2020 GLOBE International Virtual Science Symposium

The Relationship Between Temperature And Meteorological Factors.

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Summary

Since global warming has been serious these days, there are more concerns about eco-friendly issues; therefore, we want to prove whether Geothermal Heat Pump could be implemented in our school by analyzing the data at our station. We want to discuss the relationship between several factors, air temperature, and soil temperature. And the data was collected from 2019/08 to 2020/02 because these months contain the highest and lowest temperatures in one year.

Research Motivation and Purpose

Air conditioner is a necessity in the hot summer days, but it causes a great amount of energy consumption. To prevent the global warming from being worse, people start to generalize the thought of Energy Efficiency and Carbon Reduction.
Therefore, Geothermal Heat Pump came out. For soil featuring homeothermy, when the air temperature become higher than earth temperature, building pipes import air into the soil to cool the air, and then import the air to the house to achieve the effect of cooling; instead in the winter, we still can use the same way to warm our houses. This way not only have the same effect with the air conditioner, but attain the goal of Energy Efficiency and Carbon Reduction. Thus, we are going to discuss the relevance between air temperature and earth temperature, whether it is influenced by some factors or not (for example: rainfall, or sunshine intensity…)

Research Questions

1.Does air temperature affect earth temperature?
2.Which rainfall influences the most? Air temperature or earth temperature?
3.Which the sunshine intensity influences the most? Air temperature or earth temperature?
(Sunshine intensity include Global Rad and Cloud amount)

References

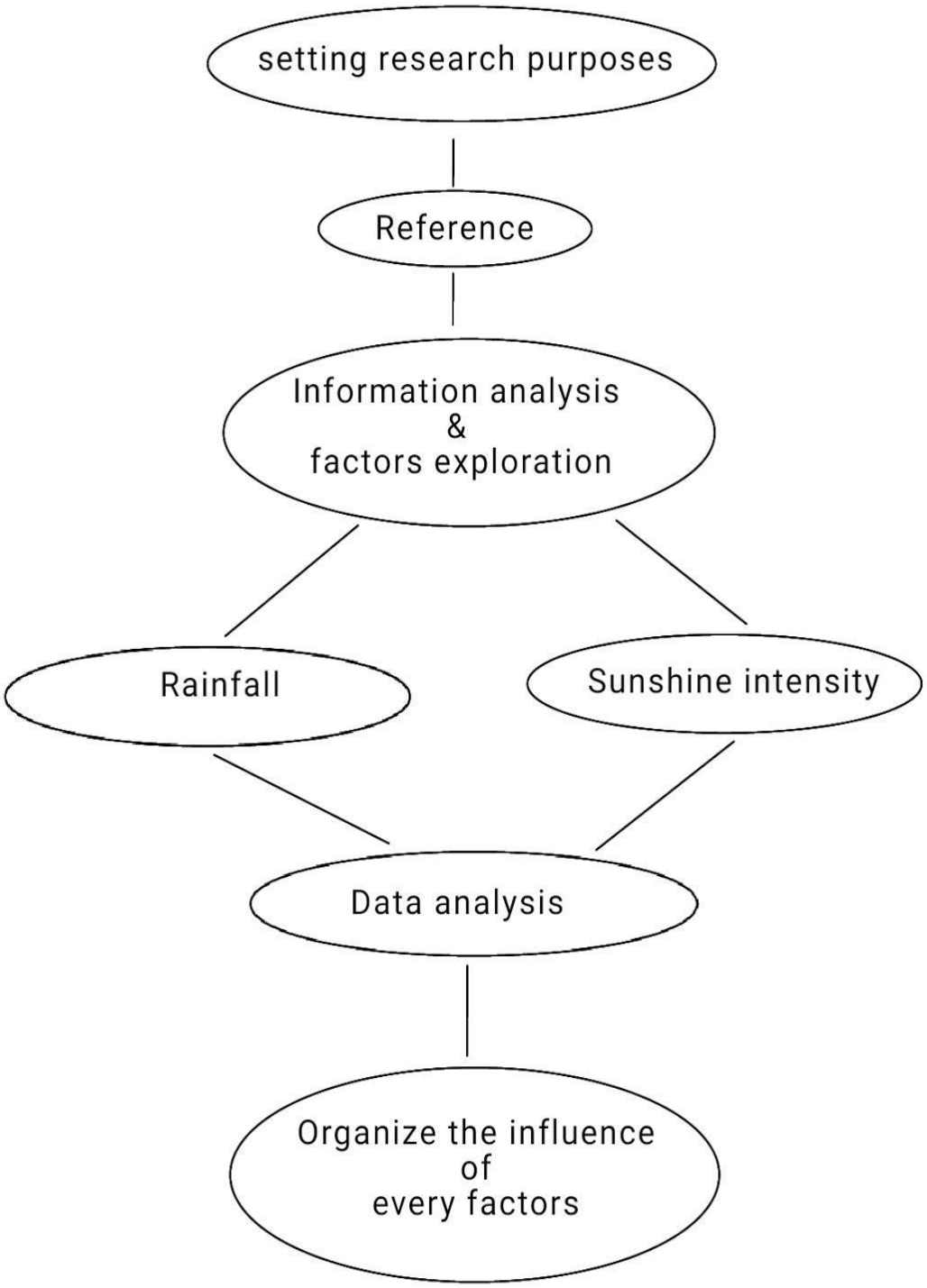
1. Because the highest subsurface soil temperatures are reached during the late fall and early winter months when above ground temperatures approach the coldest, and the coolest subsurface temperatures are present during the late spring and early summer months when the above surface temperatures are approaching the warmest. So, the underground air tempering system uses the phenomenon to reach the goal of saving energy. (FromUS4323113A - Underground air tempering system.)

2. Climatic changes at the Earth's surface propagate slowly downward into the ground and modify the ambient ground thermal regime. Changes in air temperature mainly occurred in winter, while changes in precipitation happened mainly during summer. Changes in air temperature alone cannot explain the changes in soil temperatures at this station. Soil temperature actually decreased during summer, while air temperature increased slightly. This cooling in the soil may be explained by changes in rainfall and hence soil moisture during summer due to the effect of a soil moisture feedback mechanism.(publish: April 2001,An Amplified Signal of Climatic Change in Soil Temperatures during the Last Century at Irkutsk, Russia T. Zhang, Roger G. Barry, D. Gilichinsky, S. S. Bykhovets, V. A. Sorokovikov & Jingping Ye)

3. We refer those data(Cloud Amount(1-10),GloblRad(MJ/㎡),Sunshine(hr),Precp(mm)) from CWB Observation Data System.
   (From https://e-service.cwb.gov.tw/HistoryDataQuery/index.jsp)

4. We refer those data (air temperature, soil temperature, Last 24hrs air temperature max.(°C), Last 24hrs soil temperature max.(°C)) from meteorological observation station in Kaohsiung Municipal Kaohsiung Girls' Senior High School.

Research Method



1. The station and data collection

The station we chose to collect data was in Kaohsiung Municipal Girls' Senior High School.

Please refer to the "Picture1"

(Picture1)

Address: No. 122, WuFu 3rd Rd. Kaohsiung City, Taiwan R.O.C

Latitude:22.6213°N Longitude:120.2928°E

Soil component: sand, clay, and silty

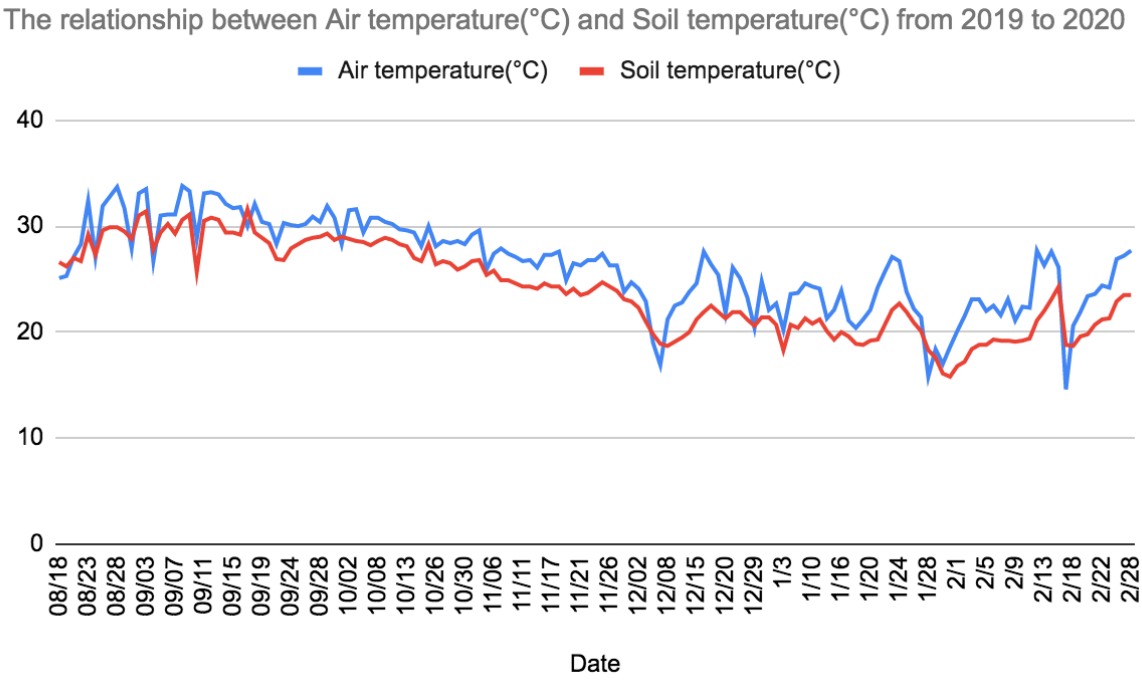
2. Information analysis

The data contains the meteorological factors and temperature, and we discussed them by drawing some diagrams and calculated the correlation coefficient. The reason why we calculated the correlation coefficient was that it told us that the factors may influence the temperature slightly.

Results and Conclusions

1. The relationship between air temperature and soil temperature

These charts show that(1-3):



(1) From August to December, air and soil temperature are gradually declining.

(2) Air temperature was usually higher than soil temperature,
except for 08/18,08/27-9/02,09/02~06,09/18,12/05~12/11,12/25,1/28,1/17,
2/16~2/18 these days.

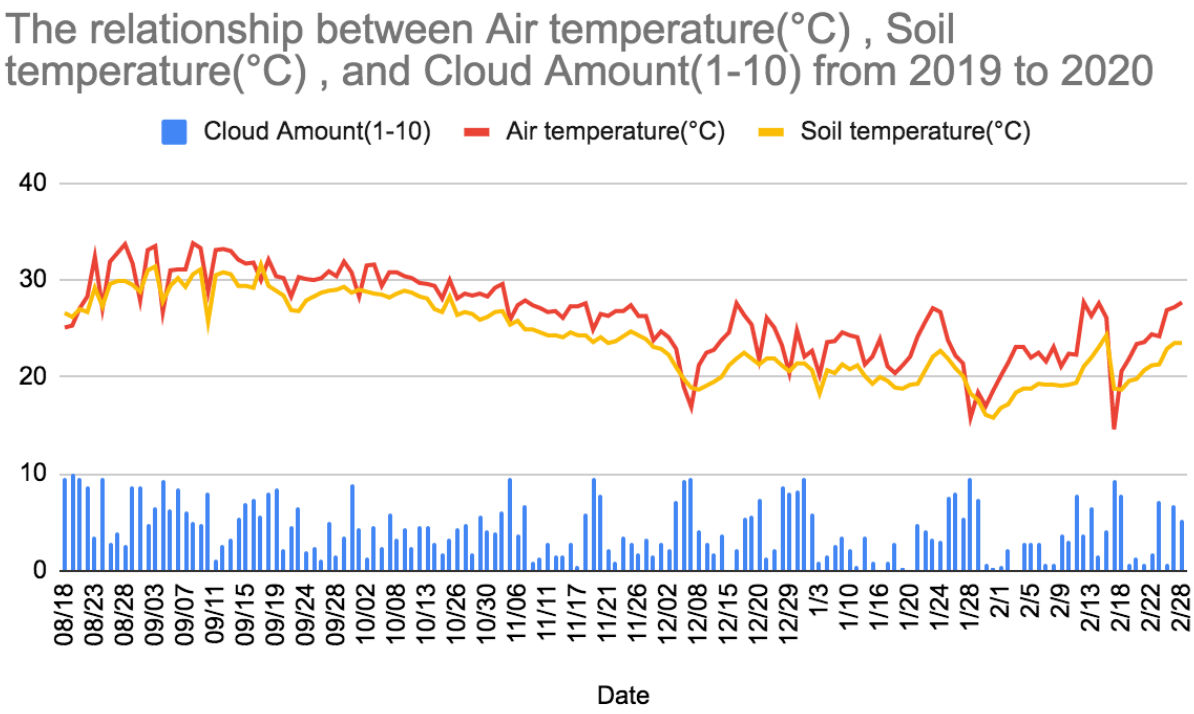
The explanation of the exceptions:

According to the form below, we found when soil temperature was lower than air temperature, there was typhoon or cold surge.And we inferred that the reason why soil temperature was higher than air temperature was that the weather rapidly changed.

Date	Probably Reason	Result (Air temperature - Soil temperature =) (°C)
8/16~8/18	Typhoon Krosa(TY)	25.1-26.6= -1.5(8/18)
8/21~8/27	Typhoon Bailu(TS)	27.1-27.3= -0.2(8/25)
8/27~9/02	Typhoon Podul(TS)	27.9-28.8= -0.9(8/30)
9/02~06	the interrelationship between	26.7-27.8= -1.1(9/4)

	Typhoon Lingling(TY) and Typhoon Kajiki(TS)	
9/16~18	Typhoon Peipah(TS)	30.0-31.6= -1.6(9/17)
9/27~10/1	Typhoon Mitag(TY)	28.3-29.0= -0.7(10/1)
12/05~12/06	Continental air mass 1	19-19.8= -0.8(12/05) 16.9-18.9= -2(12/06)
12/29	Continental air mass 2 (but it focused on North Taiwan instead of South Taiwan)	20.4-20.6= -0.2(12/29)
1/27~31	Cold surge	15.8-18.3= -2.5(1/28)
2/16~2/18	Cold surge	14.6-18.8= -4.2(2/17)

(4)Factors analysis (8/18~2/28)

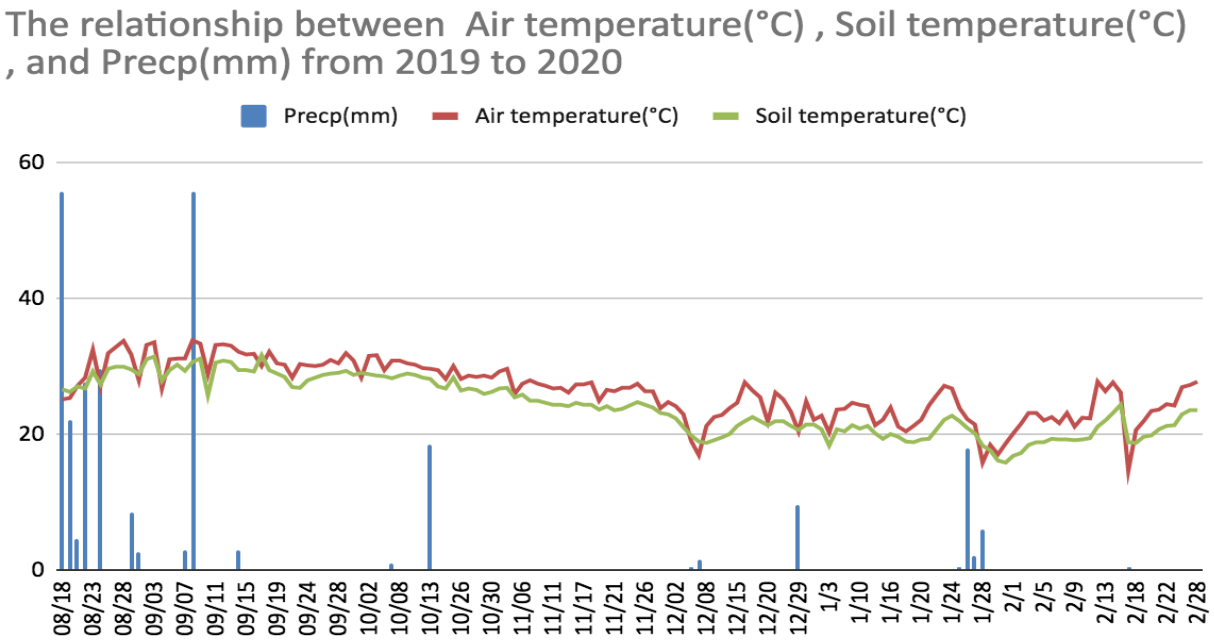


The chart shows that:

[1]When cloud amount was high, the air and soil temperature tend to be low.

[2]The soil temperature was more constant than air temperature.

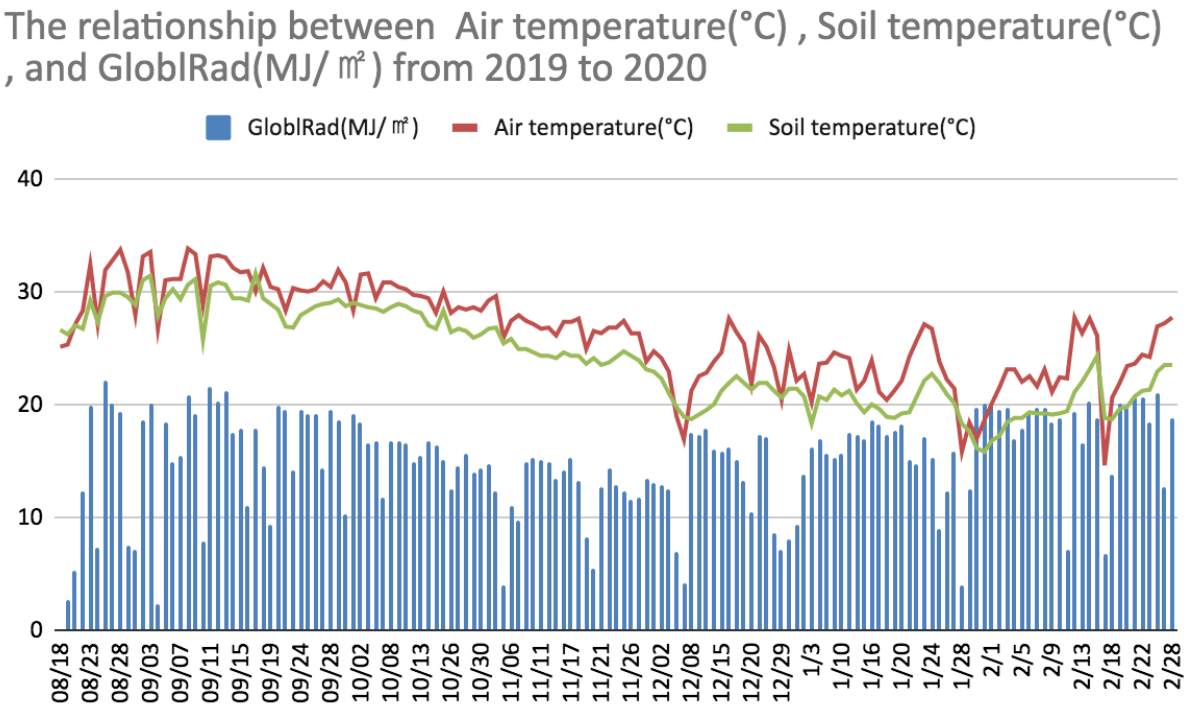
[3]The highest temperature was in August.Since then, the temperature gradually drops off.



The chart shows that:

[1] If it rained, air and soil temperature tends to drop off.

[2] Air temperature was usually higher than soil temperature.



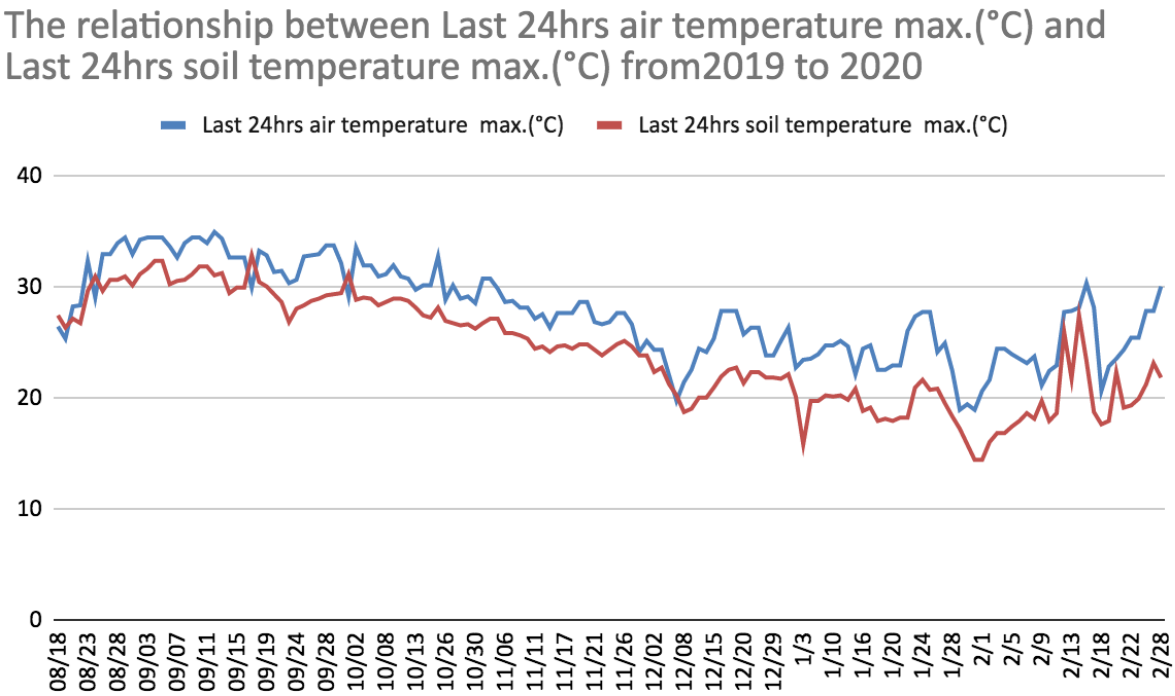
The chart shows that:

[1] When GloblRad(MJ/m²) was low, air and soil temperature tend to drop off.

[2] Air temperature was usually higher than soil temperature.

[3] Soil temperature was more constant than air temperature

2. A comparison between air temperature Max and soil temperature Max



The chart shows that:

[1]The soil temperature maximum was usually lower than air temperature maximum.

[2]The tendency of both air and soil temperatures were almost the same.

[3]The highest temperature was about 34°C in August.

2. Correlation coefficient of air temperature and soil temperature

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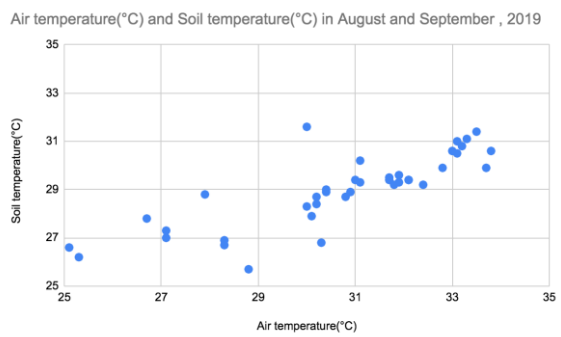
<td> 
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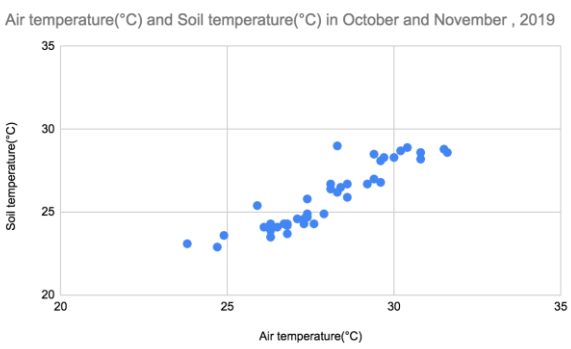
<td> 
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<tr>
<td>Correlation coefficient(Aug.~Sep.) :
0.8166679336</td>
<td>Correlation coefficient(Oct.~Nov.) :
0.9093054795</td>
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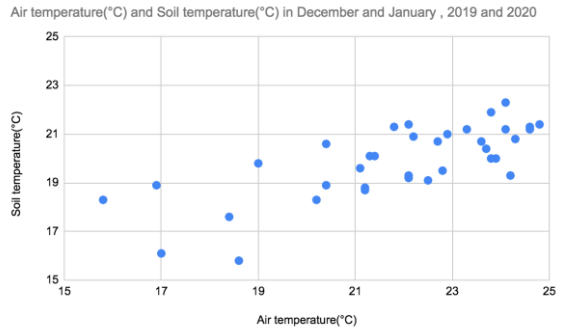
<td> 
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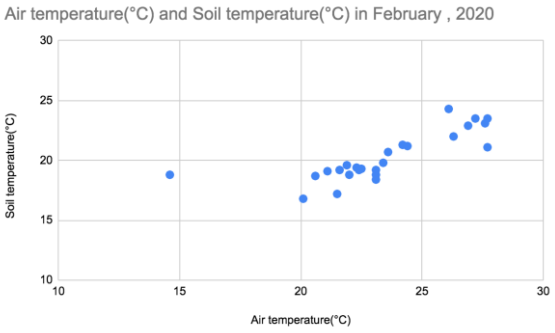
<td> 
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<tr>
<td>Correlation coefficient(Dec.~Jan.) :
0.8074141111</td>
<td>Correlation coefficient(Feb.) :
0.7902004028</td>
</tr>
</table>

Month	Aug-Sep (08-09)	Oct-Nov (10-11)	Dec-Jan (12-01)	Feb(02)
Correlation coefficient	**0.8166679336**	**0.9093054795**	**0.8074141111**	**0.7902004028**

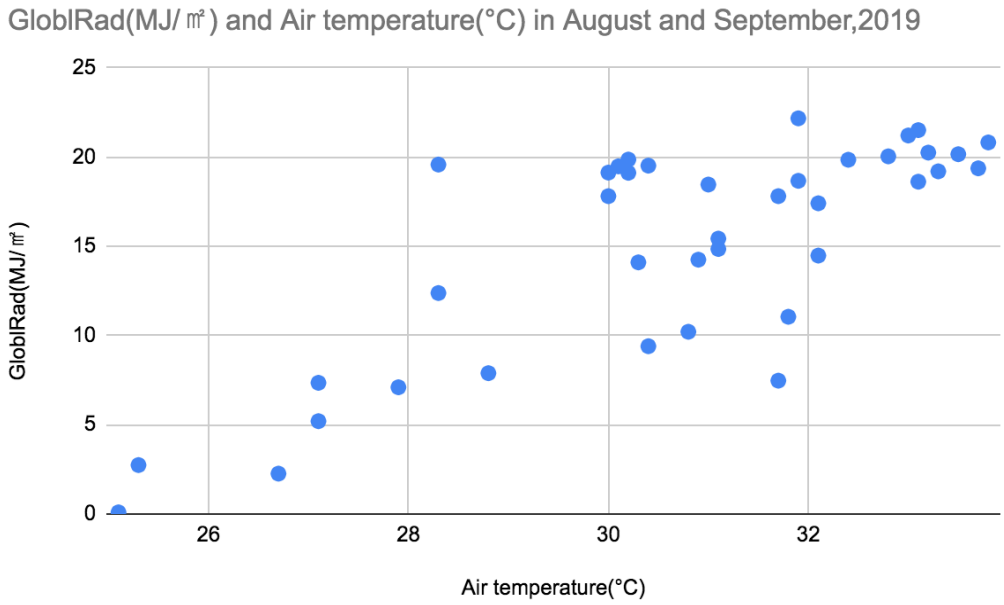
(Relevant /Not Relevant)
This form tells us that:

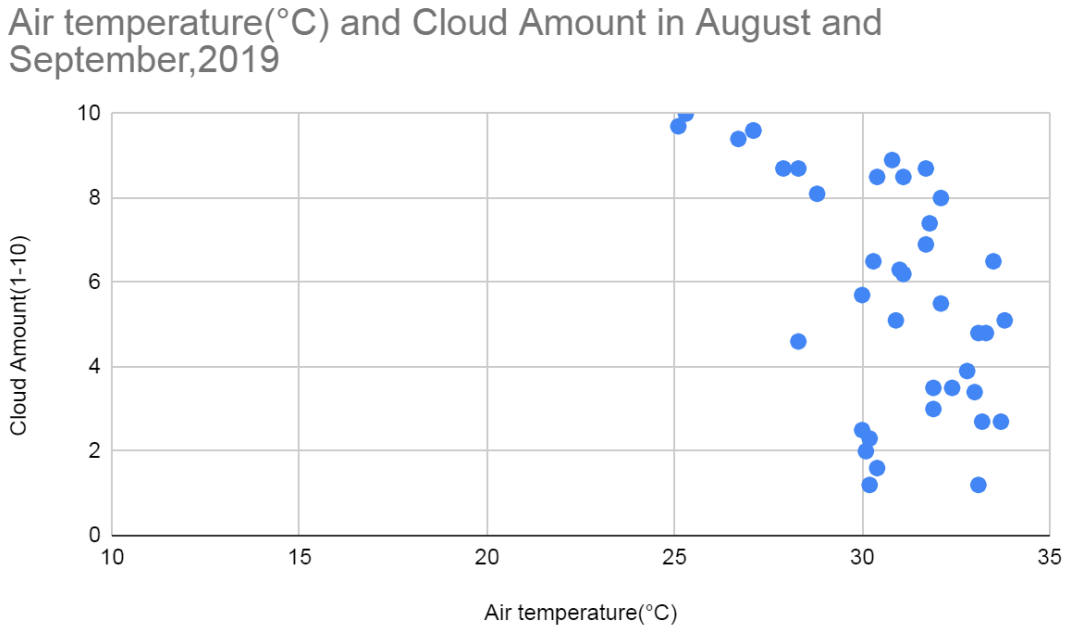
[1] From August to February, the correlation coefficient values were higher than 0.3;thus,air and soil temperature were highly relevant to each other.

[2] The highest correlation coefficient value was from October to November.

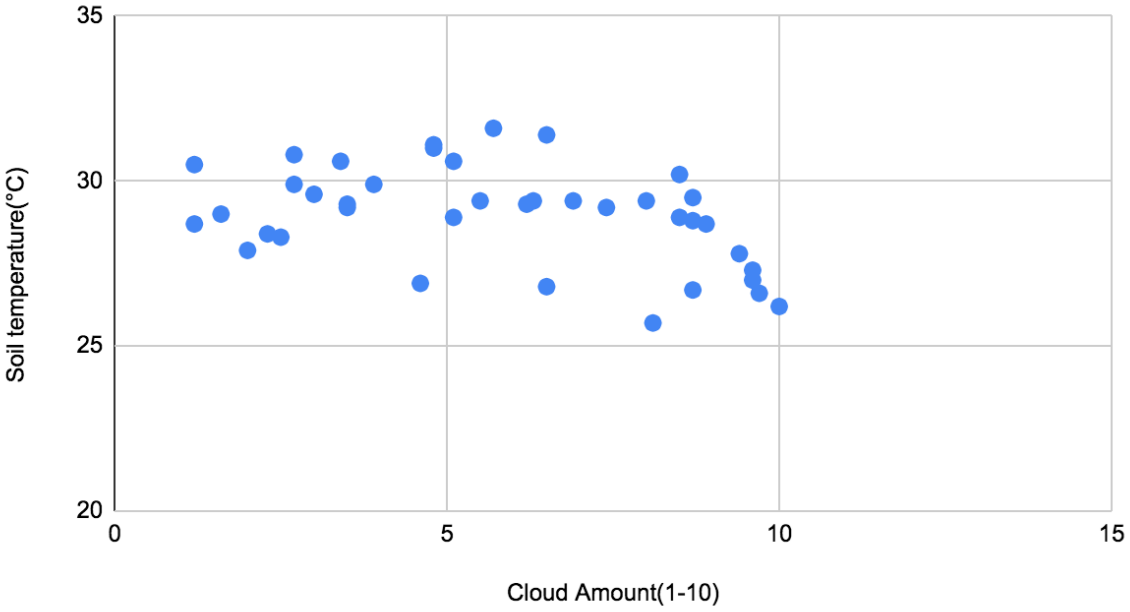
4.Factor Analysis(every two month)

(1) August and September

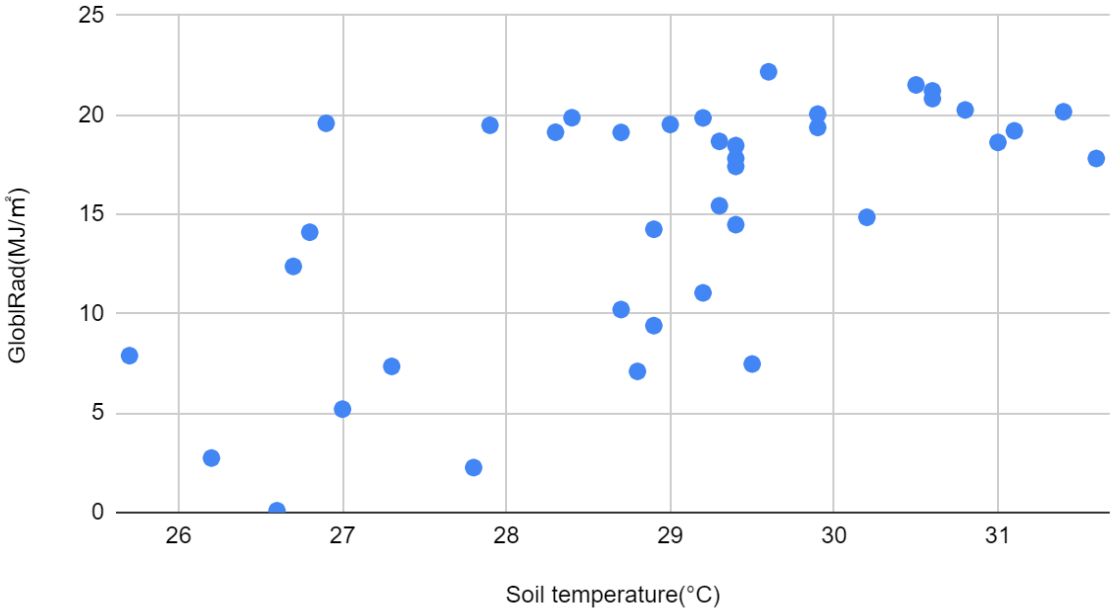


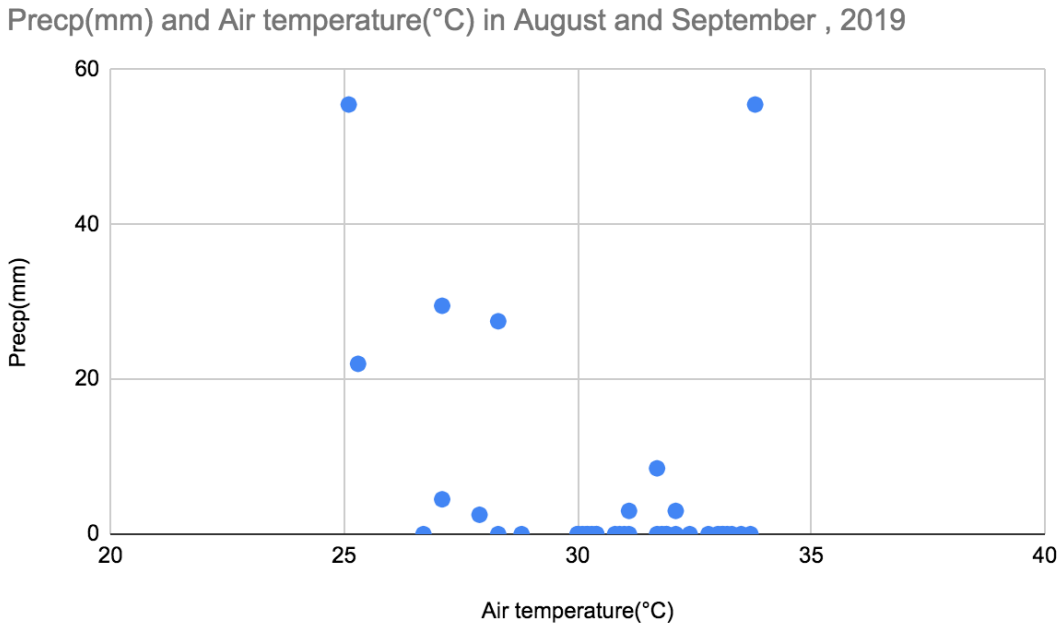


Cloud Amount(1-10) and Soil temperature(°C) in August and September , 2019



GloblRad(MJ/㎡) and Soil temperature(°C) in August and Setember,2019





Correlation coefficient(Aug.~Sep.)	AIR TEMPERATURE	SOIL TEMPERATURE
GloblRad	**0.779**	**0.623**
Cloud Amount	**-0.568**	**-0.410**
Precp	**-0.362**	-0.280

(Relevant /Not Relevant)

This form tells us that:

[1] GloblRad was highly relevant to air and soil temperatures.

On top of that,GloblRad was positive correlative to both two temperatures.

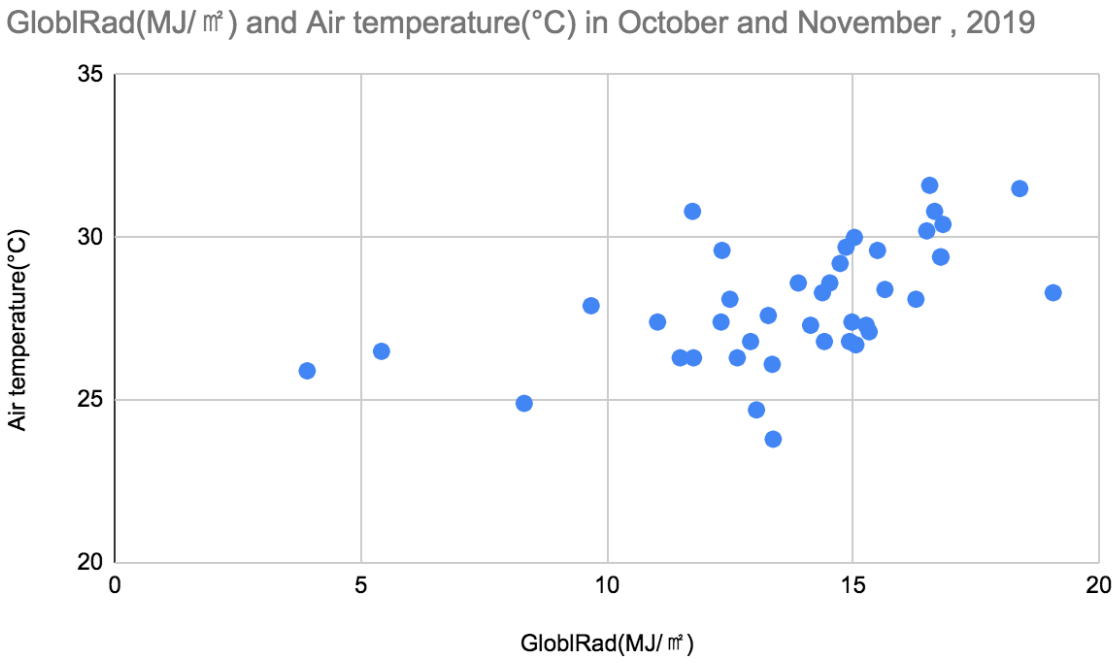
[2] Cloud Amount was highly relevant two air and soil temperatures.

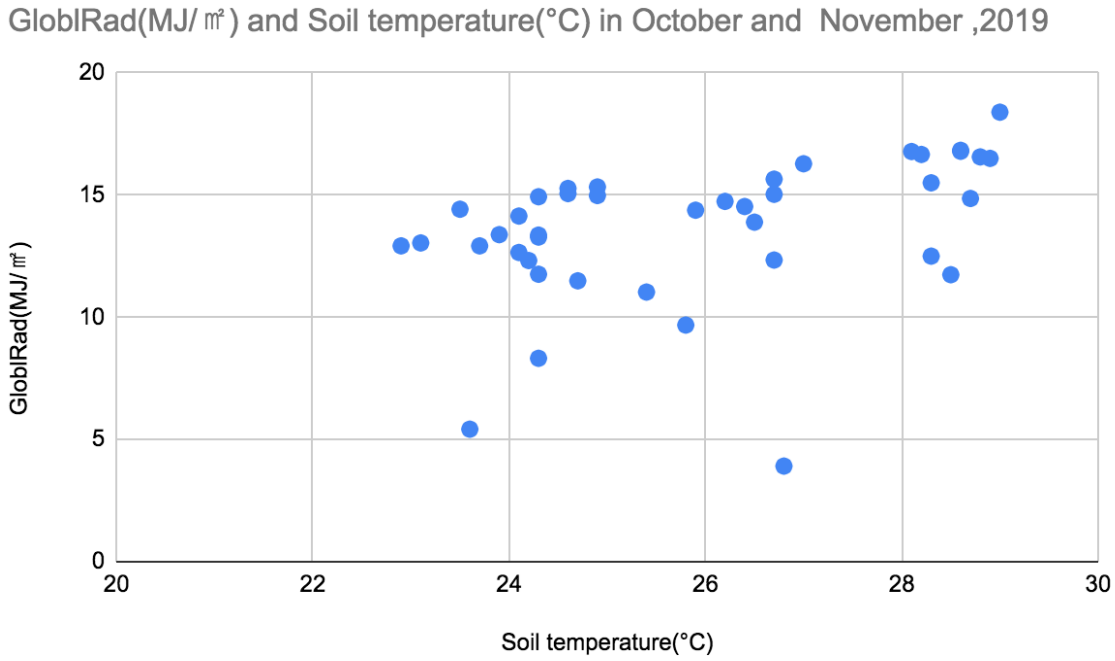
However, it was negative correlative to both two temperatures.

[3] Precp was relevant to air temperature; however, it wasn't to soil one.

On top of that, Precp was negative correlative to air temperature.

(2)October and November



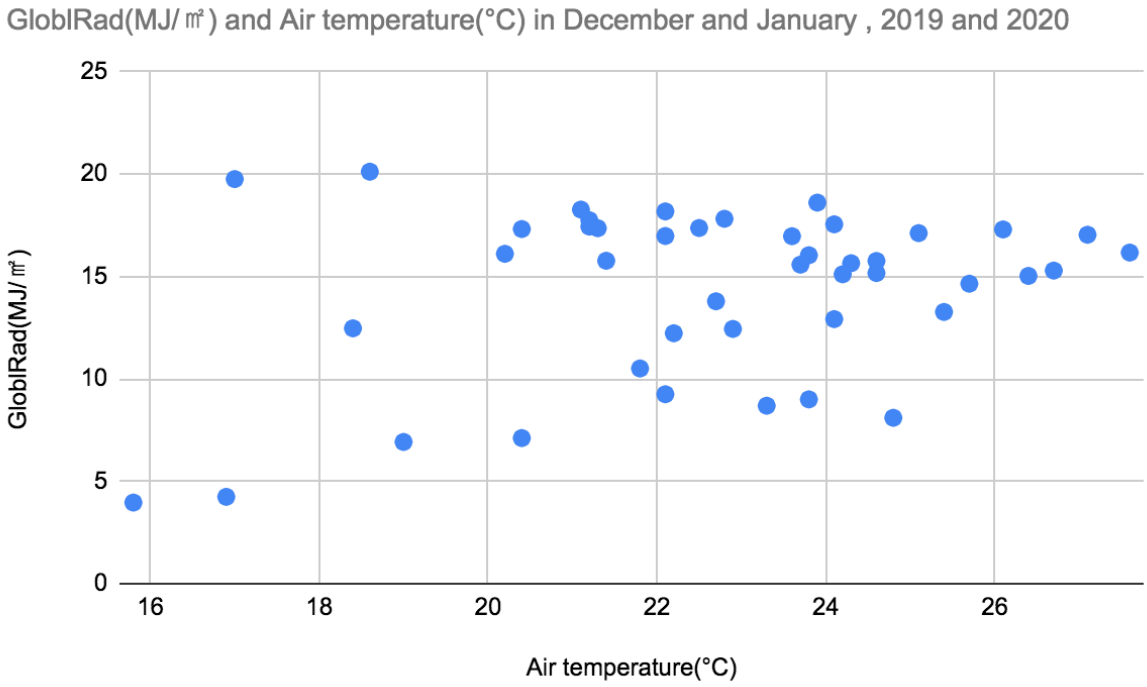


Correlation coefficient(Oct.~Nov.)	AIR TEMPERATURE	SOIL TEMPERATURE
GloblRad	**0.537**	**0.530**
Cloud Amount	0.015	0.192
Precp	0.152	0.192

(Relevant /Not Relevant)

This form tells us that:
[1] GloblRad was highly relevant to both air and soil temperatures because both the absolute correlation coefficient values were higher than 0.3.
On top of that, GlobRad was positive correlative to both two temperatures.
[2] Cloud Amount wasn't really relevant to both two temperatures because the correlation coefficient values of two were negative.
[3]Precp wasn't really relevant to both two temperatures because the correlation coefficient values of two were negative.

3.December and January

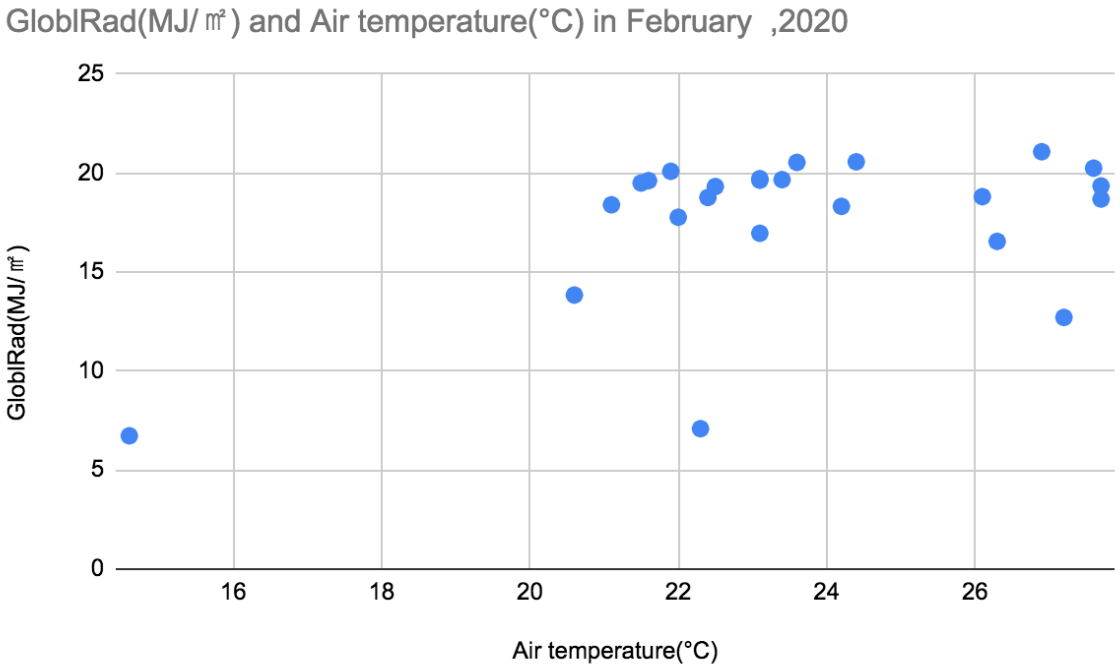


Correlation coefficient(Dec.~Jan.)	AIR TEMPERATURE	SOIL TEMPERATURE
GloblRad	**0.537**	0.006
Cloud Amount	-0.250	-0.195
Precp	-0.224	0.176

(Relevant /Not Relevant)

This form tells us that:
[1]GloblRad was highly relevant to air temperature;however,it wasn't to soil one. On top of that,GloblRad was positively correlated to air temperature.
[2]Cloud Amount wasn't really relevant to air and soil temperatures because both the absolute correlation coefficient values were lower than 0.3.
[3]Precp wasn't really relevant to air and soil temperatures because both absolute correlation coefficient values were lower than 0.3.

4.February

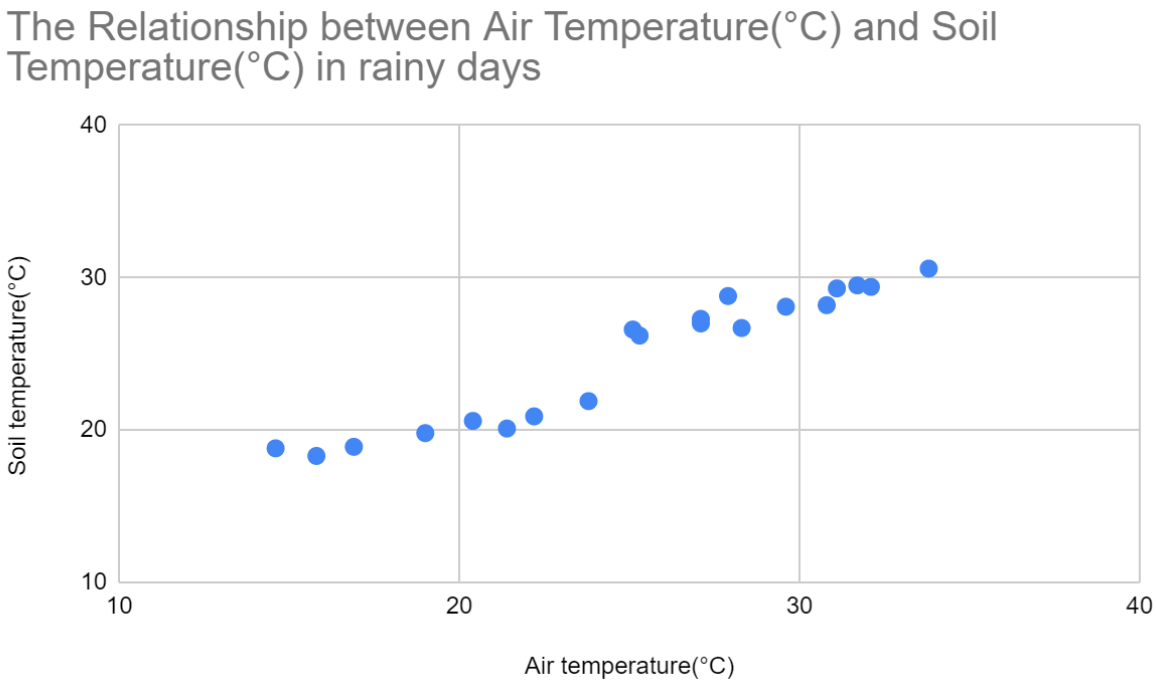


Correlation coefficient(Feb.)	AIR TEMPERATURE	SOIL TEMPERATURE
Globl Rad	**0.418**	0.089
Cloud Amount	0.140	0.198
Precp	**-0.613**	-0.147

(Relevant /Not Relevant)

This form tells us that:
[1] GloblRad was more relevant to air temperature than soil temperature, and it was positively correlated to both two temperatures.
[2] Cloud Amount seemed to be not relevant to both two temperatures because the absolute correlation coefficient values of two were less than 0.3.
[3] Precp was negative correlative to both temperatures. And the Precp was highly relevant to air temperature because the absolute value was higher than 0.3; however, the soil one wasn't, though.

We pick out rainy days(20 days in total) and discuss the relationship between air temperature, soil temperature, precp, and sunshine intensity.



Correlation coefficient:0.9623958793

Correlation coefficient comparison:

Correlation coefficient	AIR TEMPERATURE	SOIL TEMPERATURE
Precp	**0.335**	**0.385**
Globl Rad	**0.542**	**0.376**
Cloud Amount	**-0.530**	**-0.372**

(Relevant /Not Relevant)

This form tells us that:
[1]GloblRad was highly relevant to air and soil temperatures.
On top of that,GloblRad was positively correlated to both two temperatures.
[2]Cloud amount was negative correlative to both two temperatures, and cloud amount was more relevant to air temperature than soil temperature.

Month	8-9		10-11		12-1		2		rainy days
GloblRad	air	**0.779**	air	**0.537**	air	**0.537**	air	**0.542**	**0.542**
	soil	**0.623**	soil	**0.530**	soil	0.006	soil	0.090	**0.376**
Cloud Amount	air	**-0.568**	air	0.015	air	-0.250	air	0.140	**-0.530**
	soil	**-0.410**	soil	0.192	soil	-0.195	soil	0.198	**-0.372**
Precp	air	**-0.362**	air	0.152	air	-0.224	air	**-0.613**	**0.335**
	soil	-0.280	soil	0.192	soil	0.176	soil	-0.147	**0.385**
air and soil	**0.817**		**0.817**		**0.807**		**0.790**		**0.962**

(The data are correlation coefficient)

(Relevant /Not Relevant)

This form tells us that:

(1)From August to September or during rainy days, the factors were more relevant to temperatures.

(2)During any time, air and soil temperatures were highly relevant to each other.

Conclusion and Suggestions

1.The relationship between air and soil temperatures during weather rapid change:

(1)We found when soil temperature was lower than air temperature,there was typhoon or cold surge.And we inferred that the reason why soil temperature was higher than air temperature was that the weather rapidly changed.

2.The relationship between air and soil temperatures:

(1) The line chart of air and soil temperatures showed that air temperature was usually higher than soil one,though sometimes it was lower than soil one.

(2) The correlation coefficient value of air and soil temperatures were all higher than 0.3, which means they were highly positive correlative to each other.

(3) The highest air and soil temperatures were in August,and they all gradually dropped off as the winter was coming.

(4) In the line chart of air and soil temperature maximums, soil temperature was usually lower than air temperature

(5) In the line chart of air and soil temperature minimums,soil temperature was usually lower than air temperature.

(6) According to the above, though soil temperature was highly positive relevant to soil temperature,soil temperature was usually lower than air temperature.On top of that,even at the highest and lowest temperature of the day, soil temperature tended to be lower than air temperature. As a result, we can conclude that air temperature was lower than air temperature at most time.

3.How GloblRad(sunshine intensity) influenced air and soil temperatures?

(1) The line chart showed when the GloblRad was low ,the air and soil temperatures tended to drop off.

(2) According to the correlation coefficients of GloblRad,air and soil temperature,GloblRad was always highly positive relevant to air temperature,and air temperature was more relevant to GloblRad than soil one was.

(3) According to the above,we can conclude that GloblRad influences air temperature more than soil temperature.

4.How Cloud Amount influenced air and soil temperatures?

(1) The line chart showed that when Cloud Amount was high, air and soil temperatures tended to be low.

(2) According to the correlation coefficients of Cloud Amount, air and soil temperatures, the absolute values of air temperatures were all higher than soil temperatures, which means that Cloud Amount influences air temperature more than soil temperature.

5.How Precp influenced air and soil temperatures?

(1) The line chart showed when it rained, air and soil temperatures tended to dropped off

(2) According to the correlation coefficients of Precp, air and soil temperatures, we got to know that air temperatures' absolute values were usually higher than soil temperatures', which means that Precp influenced air temperatures more than soil temperatures.

6.How the factors (GloblRad, Cloud Amount, and Precp) influenced air and soil temperatures on rainy days?

(1) According to the correlation coefficients, we got to know that on rainy days, the factors (GloblRad, Cloud Amount, and Precp) were highly relevant to air and soil temperatures because the absolute correlation coefficient values were higher than 0.3.

According to the information above, air temperatures were highly relevant to soil temperatures; even though, soil temperatures were usually lower than air temperatures. On top of that, the other meteorological factors we chose to discussed also influenced air and soil temperatures, but as we delved into it, we found that the factors were more relevant to air temperatures than soil temperatures.

As a result, we can conclude that soil temperatures were more constant than air temperatures.

Future Work

Regardless of the highly relevance of air and soil temperatures, meteorological factors are less relevant to soil temperature than air temperature.
Thus, it’s proven that soil temperature is more constant than air temperature. And the Geothermal Heat Pump Plan is feasible in our school (Kaohsiung Municipal Girls’ Senior High School).