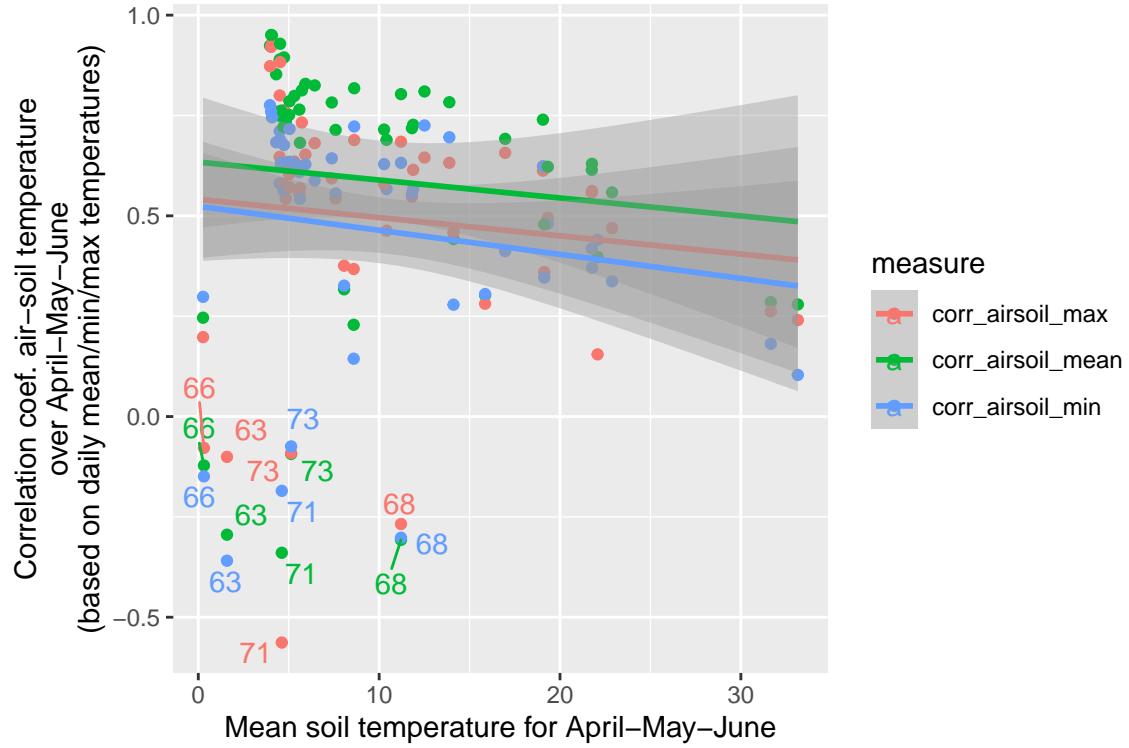
measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5785841	0.0760572	7.6072199	0.0000000
corr_airsoil_max	meansoiltemp	-0.0013093	0.0055804	-0.2346308	0.8152108
corr_airsoil_mean	(Intercept)	0.6203165	0.0770292	8.0530023	0.0000000
corr_airsoil_mean	meansoiltemp	0.0035875	0.0056517	0.6347594	0.5277470
corr_airsoil_min	(Intercept)	0.6040421	0.0641400	9.4175546	0.0000000
corr_airsoil_min	meansoiltemp	0.0022357	0.0047060	0.4750609	0.6362886

Non-significant in all cases.

### Analyses using pairs with distance < 2

**Correlations soil-air temperature over the period April-May-June** For each date and logger pair, calculate mean, max and min of air and soil temperature (from, respectively, the above and belowground logger). Then, calculate the correlation coefficient for air and soil temperatures over the period April-May-June. Finally, regress these correlation coefficients on mean soil temperature (from the aboveground logger) **for the same period (April-May-June)**.

Using only data till June 5th, included (as most loggers stop on June 6th).

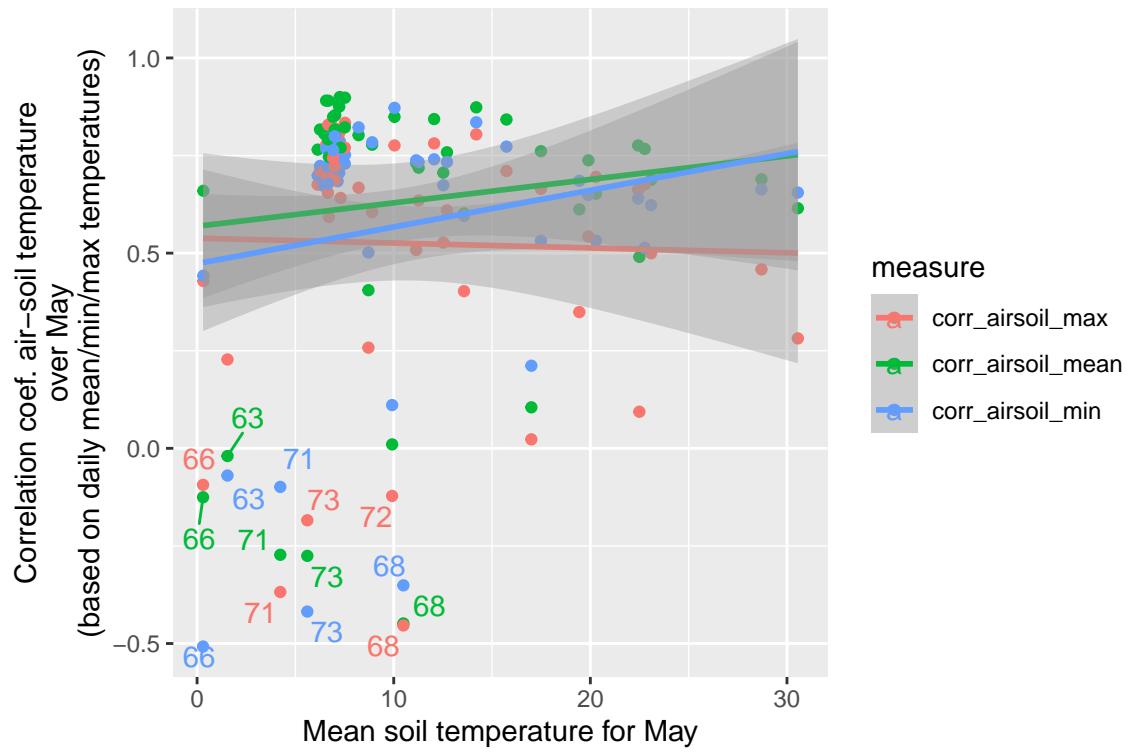


Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5412018	0.0730126	7.4124424	0.0000000
corr_airsoil_max	meansoiltemp	-0.0045490	0.0057725	-0.7880522	0.4346228
corr_airsoil_mean	(Intercept)	0.6339837	0.0817068	7.7592488	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0044757	0.0064598	-0.6928554	0.4918098
corr_airsoil_min	(Intercept)	0.5239921	0.0679939	7.7064560	0.0000000
corr_airsoil_min	meansoiltemp	-0.0059941	0.0053757	-1.1150441	0.2705007

Non-significant in all cases.

**Correlations soil-air temperature for May only** For each date and logger pair, calculate mean, max and min of air and soil temperature (from, respectively, the above and belowground logger). Then, calculate the correlation coefficient for air and soil temperatures over the month of May. Finally, regress these correlation coefficients on mean soil temperature (from the aboveground logger) **for the same period (May)**.

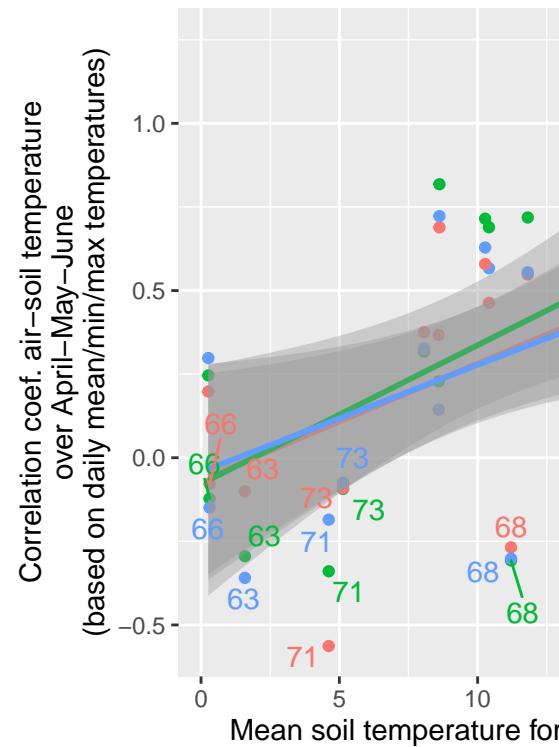


Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5383145	0.0893989	6.0214857	0.0000002
corr_airsoil_max	meansoiltemp	-0.0012488	0.0068136	-0.1832821	0.8553651
corr_airsoil_mean	(Intercept)	0.5687274	0.0938621	6.0591779	0.0000002
corr_airsoil_mean	meansoiltemp	0.0060063	0.0071538	0.8396009	0.4053828
corr_airsoil_min	(Intercept)	0.4729755	0.0889895	5.3149564	0.0000029
corr_airsoil_min	meansoiltemp	0.0094028	0.0067824	1.3863492	0.1721821

Non-significant in all cases.

Analyses using the 17 pairs where above- and belowground loggers are at the same plant

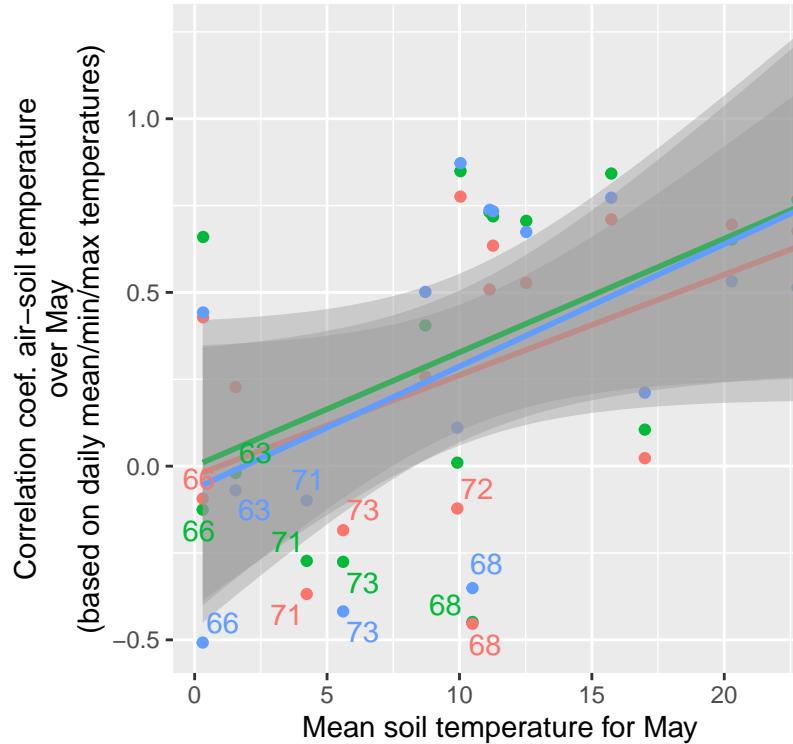


### Correlations soil-air temperature over the period April–May–June

Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	-0.0655494	0.1467299	-0.4467350	0.6618991
corr_airsoil_max	meansoiltemp	0.0347083	0.0130468	2.6602877	0.0186506
corr_airsoil_mean	(Intercept)	-0.0784892	0.1638790	-0.4789461	0.6393713
corr_airsoil_mean	meansoiltemp	0.0415087	0.0145717	2.8485919	0.0128857
corr_airsoil_min	(Intercept)	-0.0421213	0.1495292	-0.2816926	0.7823003
corr_airsoil_min	meansoiltemp	0.0319594	0.0132957	2.4037345	0.0306489

Positive relationships are significant in all cases!



### Correlations soil-air temperature for May only

Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	-0.0276078	0.1750043	-0.1577549	0.8769027
corr_airsoil_max	meansoiltemp	0.0289399	0.0145605	1.9875608	0.0667839
corr_airsoil_mean	(Intercept)	0.0003969	0.1954119	0.0020309	0.9984083
corr_airsoil_mean	meansoiltemp	0.0327253	0.0162584	2.0128209	0.0637783
corr_airsoil_min	(Intercept)	-0.0652332	0.1888010	-0.3455128	0.7348455
corr_airsoil_min	meansoiltemp	0.0352129	0.0157084	2.2416601	0.0417043

Significant only for min, near significance for the others.