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

Analyses with logger data

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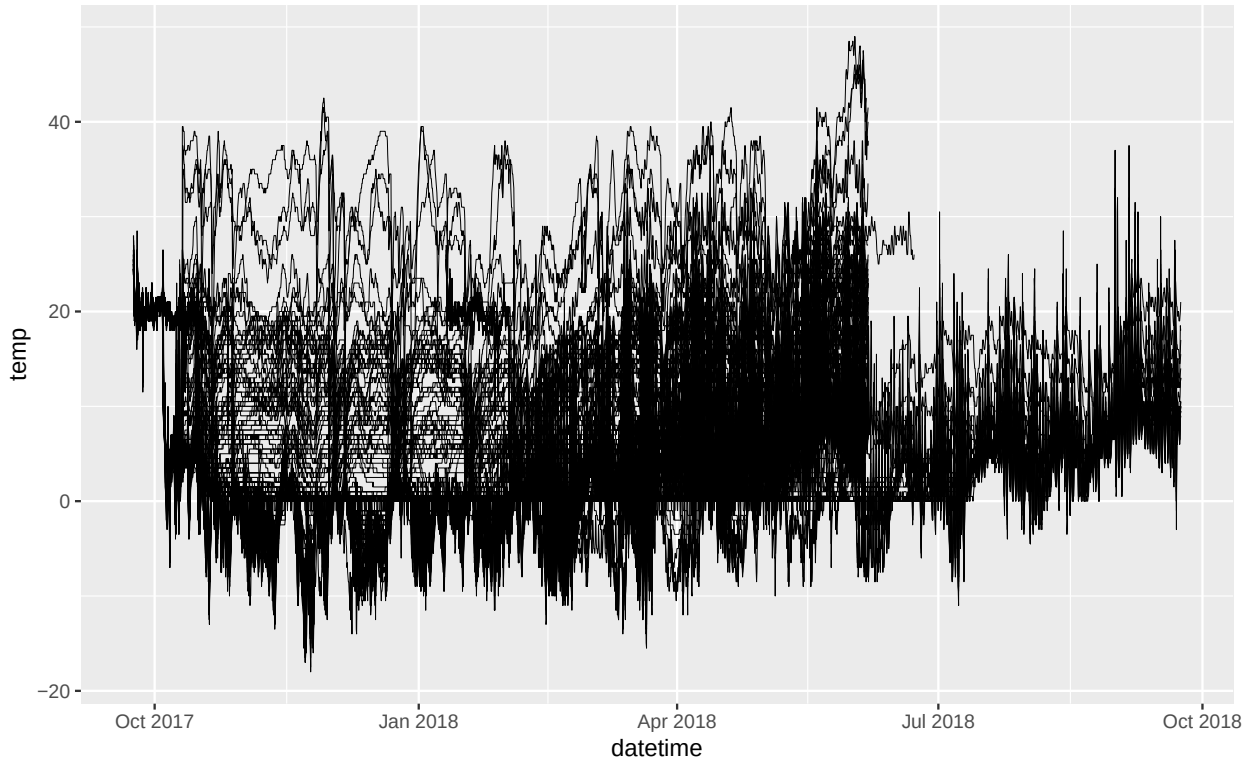
Contents

Read data

Plot with all logger data, one line per logger id

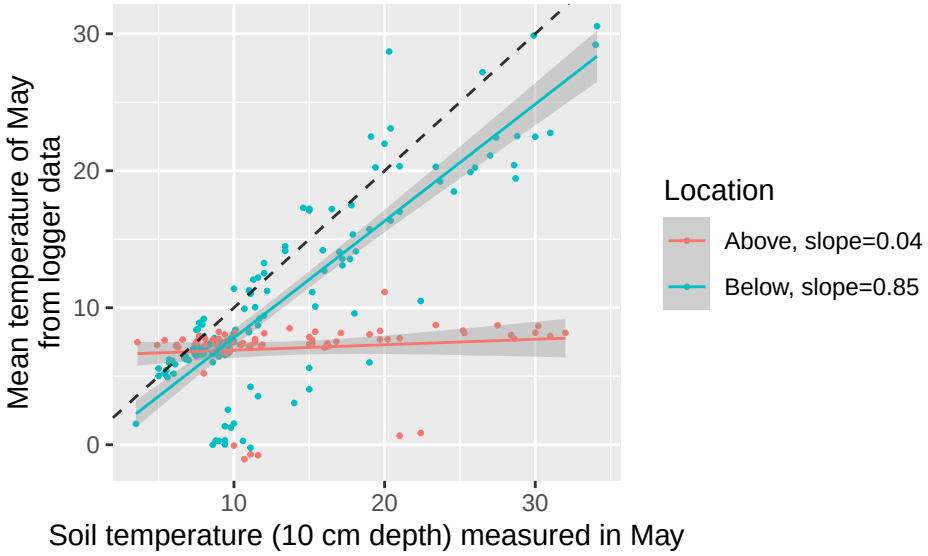


Q1: Are instantaneous measures of soil temperature representative for the conditions during the entire spring/growing season?

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^2	0.016
Adj. R^2	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

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

F(1,139)	399.799
R^2	0.742
Adj. R^2	0.740

	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

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

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

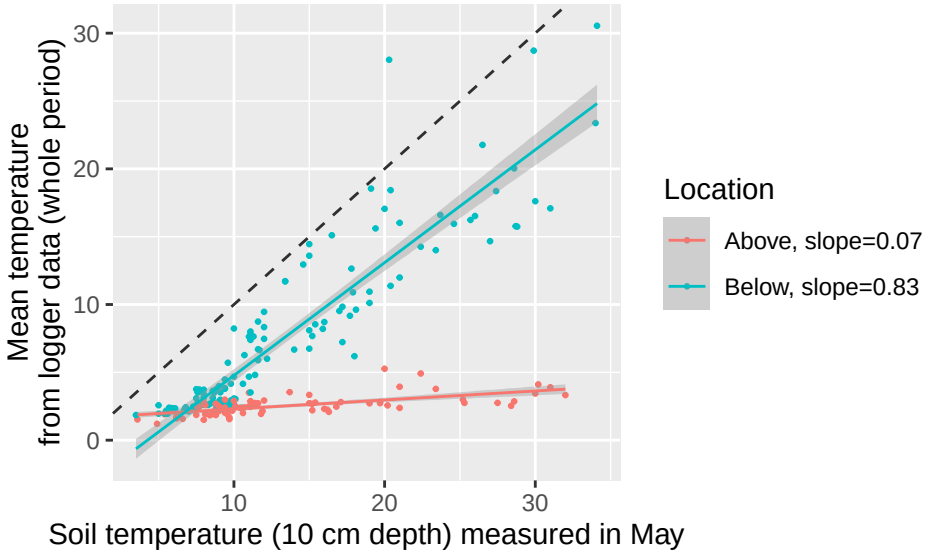
```
## [1] 0.8614051
```

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

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

F(1,76)	54.027
R^2	0.416
Adj. R^2	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

Observations	141
Dependent variable	mean_logger
Type	OLS linear regression

F(1,139)	686.807
R^2	0.832
Adj. R^2	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

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

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
```

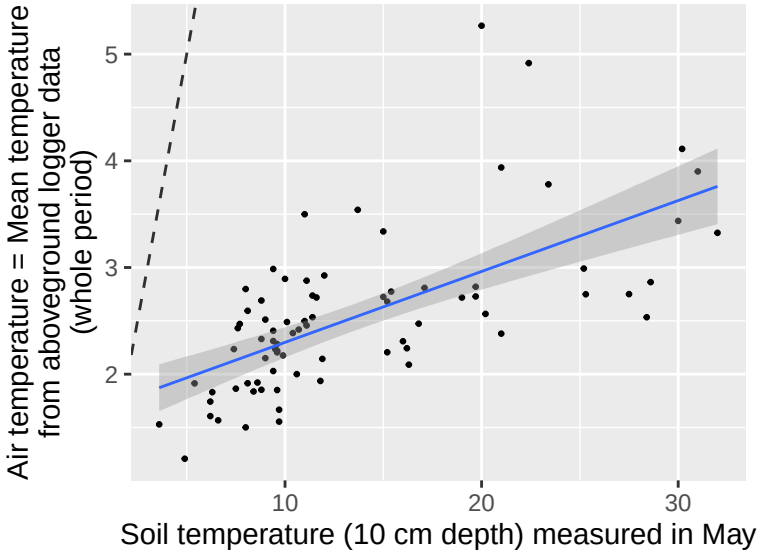
The correlation values seem to indicate that the temperature measured with a thermometer represents quite well longer-term conditions

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

F(1,76)	54.027
R^2	0.416
Adj. R^2	0.408

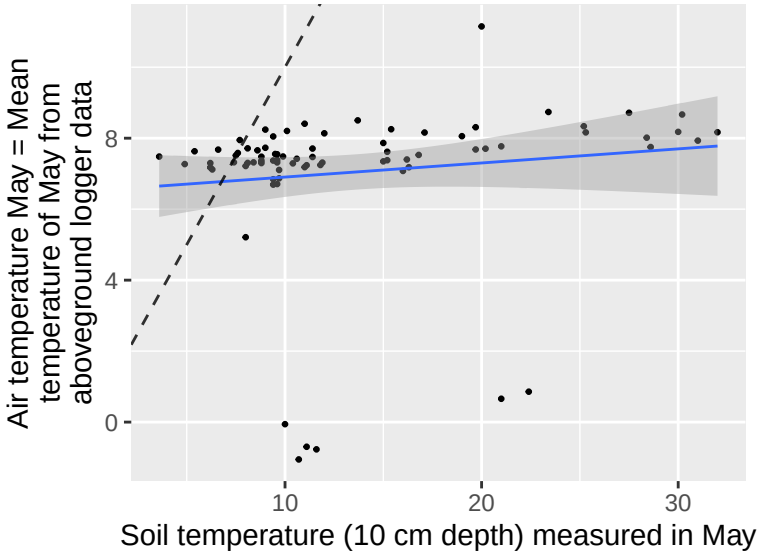
	Est.	S.E.	t val.	p
(Intercept)	1.633	0.138	11.819	0.000
temp_term	0.066	0.009	7.350	0.000

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^2	0.016
Adj. R^2	0.003

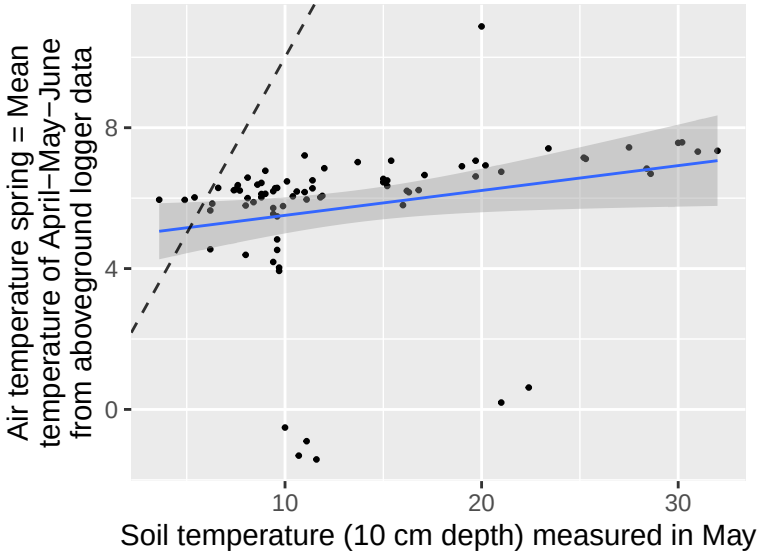
	Est.	S.E.	t val.	p
(Intercept)	6.507	0.547	11.900	0.000
temp_term	0.040	0.036	1.111	0.270

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^2	0.058
Adj. R^2	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

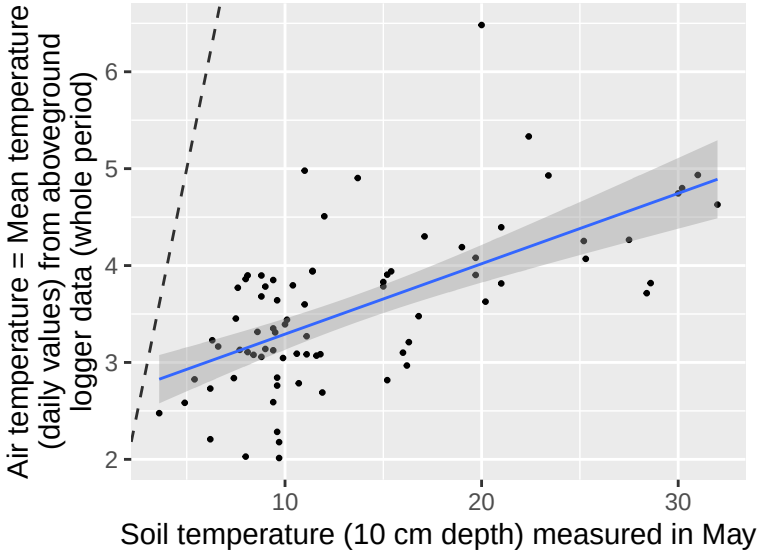
```
## Linear hypothesis test
##
## Hypothesis:
## temp_term = 1
##
## Model 1: restricted model
## Model 2: meanspring_logger ~ temp_term
##
##   Res.Df    RSS Df Sum of Sq      F    Pr(>F)
## 1     77 3597.1
## 2     76  310.6  1    3286.5 804.06 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 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^2	0.397
Adj. R^2	0.389

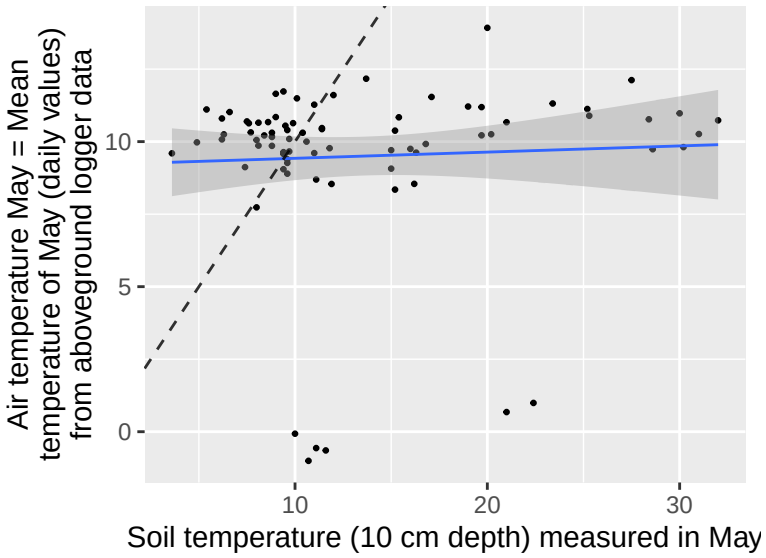
	Est.	S.E.	t val.	p
(Intercept)	2.566	0.157	16.343	0.000
temp_term	0.073	0.010	7.074	0.000

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^2	0.003
Adj. R^2	-0.011

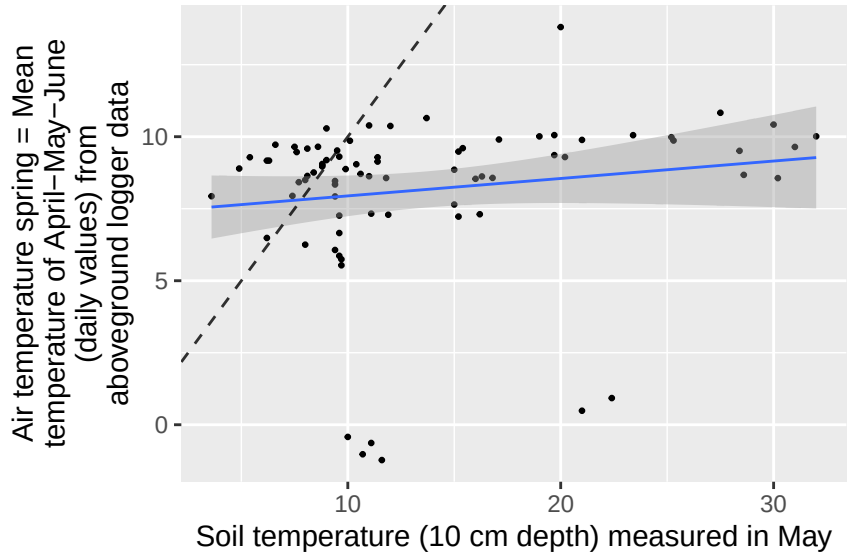
	Est.	S.E.	t val.	p
(Intercept)	9.212	0.736	12.516	0.000
temp_term	0.021	0.048	0.443	0.659

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^2	0.023
Adj. R^2	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

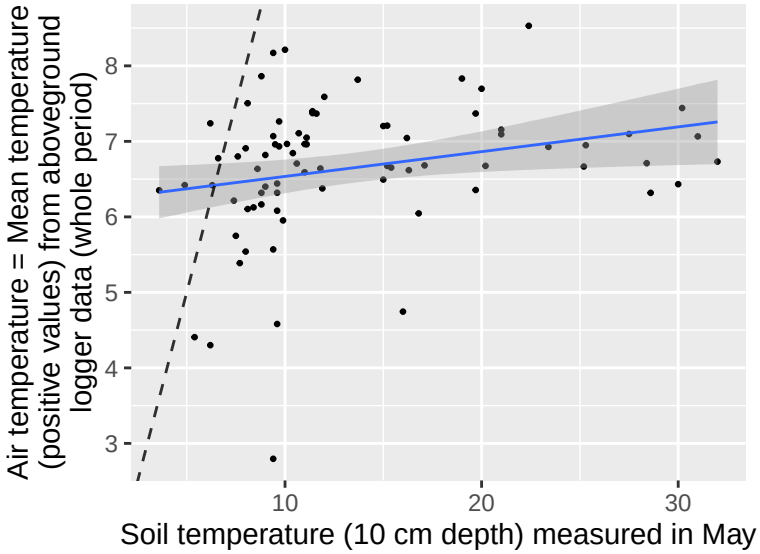
Standard errors: OLS

```
## 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^2	0.065
Adj. R^2	0.053

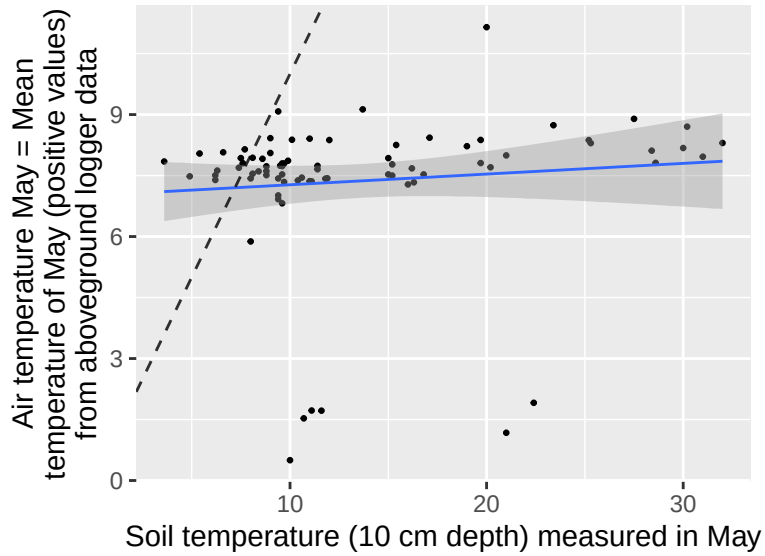
	Est.	S.E.	t val.	p
(Intercept)	6.208	0.218	28.499	0.000
temp_term	0.033	0.014	2.301	0.024

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^2	0.010
Adj. R^2	-0.003

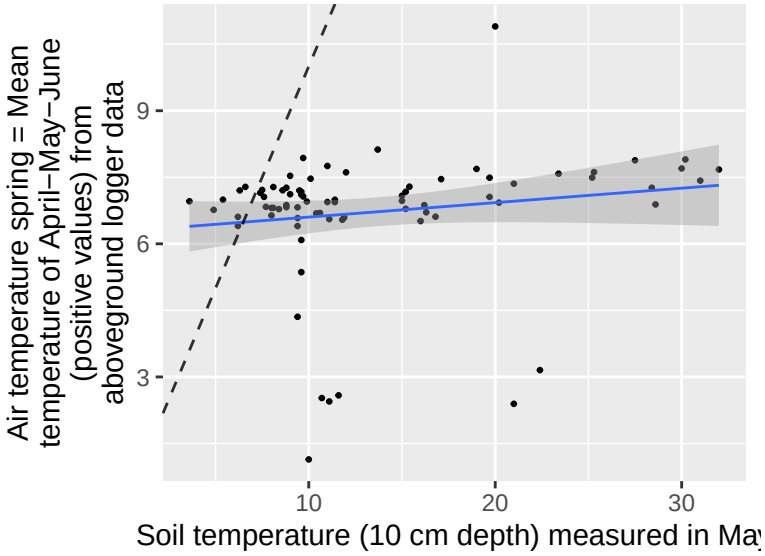
	Est.	S.E.	t val.	p
(Intercept)	7.011	0.457	15.342	0.000
temp_term	0.026	0.030	0.879	0.382

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^2	0.025
Adj. R^2	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.

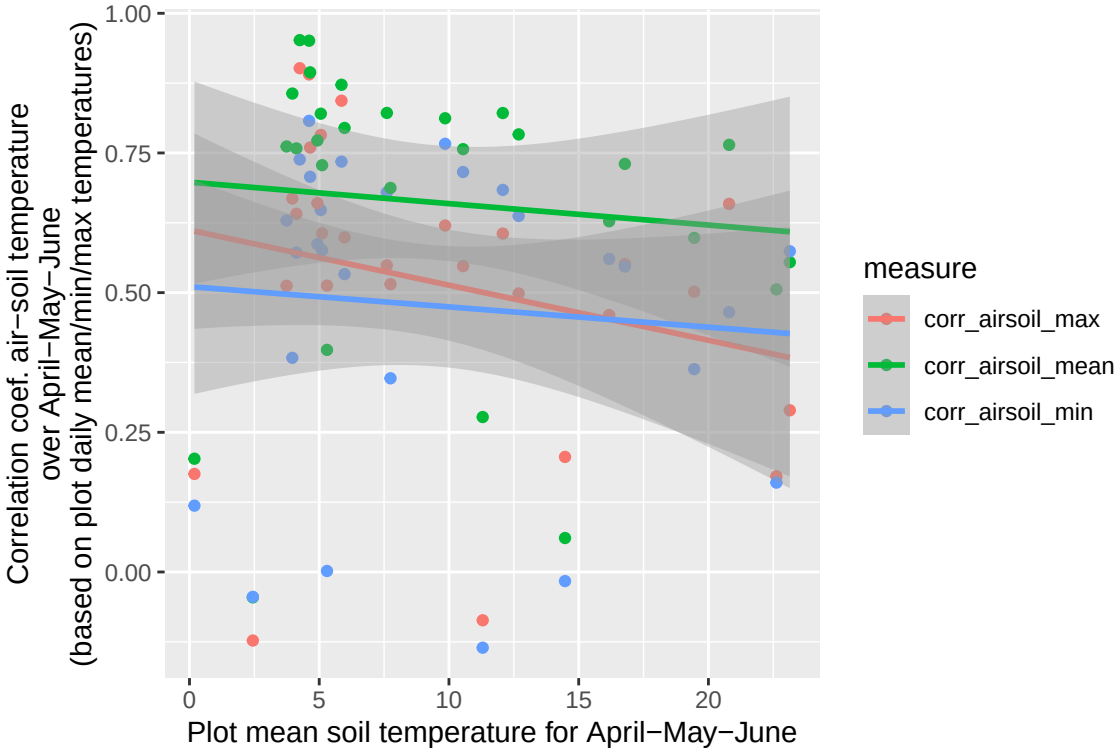
Q3: Do correlations between soil and air temperature vary with soil temperature?

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

Option 1 (probably not used): use plots to calculate correlations between soil and air logger temperatures

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 same period.



Several plots with negative correlations!

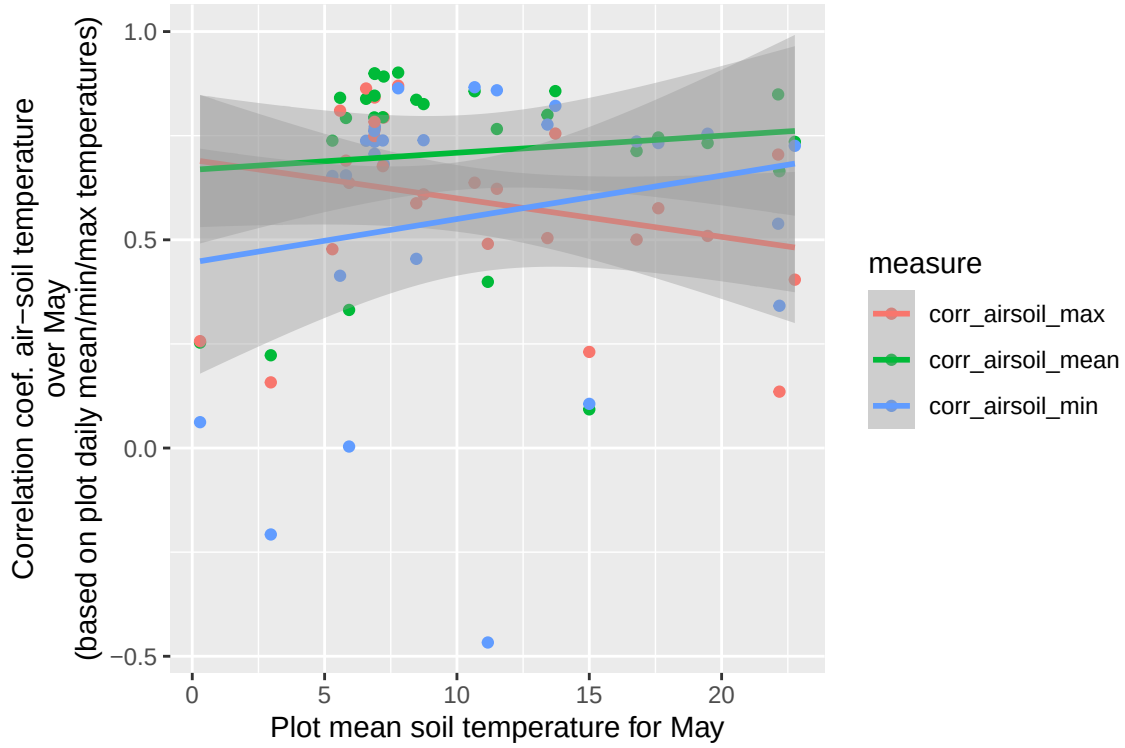
Linear models testing the effect of soil temperature on correlations between soil and air temperature:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.6119703	0.0862149	7.0981923	0.0000002
corr_airsoil_max	meansoiltemp	-0.0098613	0.0075418	-1.3075468	0.2024719
corr_airsoil_mean	(Intercept)	0.6977323	0.0892365	7.8189095	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0038386	0.0078061	-0.4917393	0.6270297
corr_airsoil_min	(Intercept)	0.5107733	0.0943600	5.4130303	0.0000113
corr_airsoil_min	meansoiltemp	-0.0036281	0.0082543	-0.4395358	0.6639051

Non-significant in all cases.

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 same period.



Several plots with negative correlations!

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

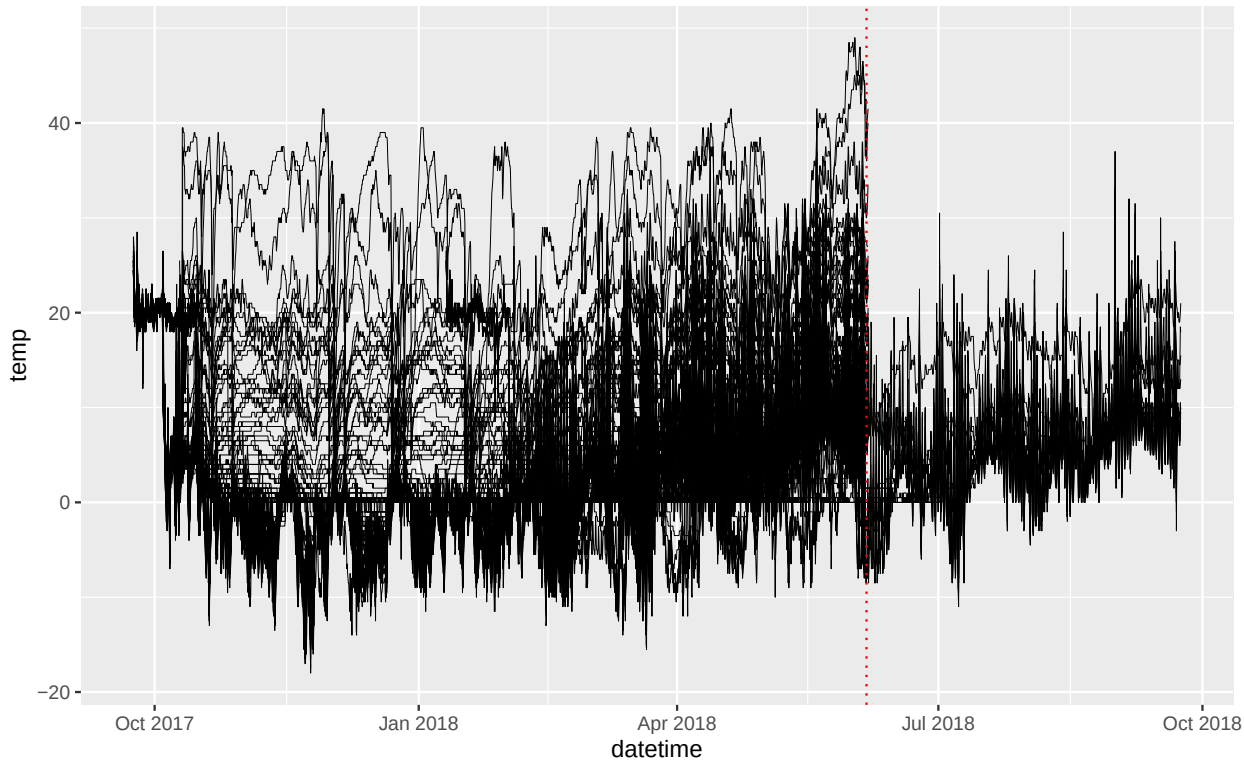
measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.6919312	0.0788774	8.7722341	0.0000000
corr_airsoil_max	meansoiltemp	-0.0092418	0.0065041	-1.4209164	0.1672242
corr_airsoil_mean	(Intercept)	0.6680271	0.0884666	7.5511777	0.0000001
corr_airsoil_mean	meansoiltemp	0.0041009	0.0072948	0.5621674	0.5788169
corr_airsoil_min	(Intercept)	0.4456083	0.1342556	3.3191049	0.0026774
corr_airsoil_min	meansoiltemp	0.0104284	0.0110705	0.9419963	0.3548655

Non-significant in all cases.

Option 2: try to pair loggers

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
```

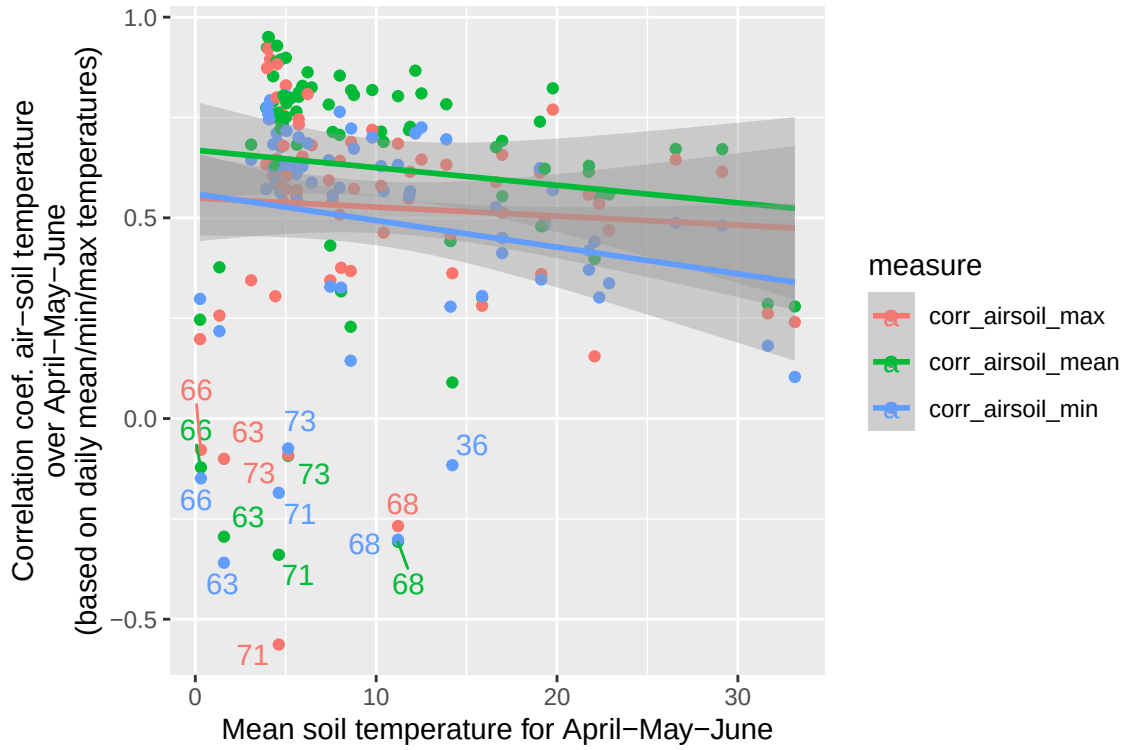
Most loggers (131 out of 145) end up on June 6th. So probably using May is OK.

Analyses using all pairs

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

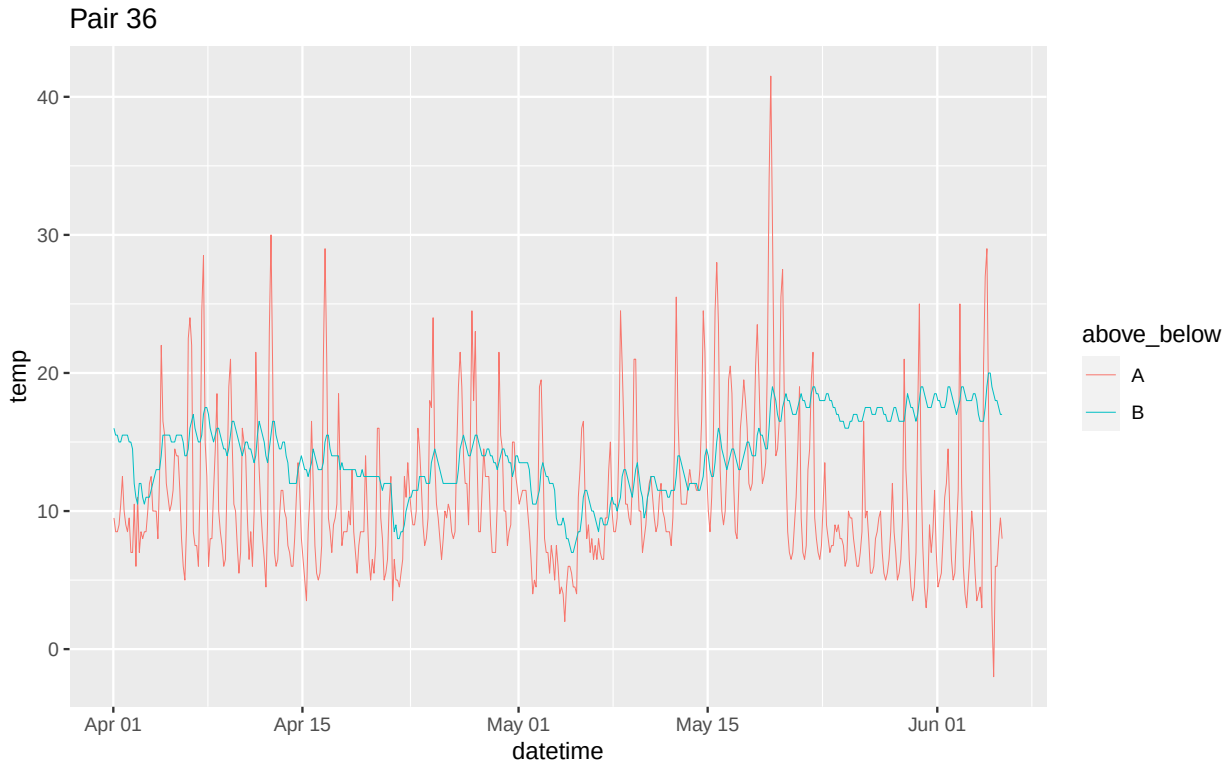
Based on 24-h values For each date and logger pair, calculate mean, max and min of air and soil temperature (from, respectively, the above and belowground logger). Then, calculate the correlation coefficient for air and soil temperatures over the period April-May-June. Finally, regress these correlation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



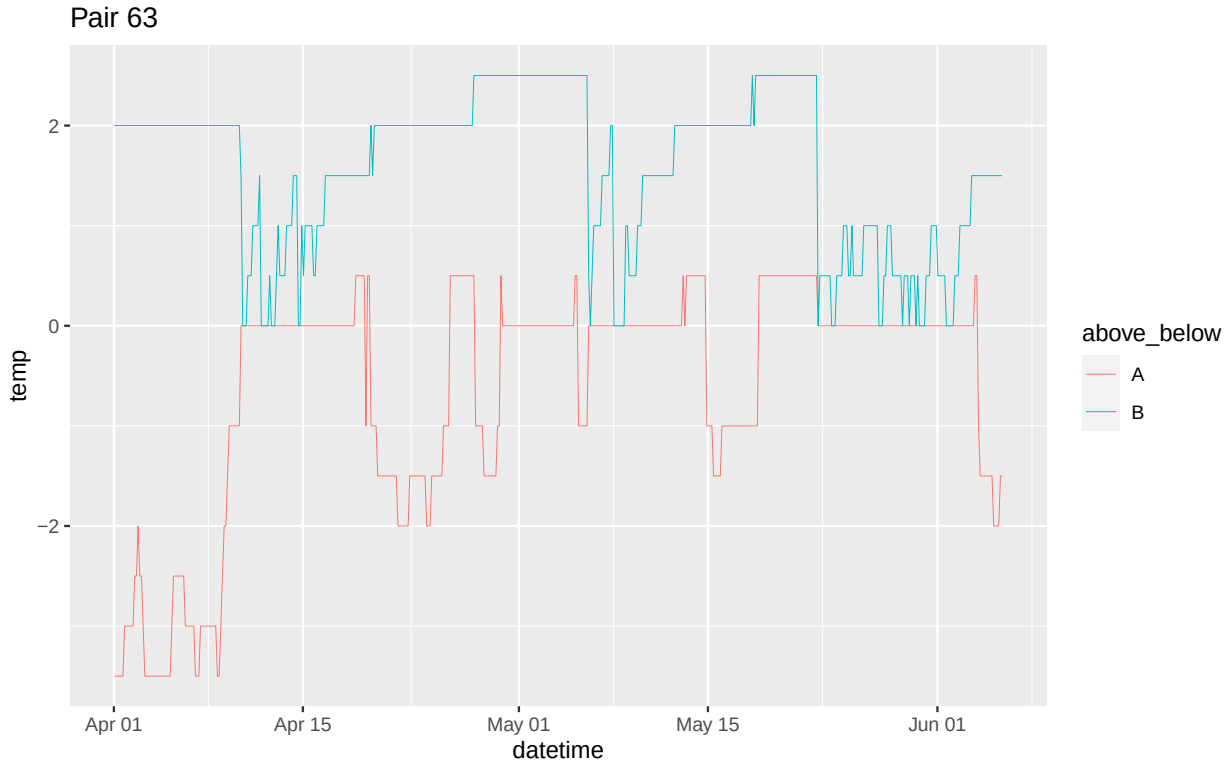
Look at the pairs with negative correlations in detail

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



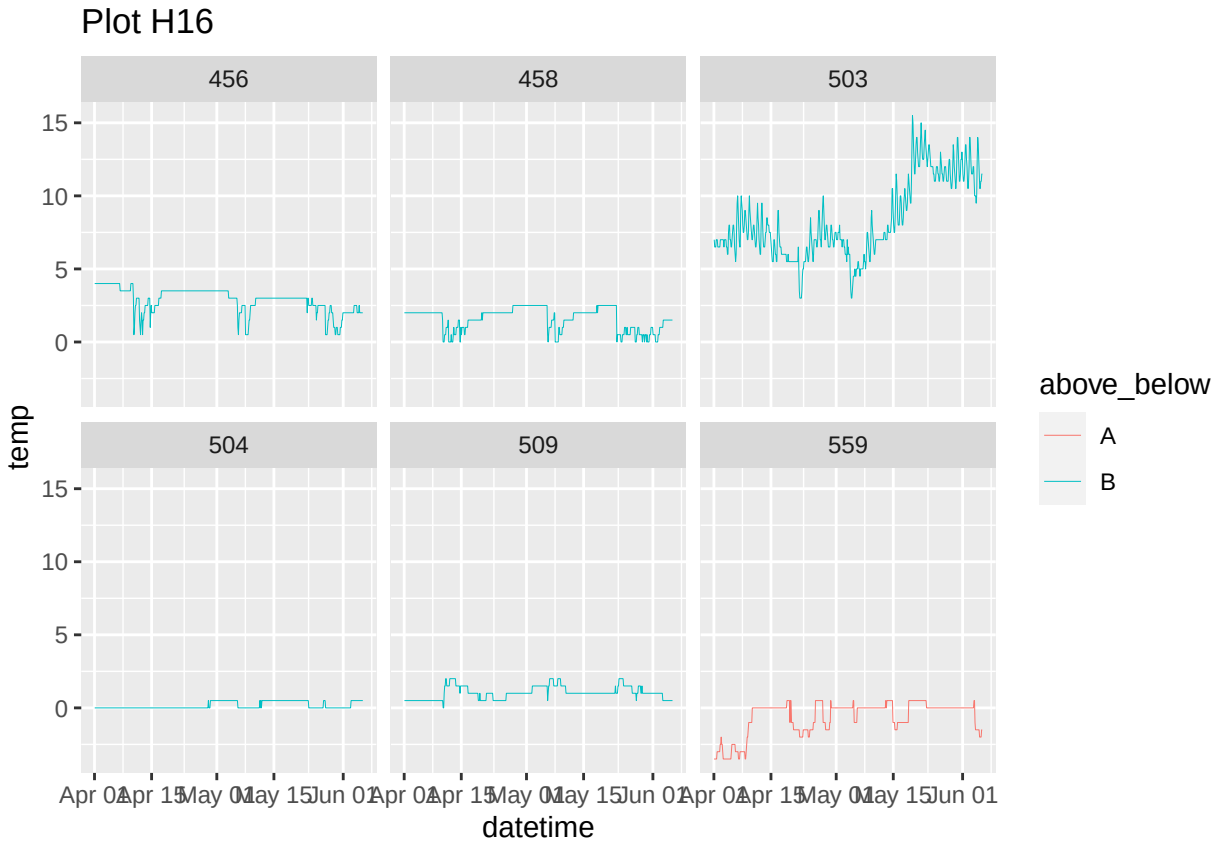
I cannot see anything worrying in the graph. As the negative correlation is only for the min temperature,

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



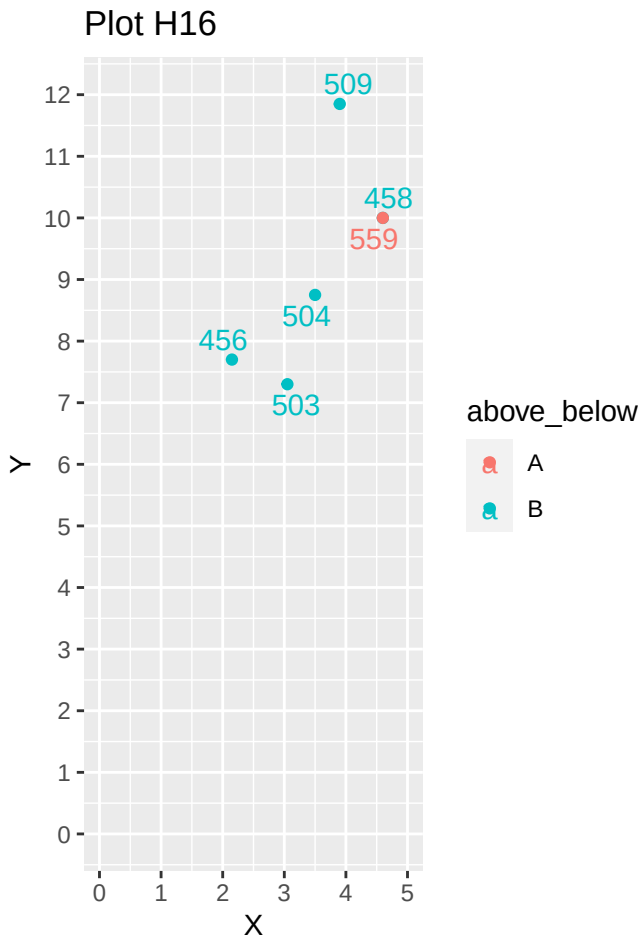
Here, both loggers have constant values of temperature for several periods of time.

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

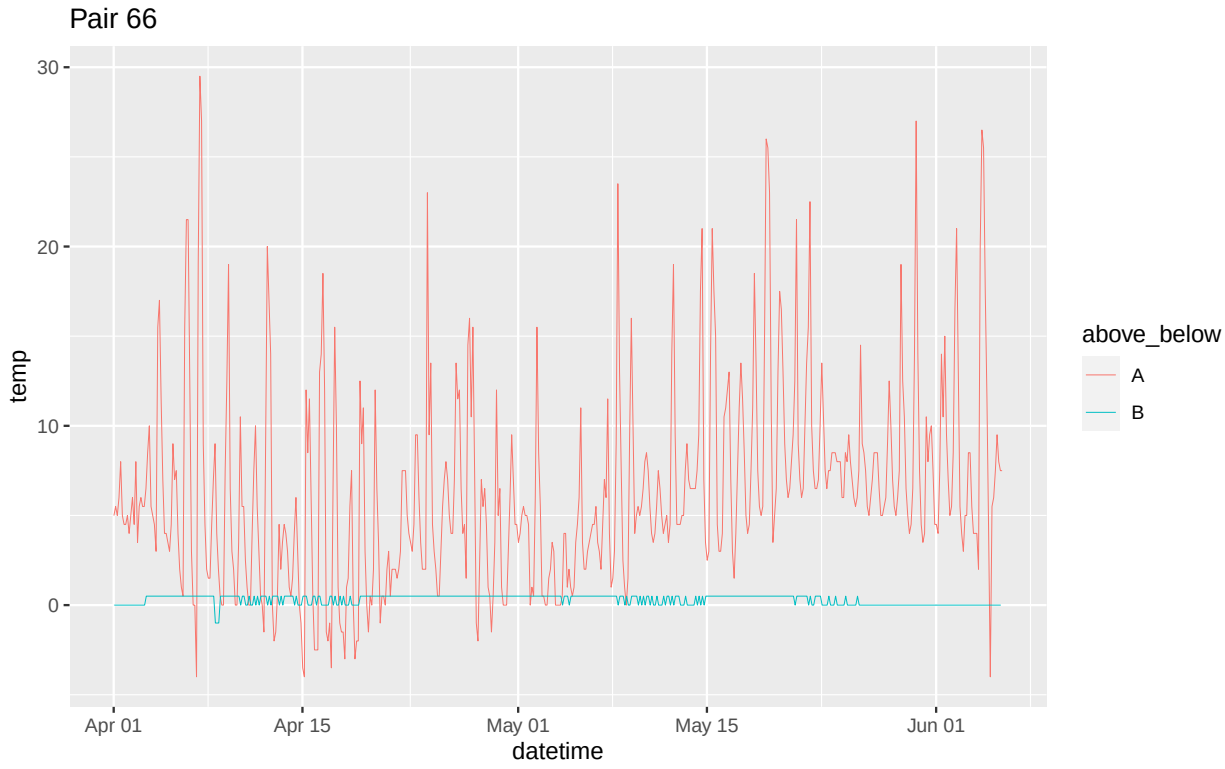


All but one have similar patterns, with constant values for some time periods.

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



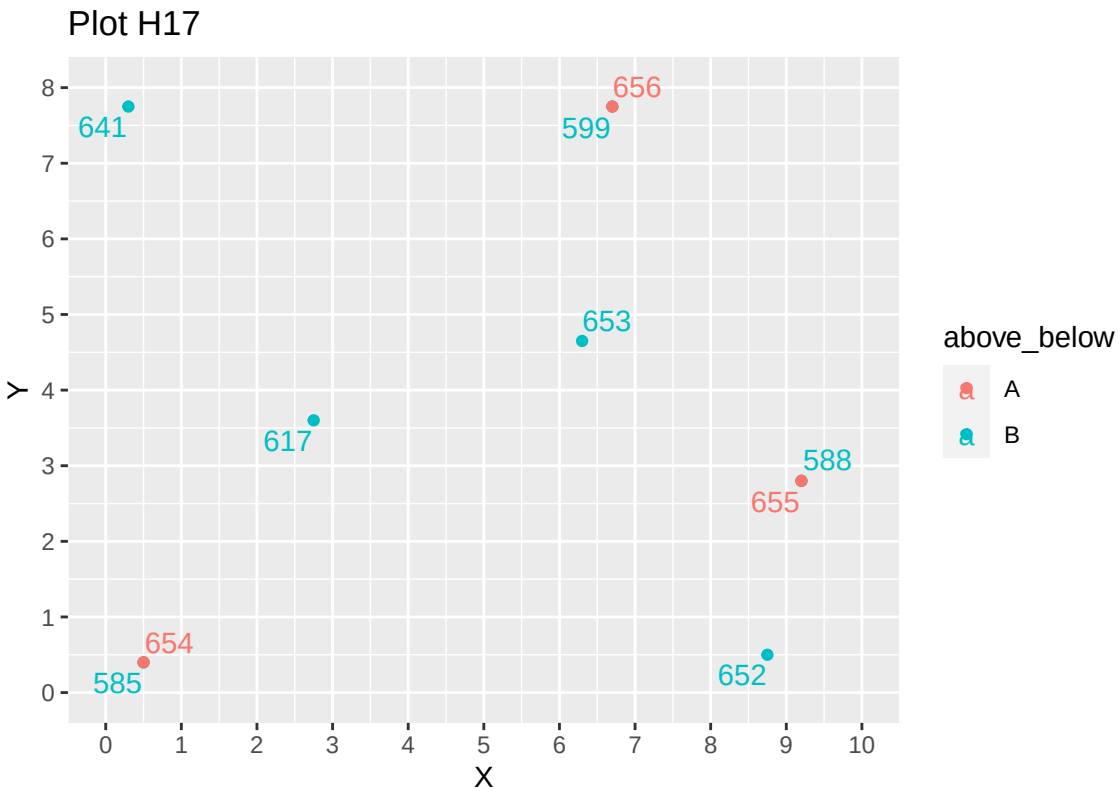
Maybe part of the plot was covered by snow, causing this low variation, and logger 503 was not?

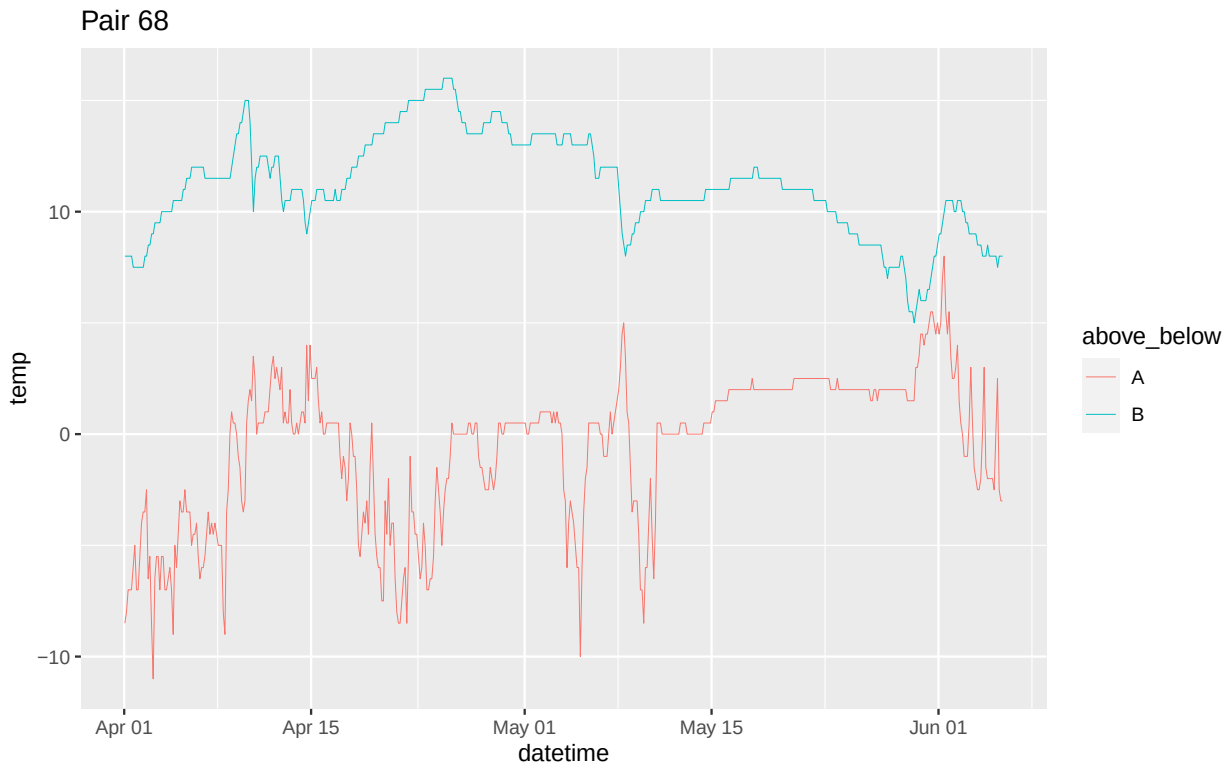


The next graph shows all loggers in the same plot as pair 66:

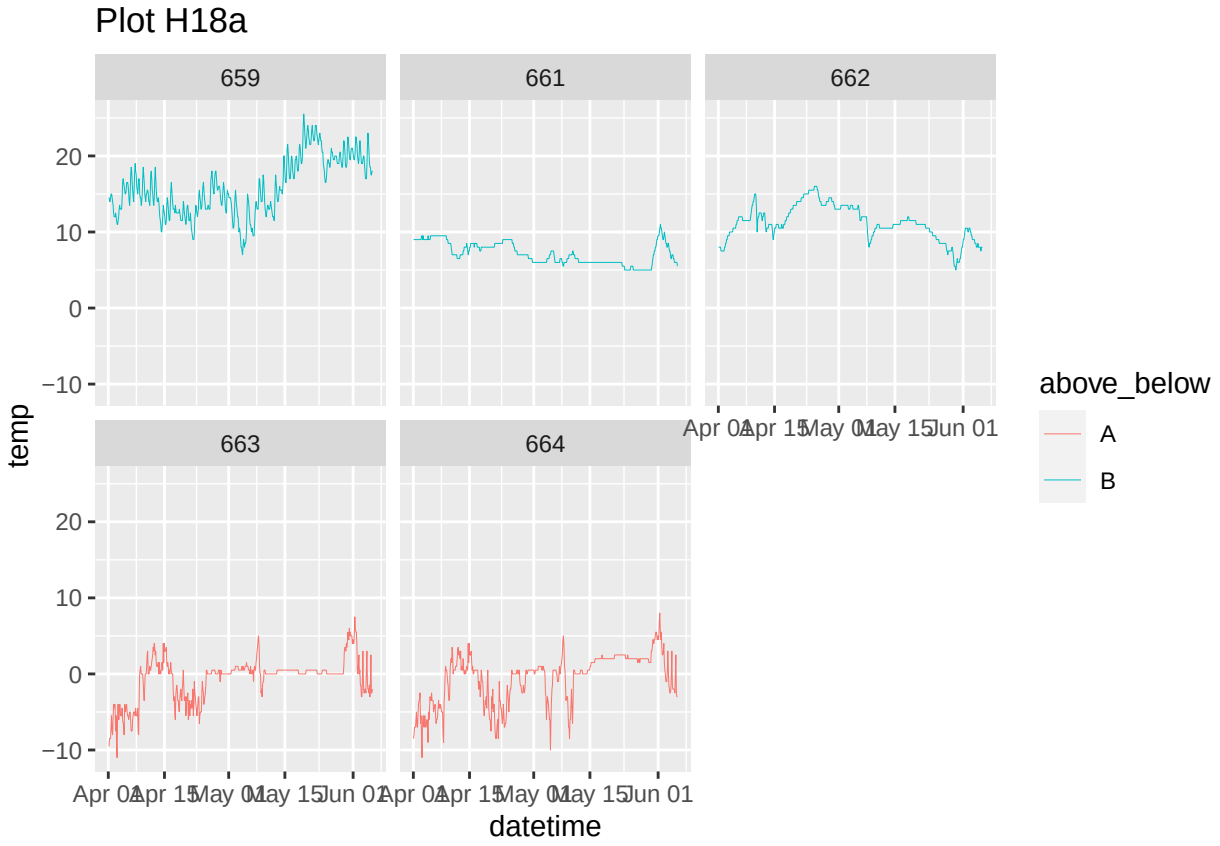
All the belowground loggers show similar patters, with very low variation. However, the aboveground loggers look fine, even if they are located at the same plant that a belowground logger (see locations in the graph below). So this is probably not due to effects of snow? Or could it be that the aboveground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

And the locations in the plot:

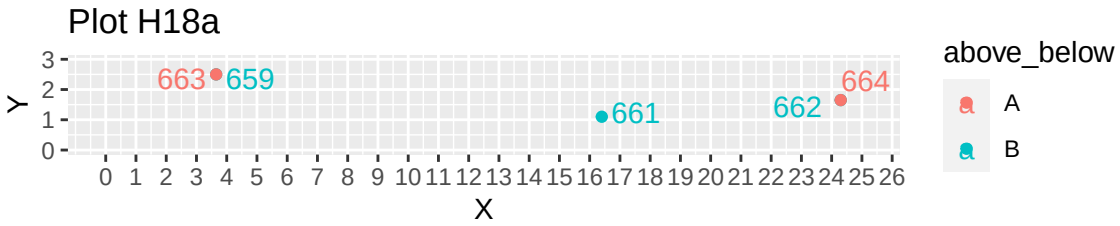


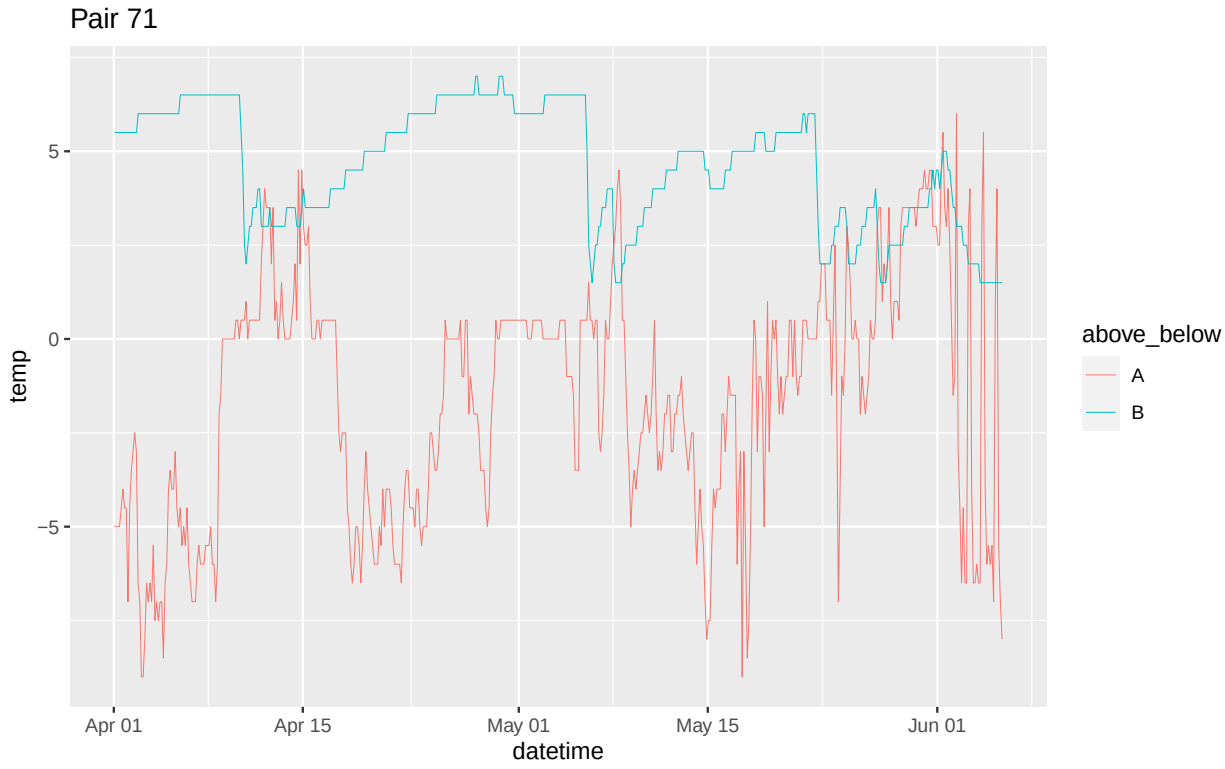


The next graph shows all loggers in the same plot as pair 68:

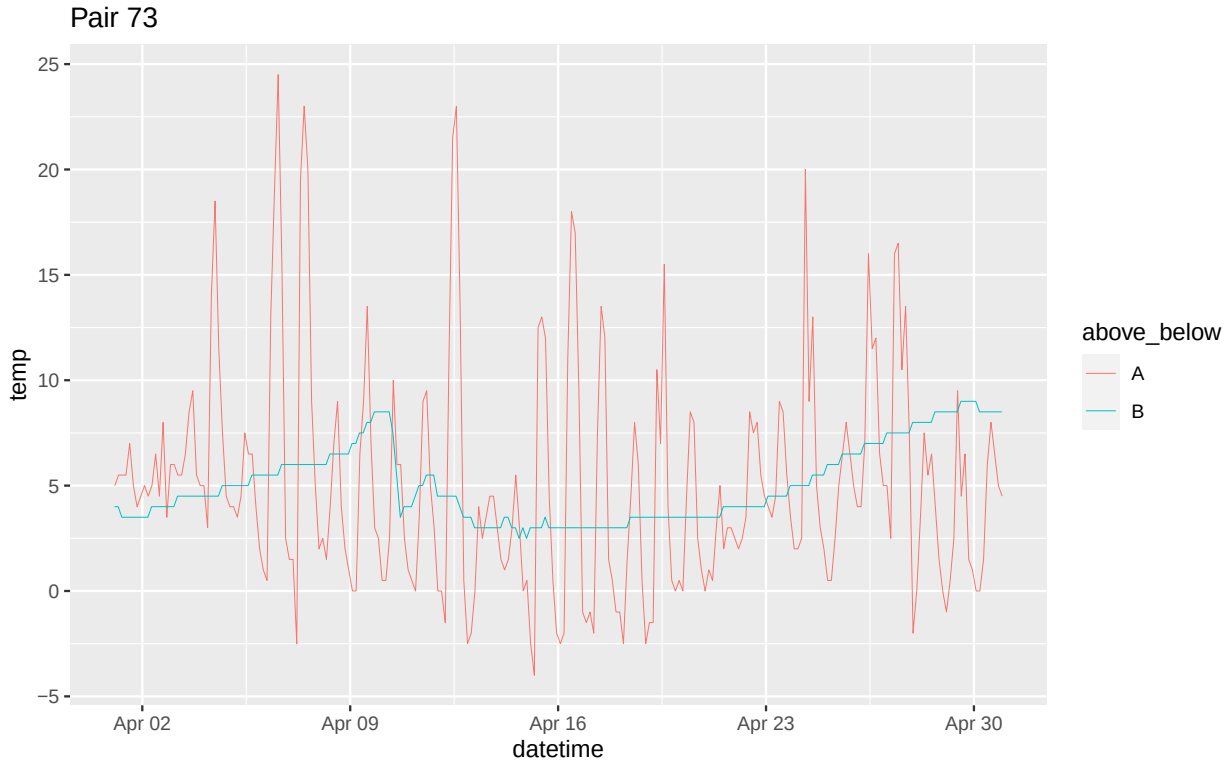


And the locations in the plot:

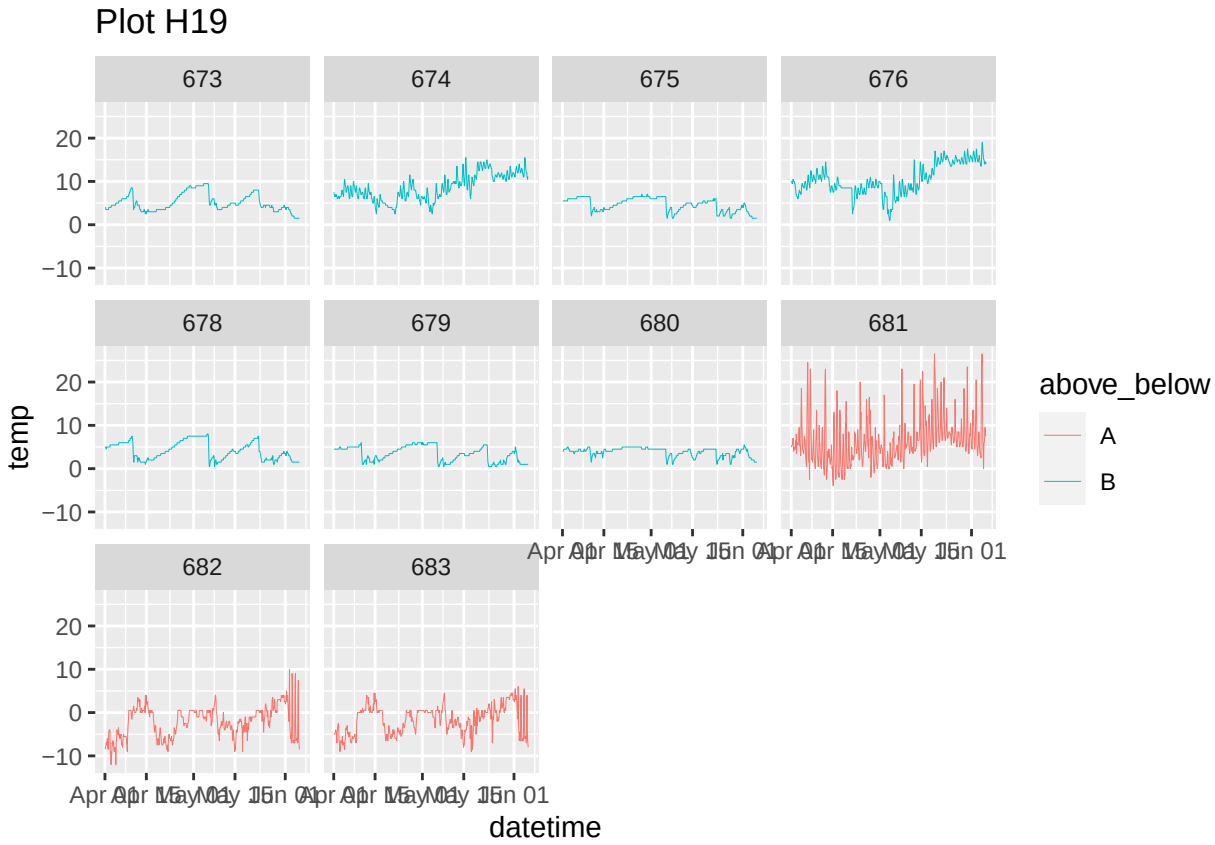




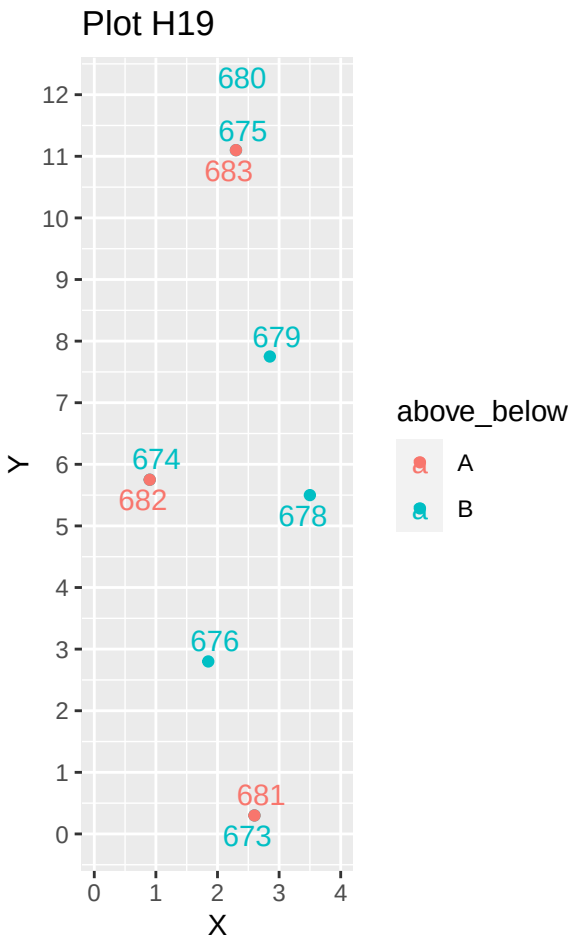
One can really see the negative correlation in this pair! The "peaks" for the aboveground logger coincide with the "valleys" for the belowground one.



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



And the locations in the plot:



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

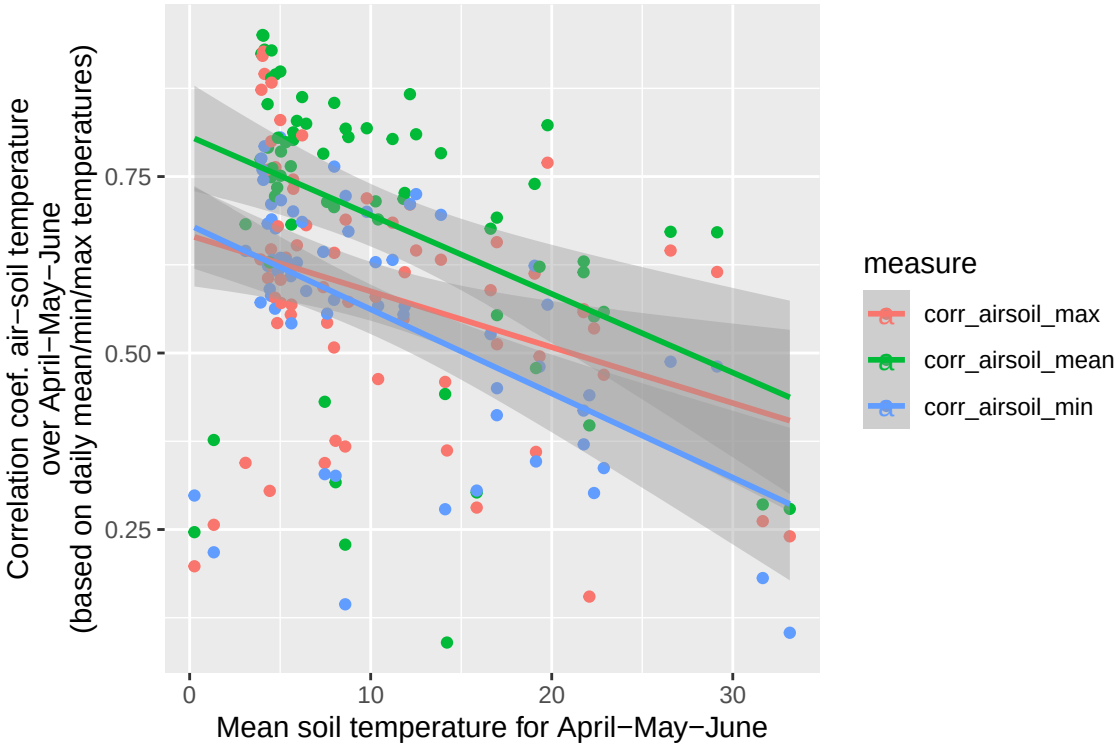
Non-significant in all cases.

Linear models testing the effect of soil temperature on correlations between soil and air temperature, removing pairs with negative correlations (5-6 pairs):

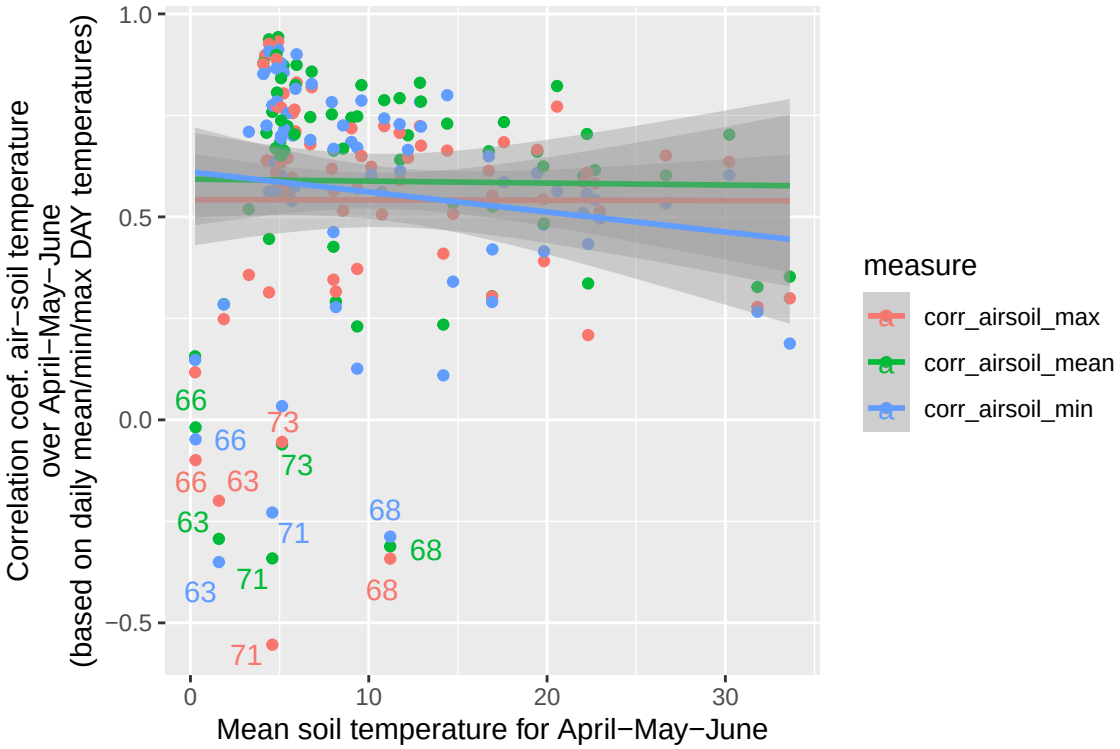
measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.6665364	0.0357063	18.667186	0.0000000
corr_airsoil_max	meansoiltemp	-0.0079128	0.0027159	-2.913459	0.0048959
corr_airsoil_mean	(Intercept)	0.8068819	0.0380291	21.217486	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0111528	0.0028926	-3.855597	0.0002673
corr_airsoil_min	(Intercept)	0.6811336	0.0298558	22.814141	0.0000000
corr_airsoil_min	meansoiltemp	-0.0119193	0.0022738	-5.241899	0.0000019

All significant!

And the graph:



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

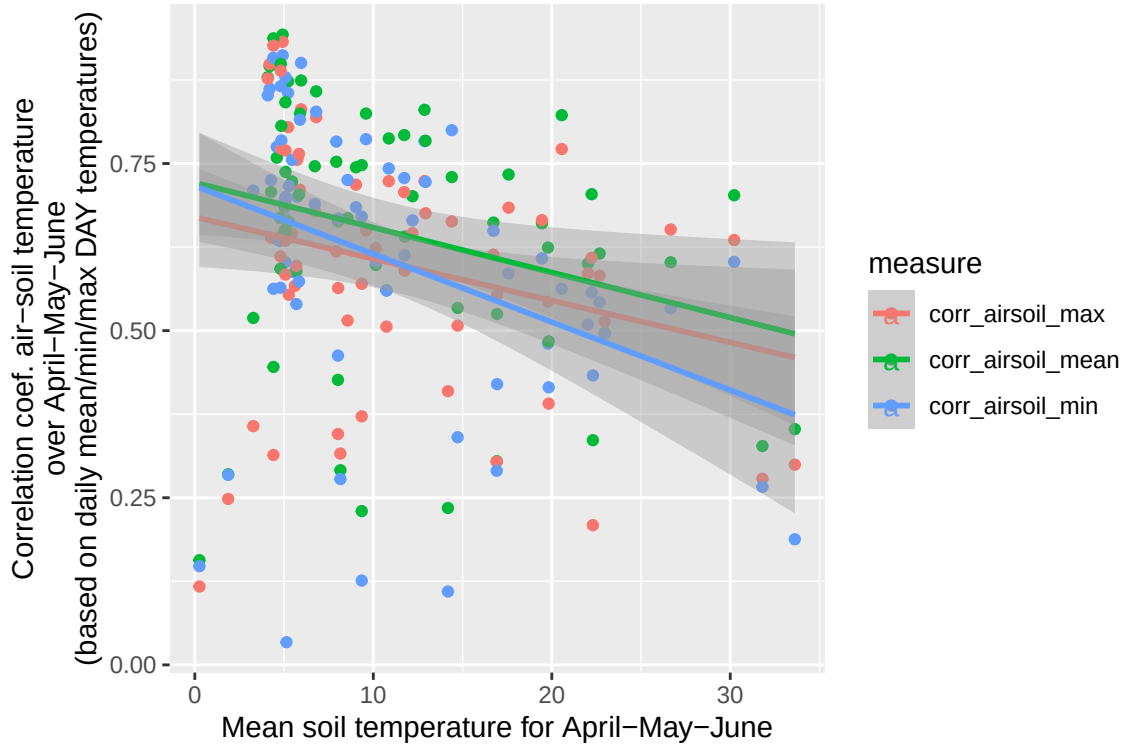
Non-significant in all cases.

Linear models testing the effect of soil temperature on correlations between soil and air temperature, removing pairs with negative correlations (5-6 pairs):

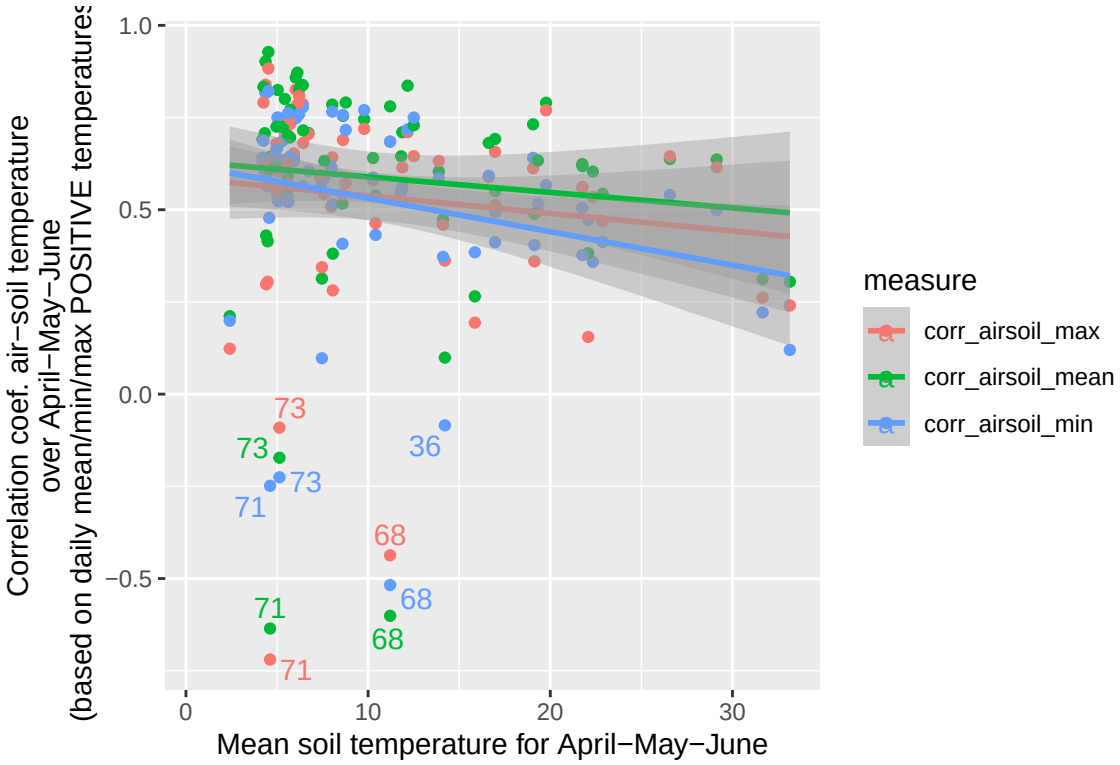
measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.6698080	0.0370403	18.083240	0.0000000
corr_airsoil_max	meansoiltemp	-0.0063071	0.0027716	-2.275618	0.0261728
corr_airsoil_mean	(Intercept)	0.7215362	0.0385325	18.725397	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0068105	0.0028833	-2.362074	0.0211781
corr_airsoil_min	(Intercept)	0.7163918	0.0410998	17.430554	0.0000000
corr_airsoil_min	meansoiltemp	-0.0102886	0.0030948	-3.324444	0.0014490

All significant!

And the graph:



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

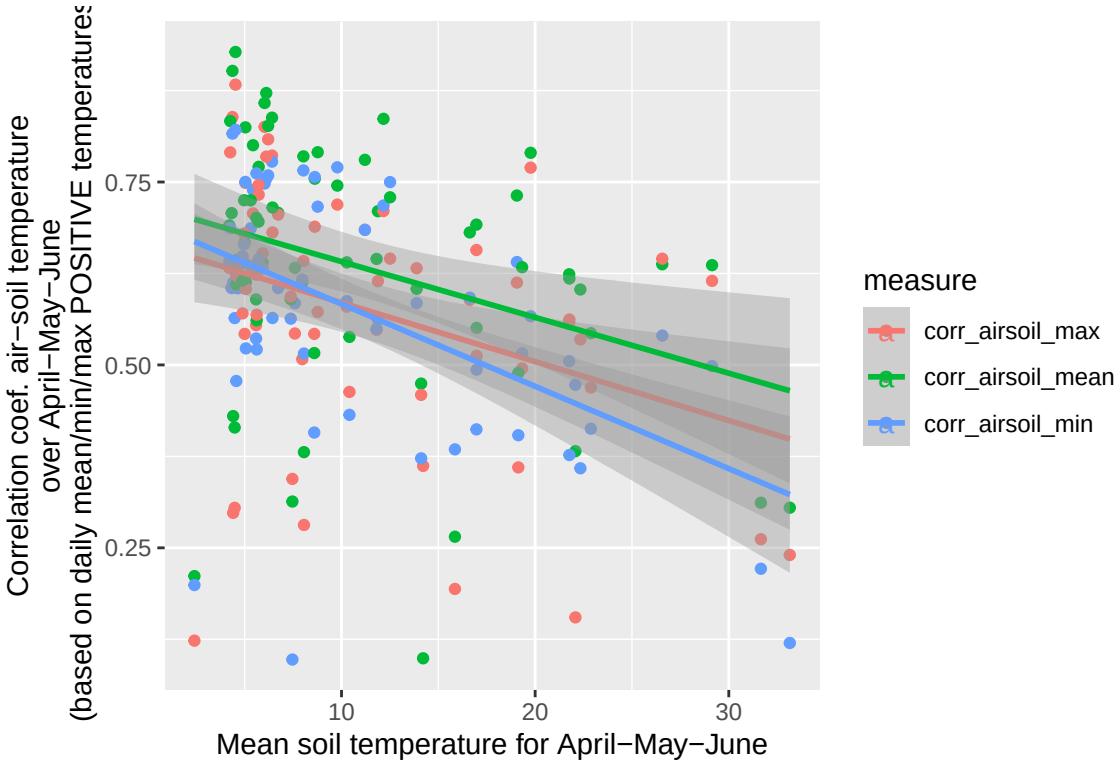
Significant for min only.

Linear models testing the effect of soil temperature on correlations between soil and air temperature, removing pairs with negative correlations:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.6656307	0.0354612	18.770687	0.0000000
corr_airsoil_max	meansoiltemp	-0.0080541	0.0026623	-3.025306	0.0035738
corr_airsoil_mean	(Intercept)	0.7175140	0.0362236	19.807892	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0076275	0.0027195	-2.804755	0.0066606
corr_airsoil_min	(Intercept)	0.6957895	0.0304617	22.841460	0.0000000
corr_airsoil_min	meansoiltemp	-0.0112521	0.0022894	-4.914925	0.0000067

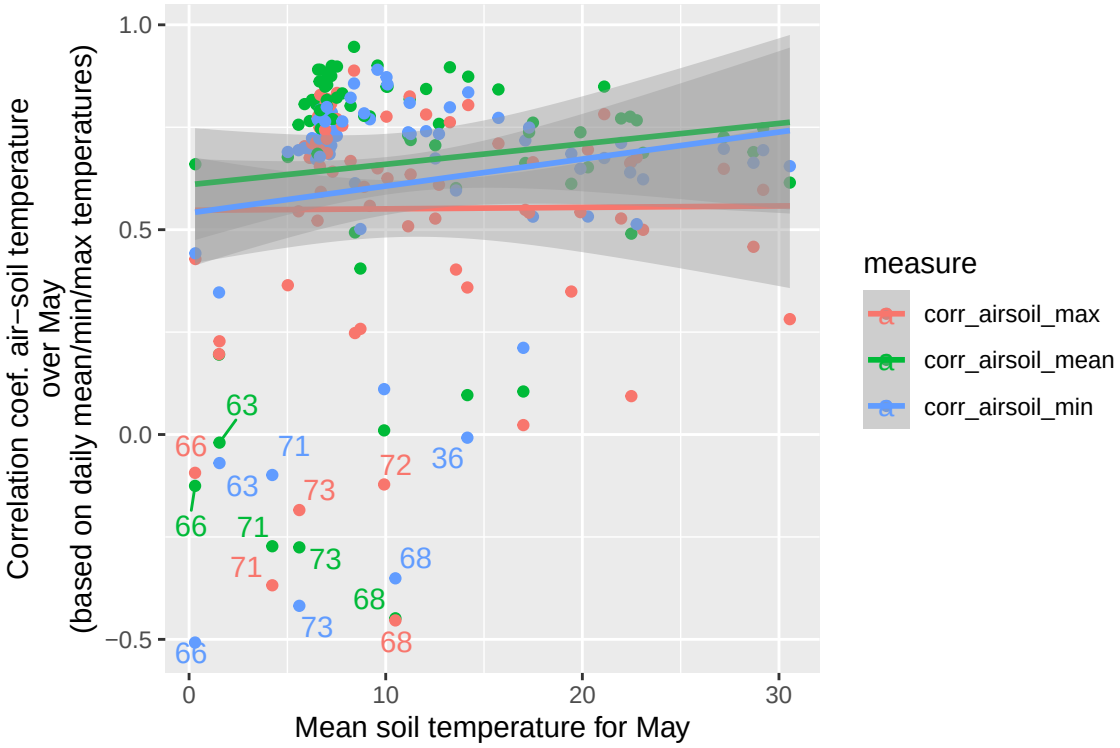
All significant!

And the graph:



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:

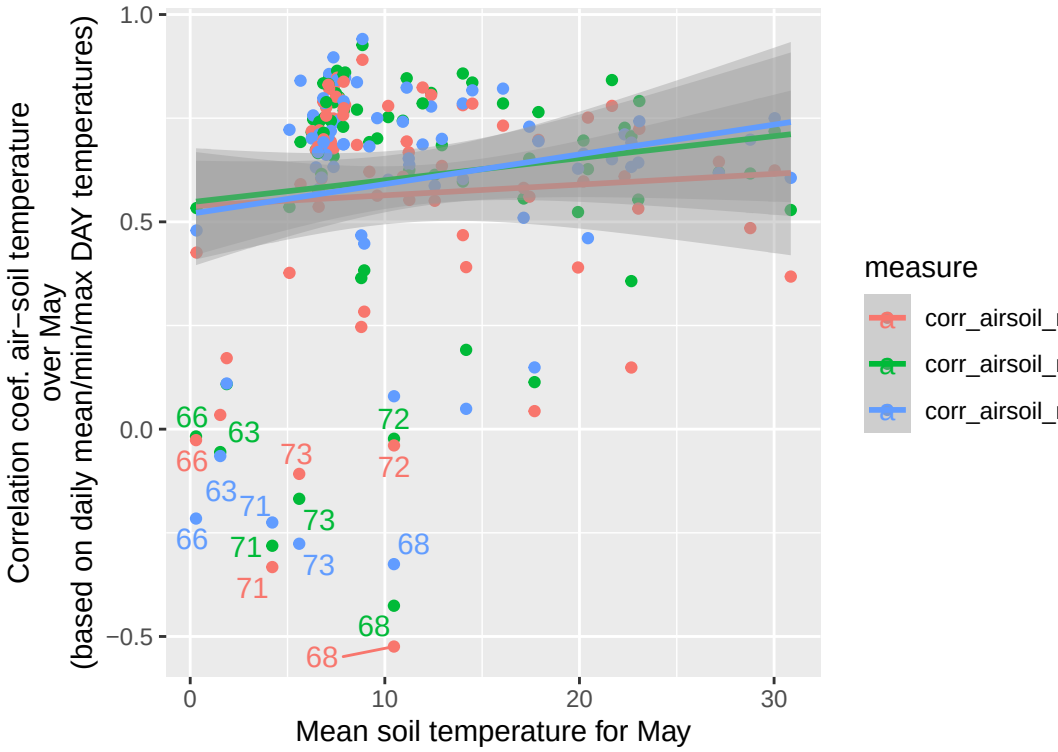
measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5472640	0.0656883	8.3312216	0.0000000
corr_airsoil_max	meansoiltemp	0.0003561	0.0049249	0.0722991	0.9425701
corr_airsoil_mean	(Intercept)	0.6096518	0.0697446	8.7412084	0.0000000
corr_airsoil_mean	meansoiltemp	0.0049926	0.0052290	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.

Linear models testing the effect of soil temperature on correlations between soil and air temperature, removing pairs with negative correlations:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.6820895	0.0453239	15.049213	0.0000000
corr_airsoil_max	meansoiltemp	-0.0060770	0.0033115	-1.835139	0.0710611
corr_airsoil_mean	(Intercept)	0.7825104	0.0462945	16.902888	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0041580	0.0033695	-1.234005	0.2216441
corr_airsoil_min	(Intercept)	0.7250859	0.0330755	21.922149	0.0000000
corr_airsoil_min	meansoiltemp	-0.0026797	0.0024085	-1.112605	0.2700399

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:

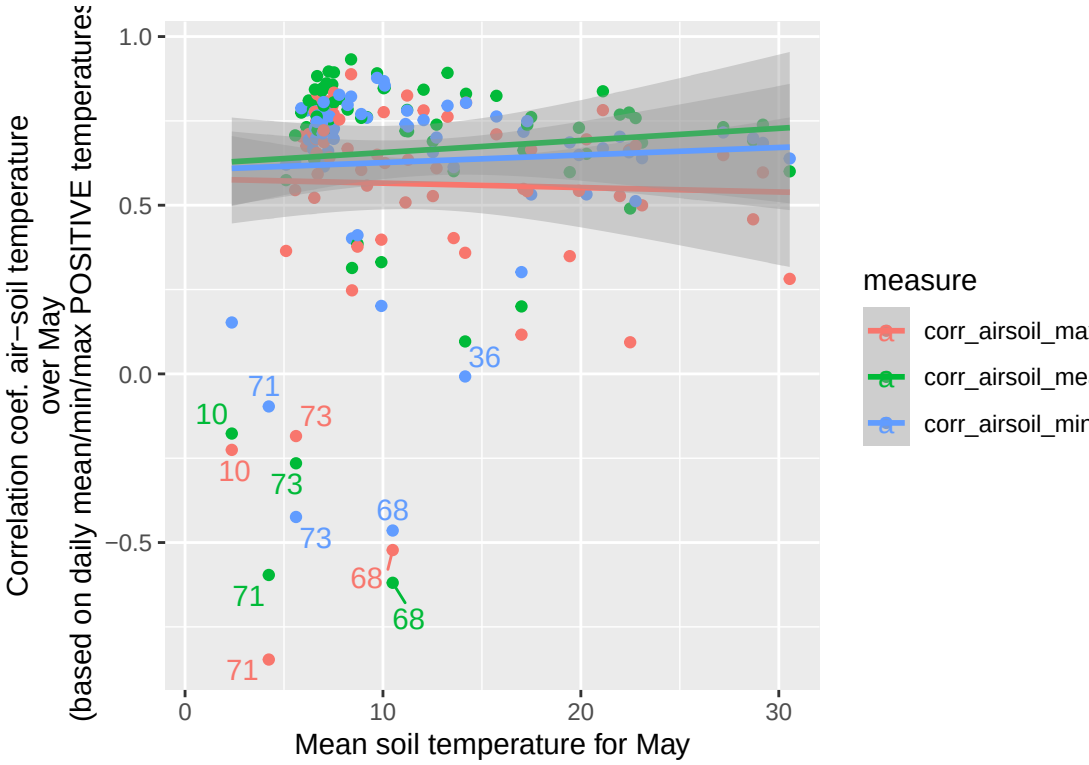
measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.5380173	0.0661380	8.1347702	0.0000000
corr_airsoil_max	meansoiltemp	0.0025902	0.0048650	0.5324127	0.5961262
corr_airsoil_mean	(Intercept)	0.5472074	0.0656852	8.3307547	0.0000000
corr_airsoil_mean	meansoiltemp	0.0053163	0.0048317	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.

Linear models testing the effect of soil temperature on correlations between soil and air temperature, removing pairs with negative correlations:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.6688216	0.0471477	14.1856790	0.0000000
corr_airsoil_max	meansoiltemp	-0.0035614	0.0033798	-1.0537455	0.2959008
corr_airsoil_mean	(Intercept)	0.7199493	0.0421961	17.0619715	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0033439	0.0030024	-1.1137351	0.2695582
corr_airsoil_min	(Intercept)	0.6841244	0.0439808	15.5550523	0.0000000
corr_airsoil_min	meansoiltemp	-0.0016330	0.0031399	-0.5200726	0.6047798

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

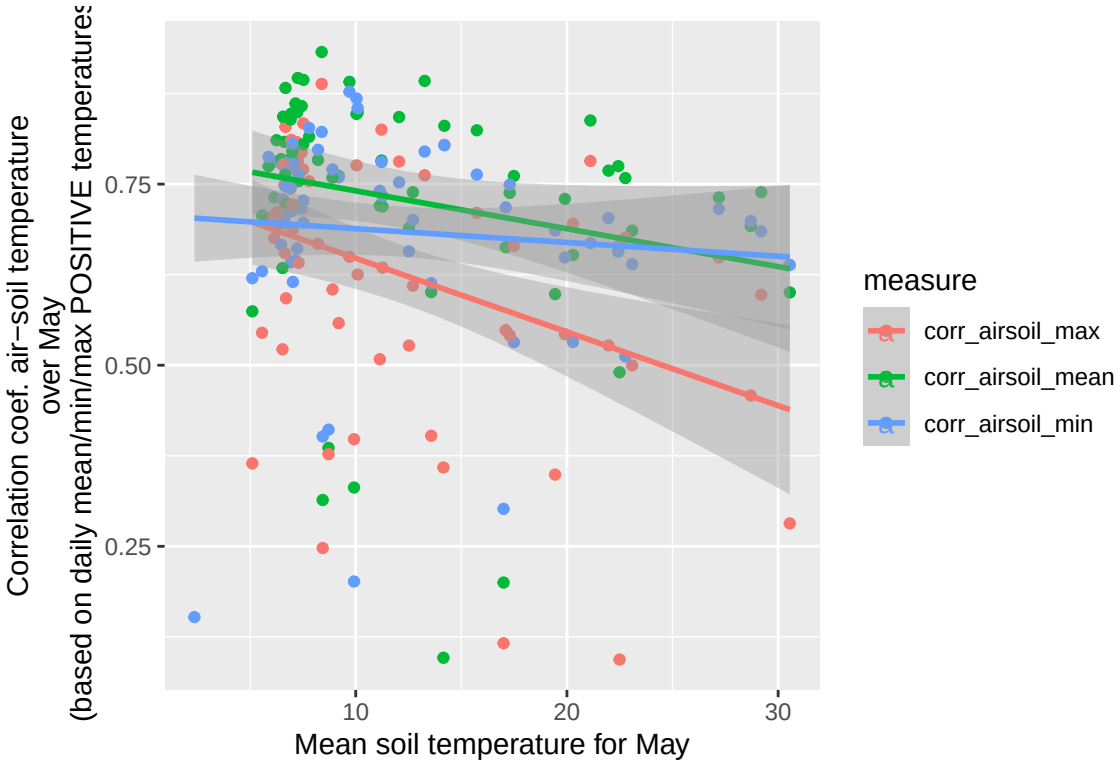
Non-significant in all cases.

Linear models testing the effect of soil temperature on correlations between soil and air temperature, removing pairs with negative correlations:

measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.7494283	0.0417613	17.945514	0.0000000
corr_airsoil_max	meansoiltemp	-0.0101740	0.0029933	-3.398965	0.0011777
corr_airsoil_mean	(Intercept)	0.7930083	0.0410498	19.318200	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0052311	0.0029423	-1.777911	0.0802444
corr_airsoil_min	(Intercept)	0.7074897	0.0351255	20.141795	0.0000000
corr_airsoil_min	meansoiltemp	-0.0019021	0.0025372	-0.749683	0.4562361

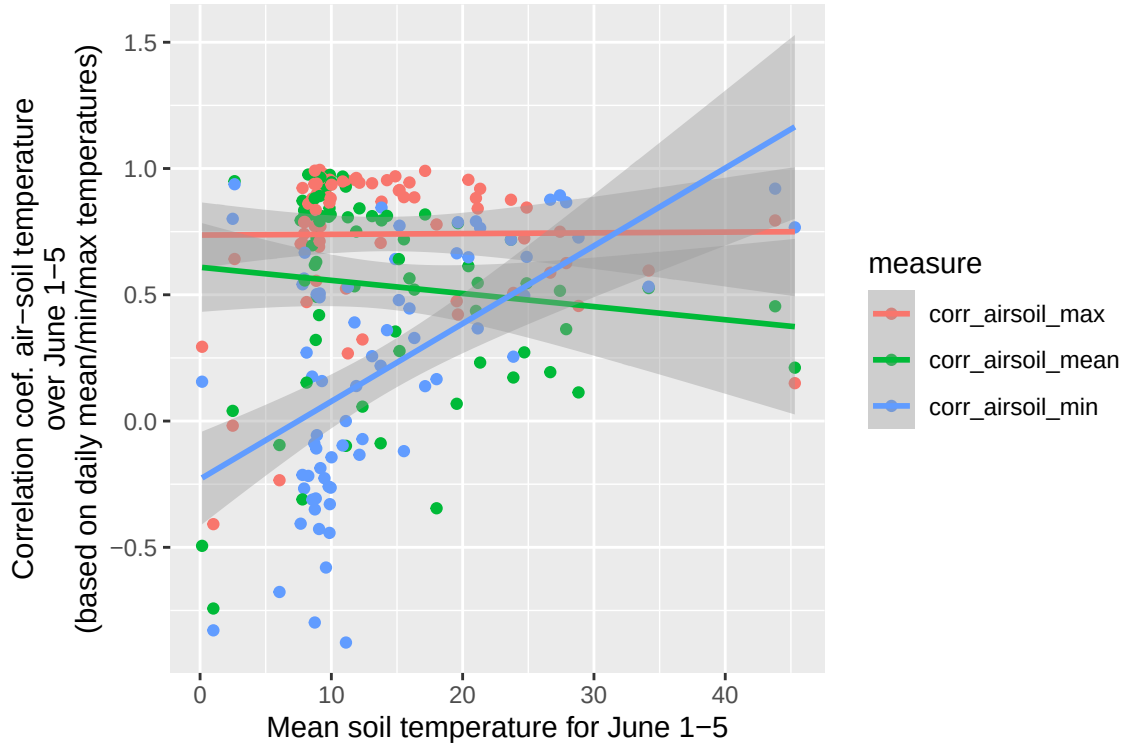
Only significant for max.

And the graph:



Correlations soil-air temperature for June 1-5

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 (June)**.



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

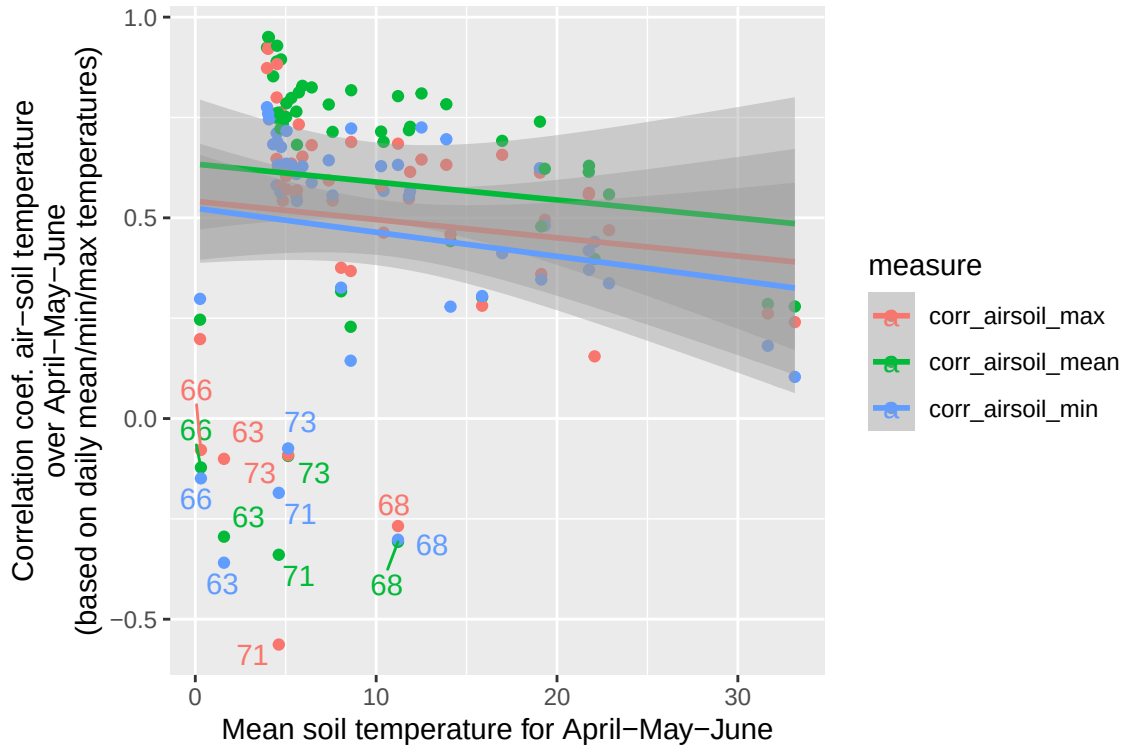
measure	term	estimate	std.error	statistic	p.value
corr_airsoil_max	(Intercept)	0.7364174	0.0652288	11.2897546	0.0000000
corr_airsoil_max	meansoiltemp	0.0002941	0.0039544	0.0743688	0.9409322
corr_airsoil_mean	(Intercept)	0.6090609	0.0887102	6.8657385	0.0000000
corr_airsoil_mean	meansoiltemp	-0.0051945	0.0053780	-0.9658770	0.3374789
corr_airsoil_min	(Intercept)	-0.2299718	0.0928467	-2.4768977	0.0157077
corr_airsoil_min	meansoiltemp	0.0307927	0.0056287	5.4706277	0.0000007

Positive significant for min.

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).

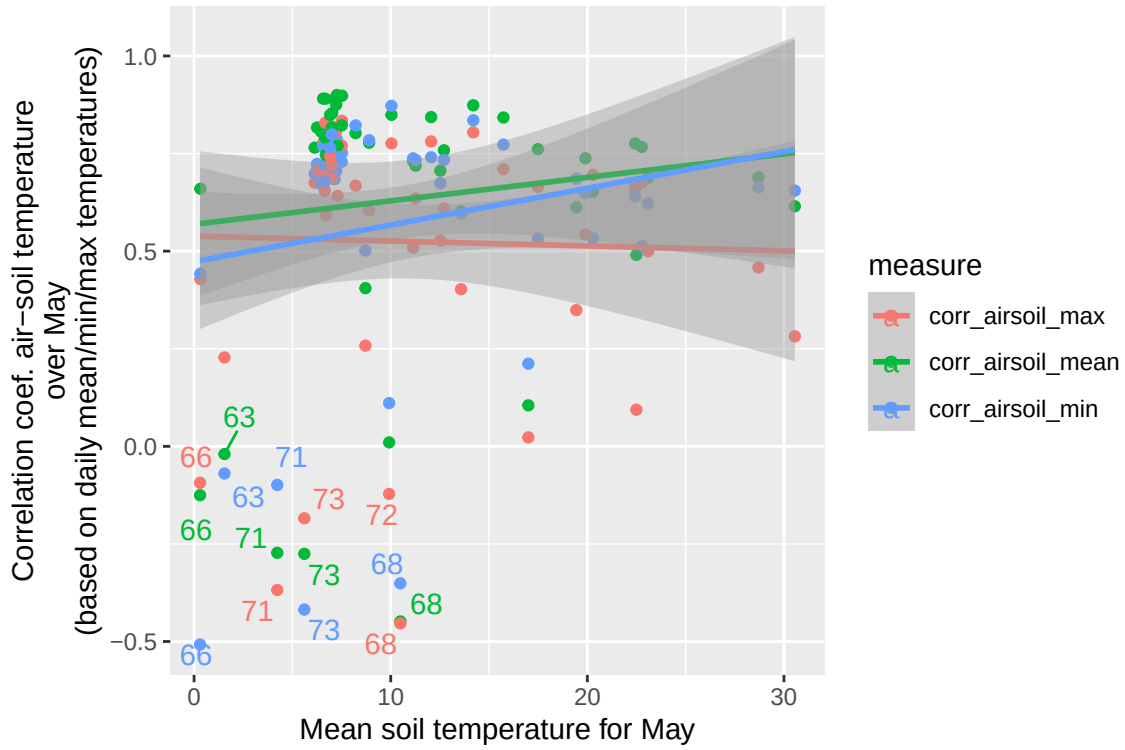


Linear models testing the effect of soil temperature on correlations between soil and air temperature:

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)**.

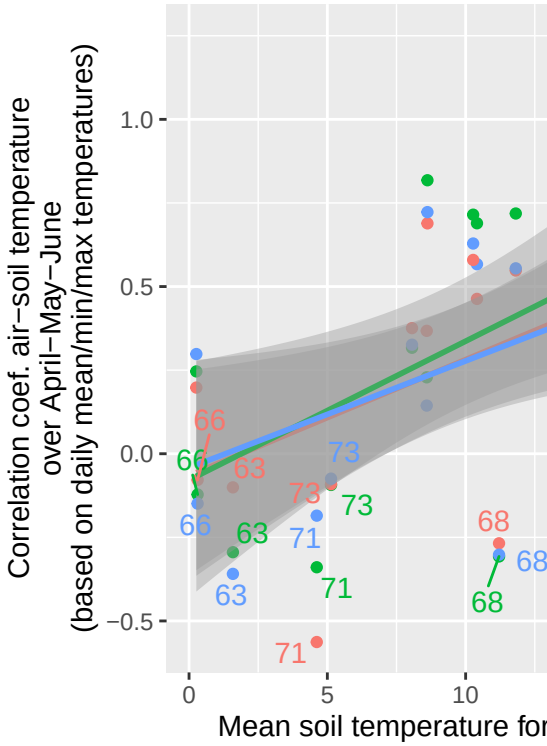


Linear models testing the effect of soil temperature on correlations between soil and air temperature:

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

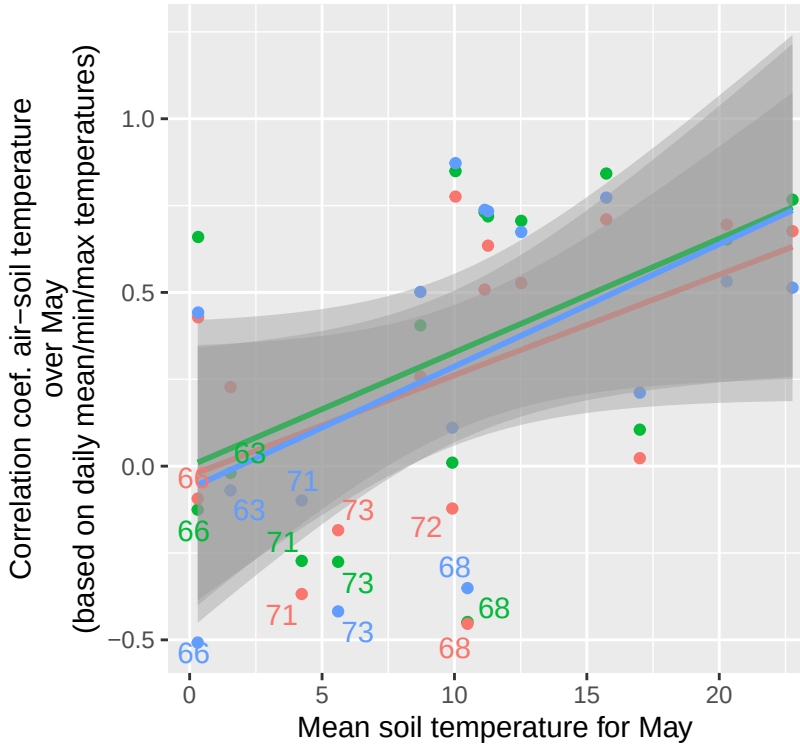


Correlations soil-air temperature over the period April-May-June

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

Postive 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.