Observation of surface temperature at Kinmen Senior High School

Instructor

李育賢 LEE YU-HSIEN

Author

林河宏 Lin HO-HONG
郭家澤 Kuo CHIA-TSE
劉宇和 LIU YU-HE
陳上友 CHEN SHANG-YU
鄭榮杰 ZHENG RONG-JIE

Summary

1. Research background：During summer training, we found that there was a significant difference between the surface temperature of the PU track and the air temperature, which aroused concern about the change of surface temperature. Especially for track and field school team athletes, long-term exposure to high temperature environments may affect training and health.

2. Research Objectives： In order to understand the difference between surface temperature and air temperature more objectively, we plan to conduct systematic data observations to explore the impact of different times, weather conditions and surface materials on surface temperature, and analyze the main reasons for the temperature difference.

3. Research methods：PU track, grass and cement ground were selected as experimental samples, the surface temperature and air temperature of various materials were measured in various climates, and the relevant environmental parameters were recorded. Use data analysis tools to compare temperature characteristics under surface materials and weather conditions.

4. Results of the study：Preliminary results show that the surface temperature of the red PU track is the highest on sunny days, with a difference of more than 15°C from the air temperature, while the temperature difference of the grass track is relatively small. On cloudy days, the temperature difference between the three types of land surface decreases significantly, indicating that weather conditions have a significant impact on the temperature difference.

5. Conclusion and application： The strong heat storage capacity of red PU track in high temperature on sunny days is the main reason, and the reflectivity and thermal conductivity characteristics of other materials are also affected. The results of this study can provide a reference for track and field athletes to choose training time and venue, and help to improve the design of the sports environment.

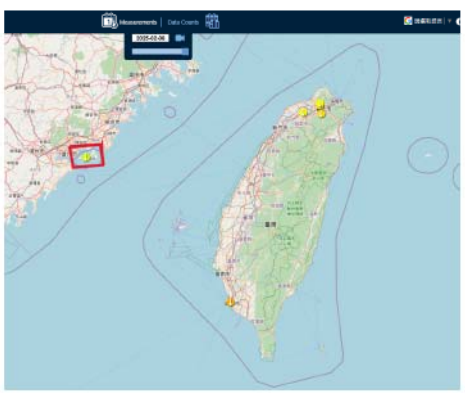
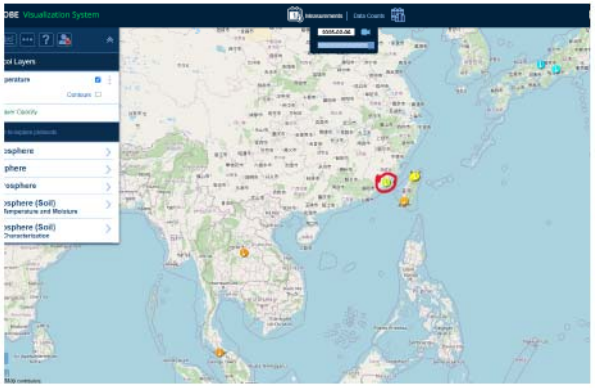
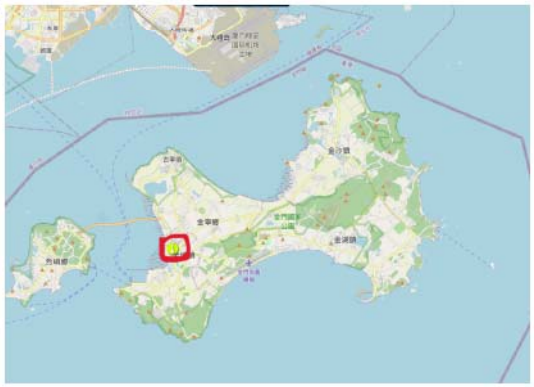
Research purpose and motivation

During summer practice, we found that the surface temperature of the PU track was significantly different from the air temperature at that time, which raised our curiosity about the changes in surface temperature. Four of the five members in our group are school team athletes and have been training in high-temperature environments for a long time, so they are particularly sensitive to this phenomenon. In order to understand this temperature difference more objectively, we decided to do systematic data measurements to observe the effects of different times, weather conditions and surface materials on temperature. Find the causes of temperature differences through measurement and analysis.

School location

Located on the eastern side of Asia. Kinmen is an outlying island to the west of Taiwan and bordered by the southeast coast of China to the west.

Kinmen is surrounded by the sea on all sides, belongs to the mainland island, the vegetation covers less, so the wind is strong, it is located in the strait, the spring and summer communication is often foggy because of the retention front, the terrain is mainly hilly, it is not easy to retain water vapor, the annual rainfall is less than the evaporation, and the land is mostly laterite.


Kinmen Senior High School is in the directly west of Kinmen Island, next to an important town

This is the campus of Kinmen Senior High School

The observation location is on the grass in front of the teaching building on the west side of the school, and the field on the west side.

(A)(B)Concrete floor (C)(D)Grass

(E)Pool

(F)Metal sheet

(G)(H)Green PU running track

(I)(J)Red PU running track

(K)metal flagpole

Research methods

Every Wednesday at noon, measure the day's weather, temperature, and humidity at the same location, along with the surface temperatures of different materials under sunlight and in the shade. Calculate the temperature difference and organize the data with daily photos and temperature comparisons.

Experimental equipment

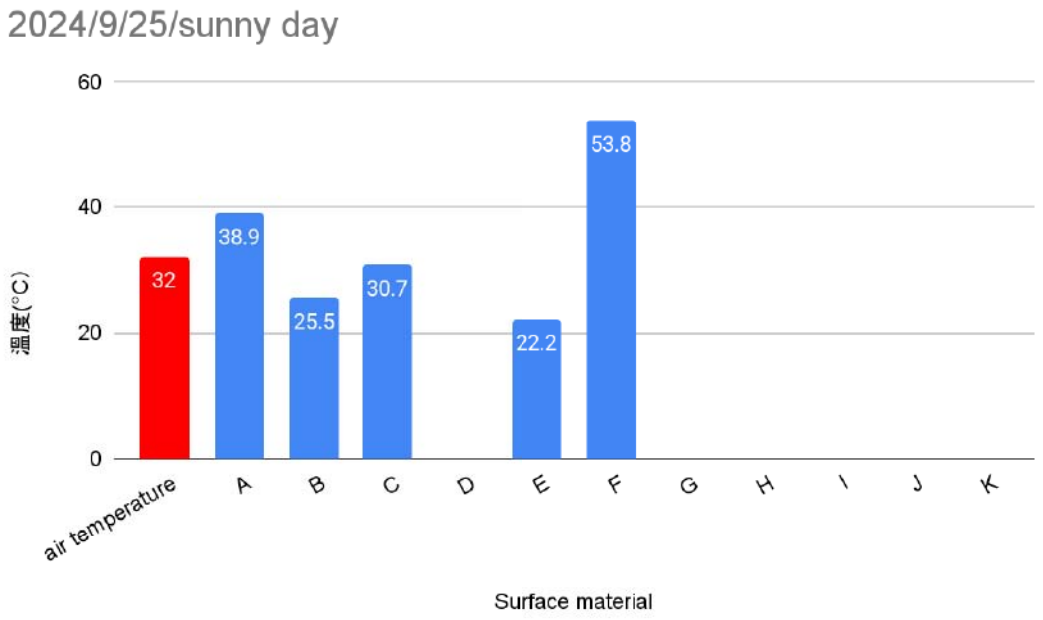
laser thermometers ,notebook and phone

Experimental results

(Observation record)

Day1：2024.9.25　　Weather： Sunny　　Air temperature：27°C

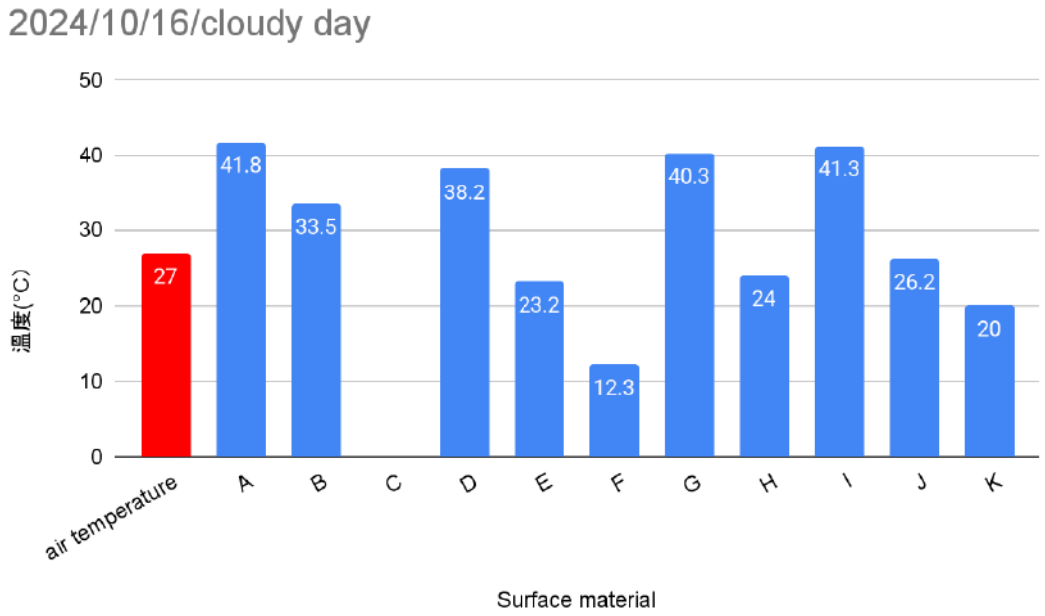
A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
38.9	25.5	30.7	unmeasured	22.2	53.8	unmeasured	unmeasured	unmeasured	unmeasured	unmeasured



Learning content：Learning how to use the Temperature gun

Day2：2024.10.16　　Weather： Cloudy　　Air temperature：27°C

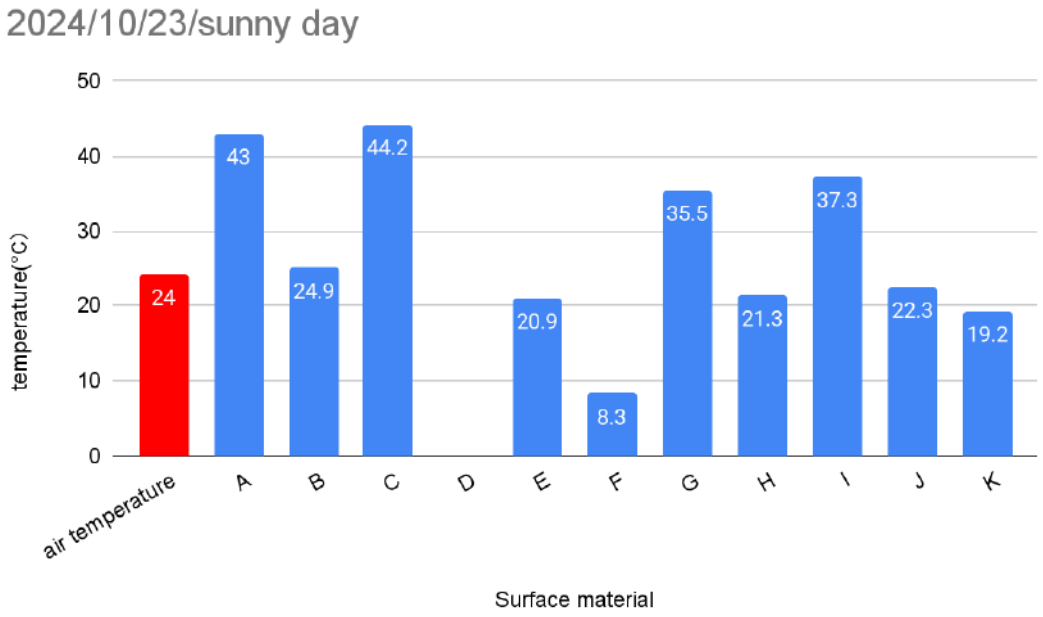
A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
41.8	33.5	unmeasured	38.2	23.2	12.3	40.3	24	41.3	26.2	20



Learning content：Add more locations for observation and try changes in different materials and temperatures.

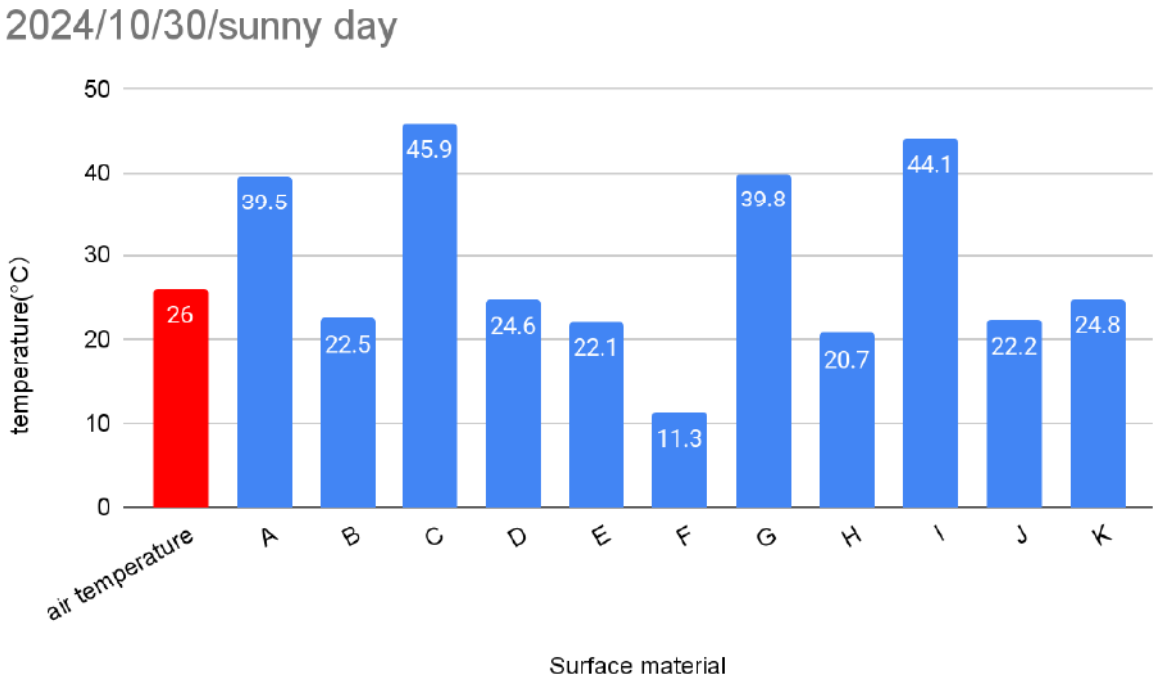
Day3：2024.10.23　Weather：Sunny　　Air temperature：24°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
43	24.9	44.2	unmeasured	20.9	8.3	35.5	21.3	37.3	22.3	19.2



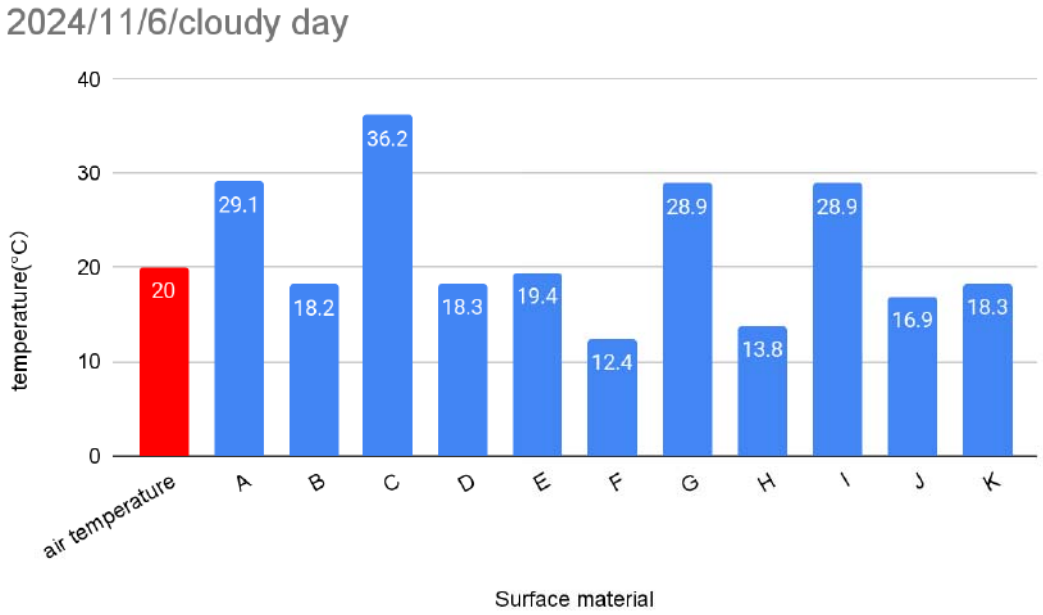
Day4：2024.10.30　　Weather：Sunny　　Air temperature：26°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
39.5	22.5	45.9	24.6	22.1	11.3	39.8	20.7	44.1	22.2	24.8



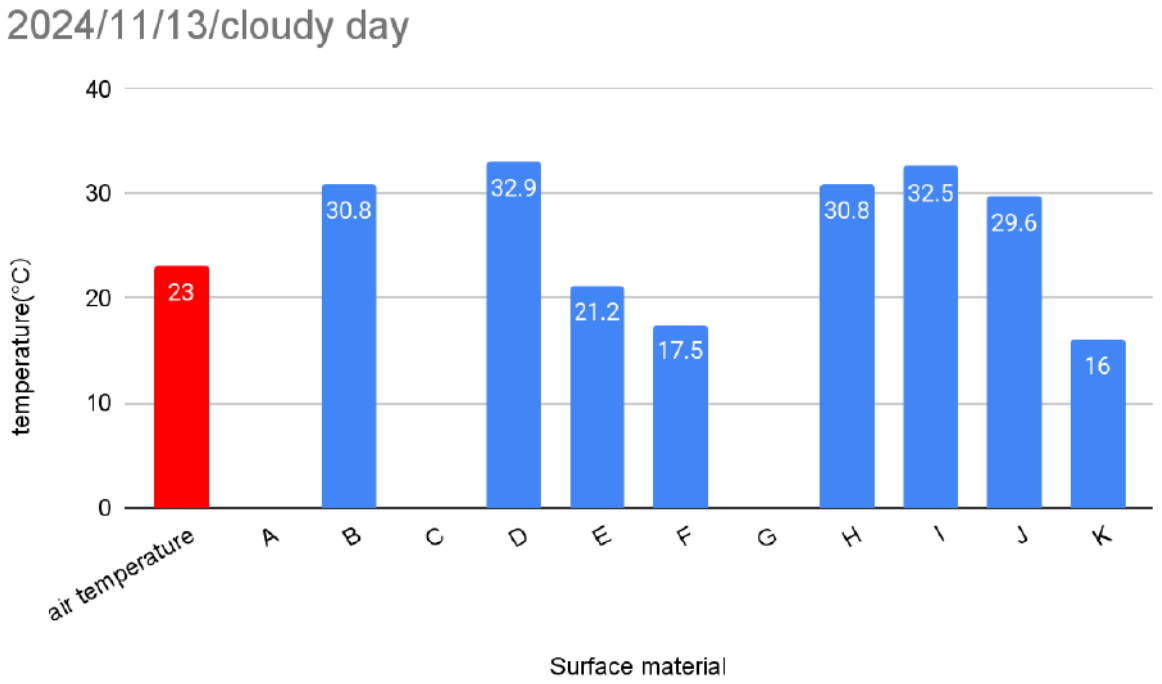
Day5：2024.11.6　　Weather：Cloudy　　Air temperature：20°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
29.1	18.2	36.2	18.3	19.4	12.4	28.9	13.8	28.9	16.9	18.3



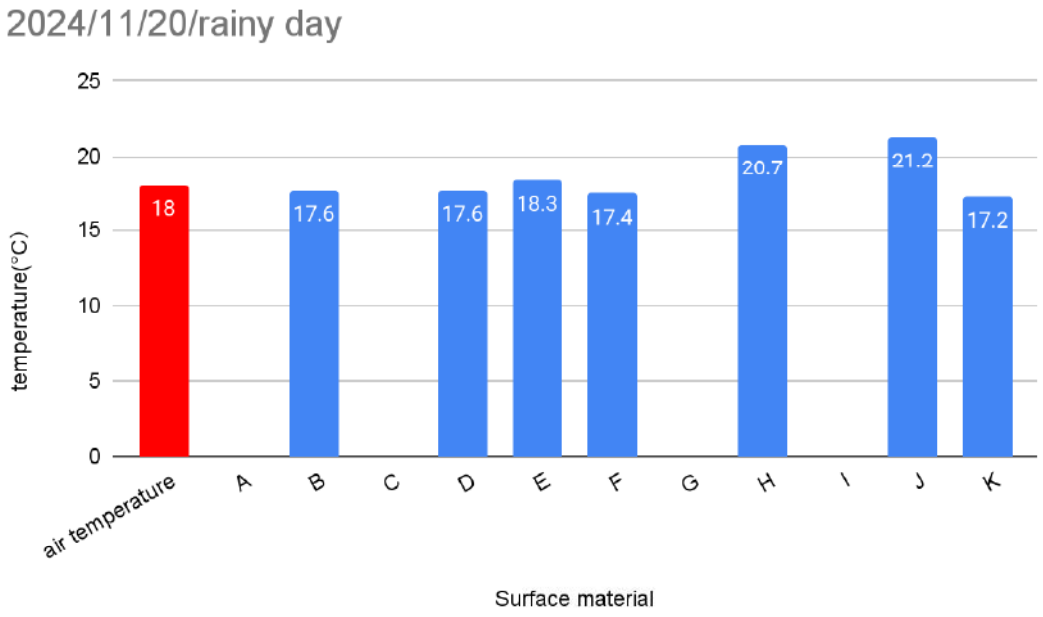
Day6：2024.11.13　　Weather：Cloudy day　　Air temperature：23°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
unmeasured	30.8	unmeasured	32.9	21.2	17.5	unmeasured	30.8	32.5	29.6	16



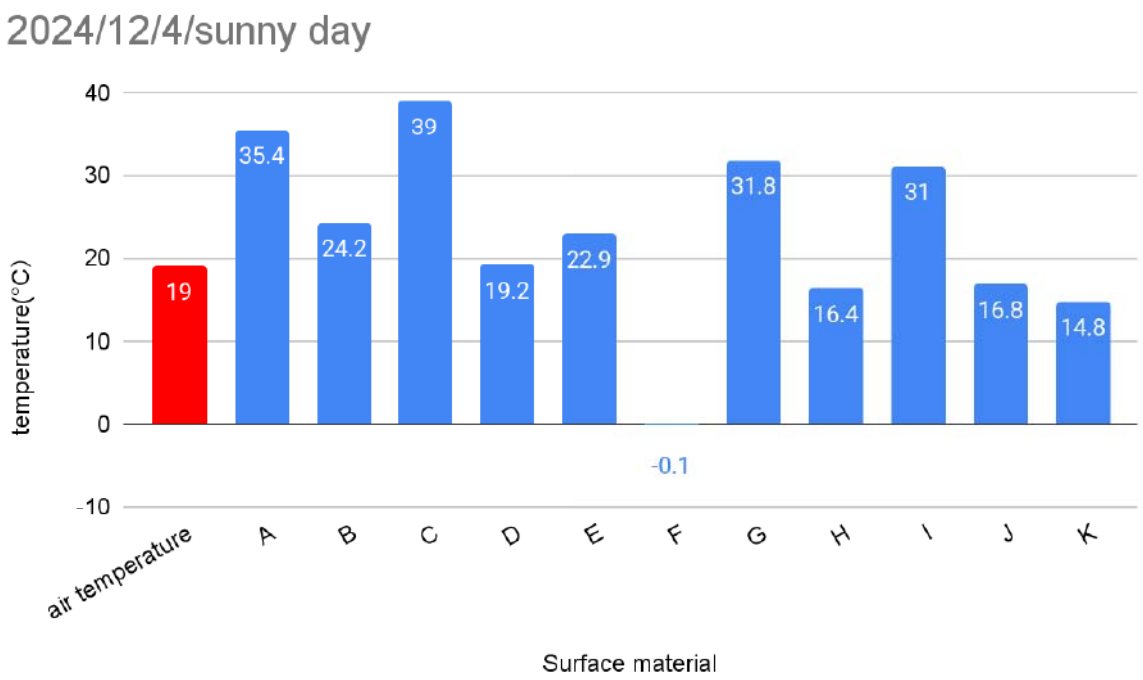
Day7：2024.11.20　　Weather：Rainy　　Air temperature：18°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
unmeasured	17.6	unmeasured	17.6	18.3	17.4	unmeasured	20.7	unmeasured	21.2	17.2



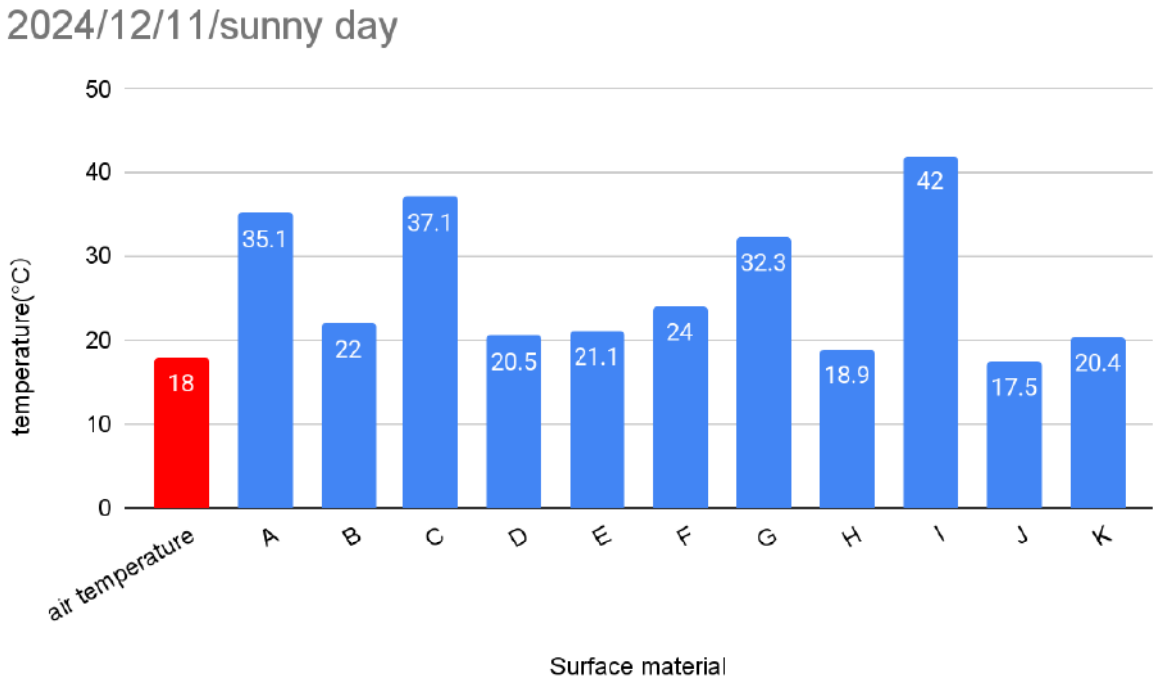
Day8：2024.12.4　　Weather：Sunny　　Air temperature：19°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
35.4	24.2	39	19.2	22.9	-0.1	31.8	16.4	31	16.8	14.8



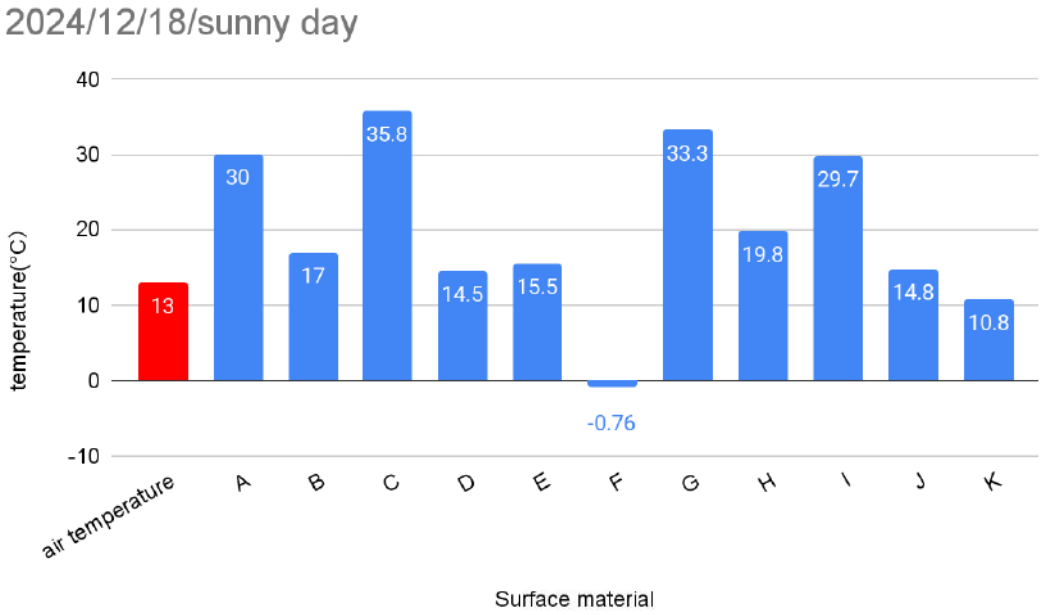
Day9：2024.12.11　　Weather：Sunny　　Air temperature：18°C

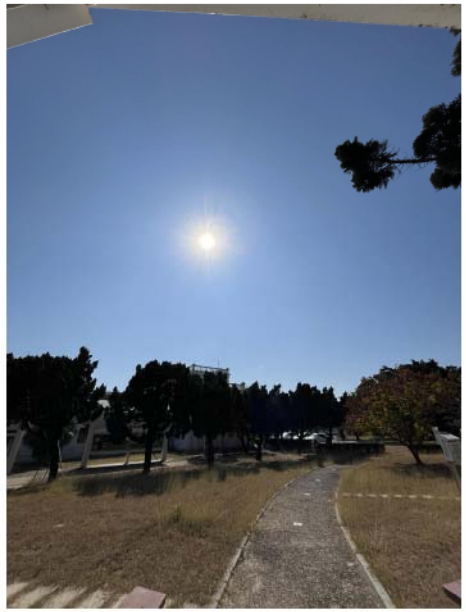
A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
35.1	22	37.1	20.5	21.1	24	32.3	18.9	42	17.5	20.4



Day10：2024.12.18　　Weather： Cloudy　　Air temperature：13°C

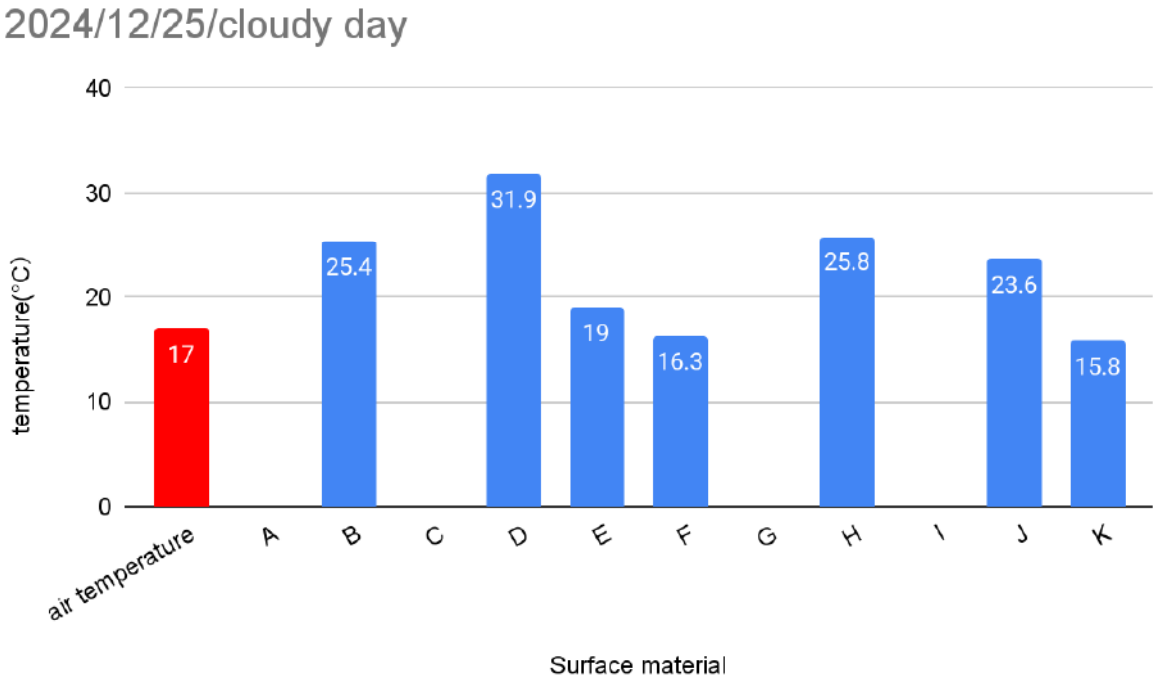
A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
30	17	35.8	14.5	15.5	-0.76	33.3	19.8	29.7	14.8	10.8





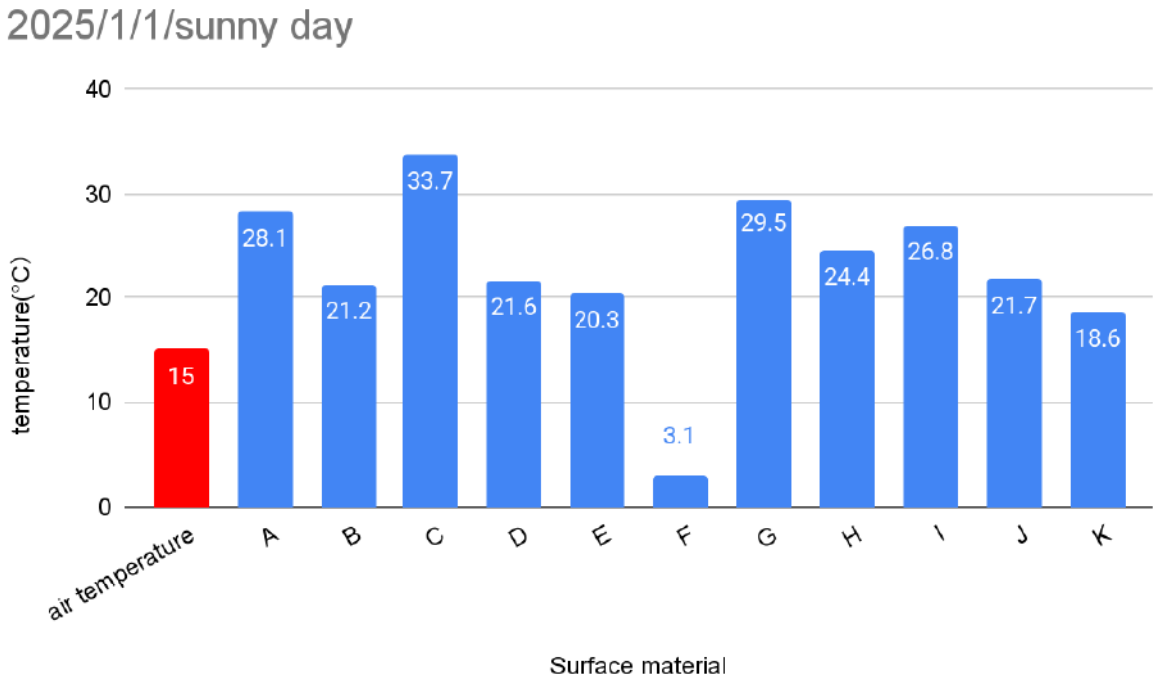
Day11：2024.12.25　　Weather：Cloudy　　temperature：17°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
unmeasured	25.4	unmeasured	31.9	19	16.3	unmeasured	25.8	unmeasured	23.6	15.8



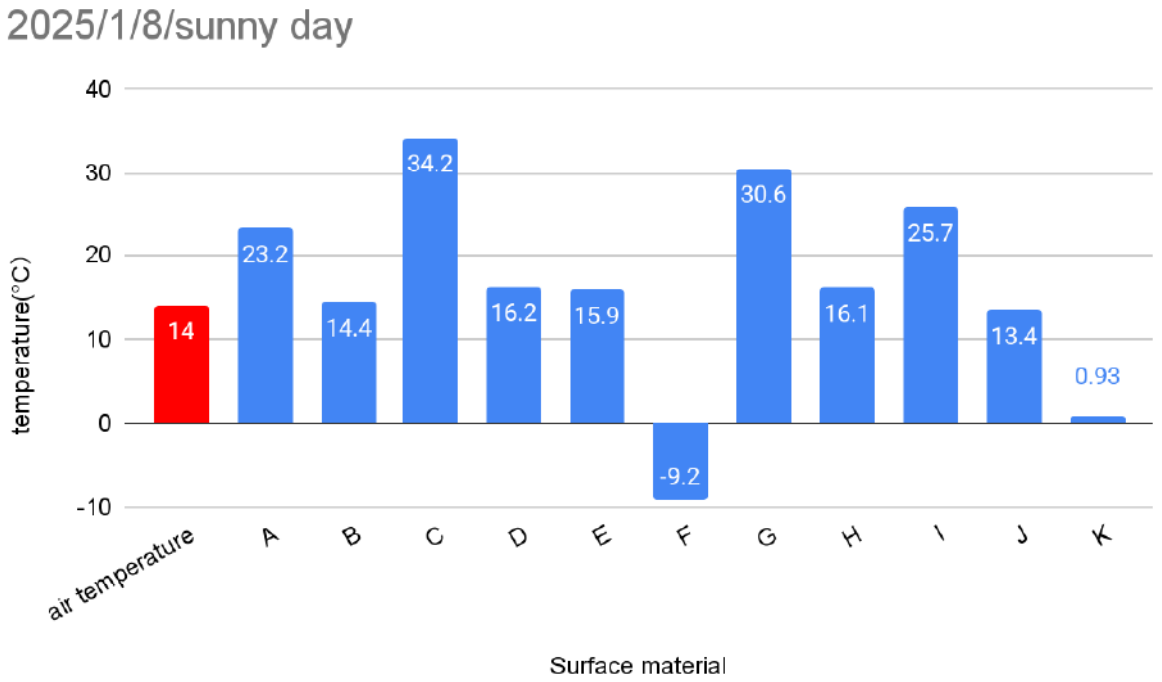
Day12：2025.1.1　　Weather：Sunny　　Air temperature：15°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
28.1	21.2	33.7	21.6	20.3	3.1	29.5	24.4	26.8	21.7	18.6



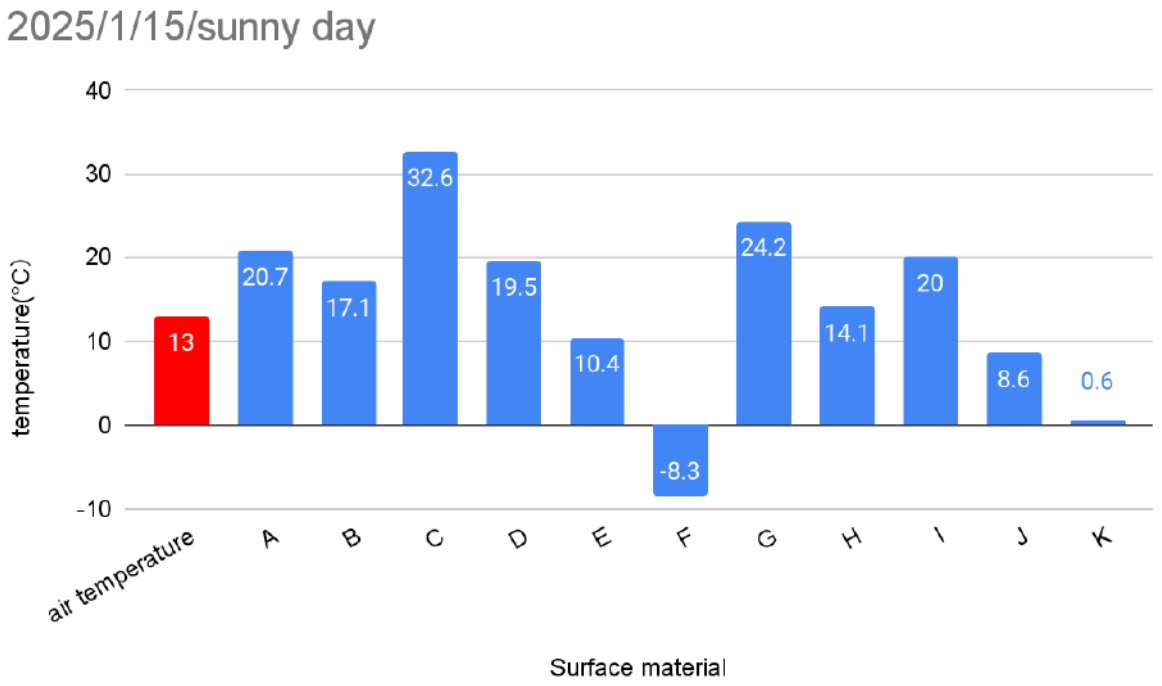
Day13：2025.1.8　　Weather：Sunny　　Air temperature：14°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
23.2	14.4	34.2	16.2	15.9	-9.2	30.6	16.1	25.7	13.4	0.93



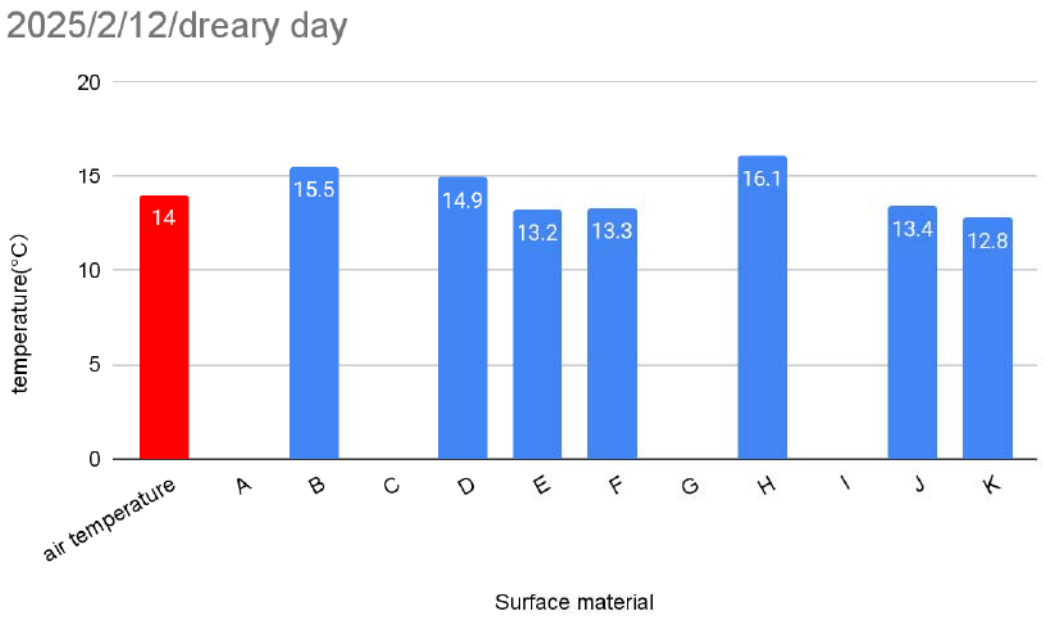
Day14：2025.1.15　　Weather：Sunny　　Air temperature：13°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
20.7	17.1	32.6	19.5	10.4	-8.3	24.2	14.1	20	8.6	0.6



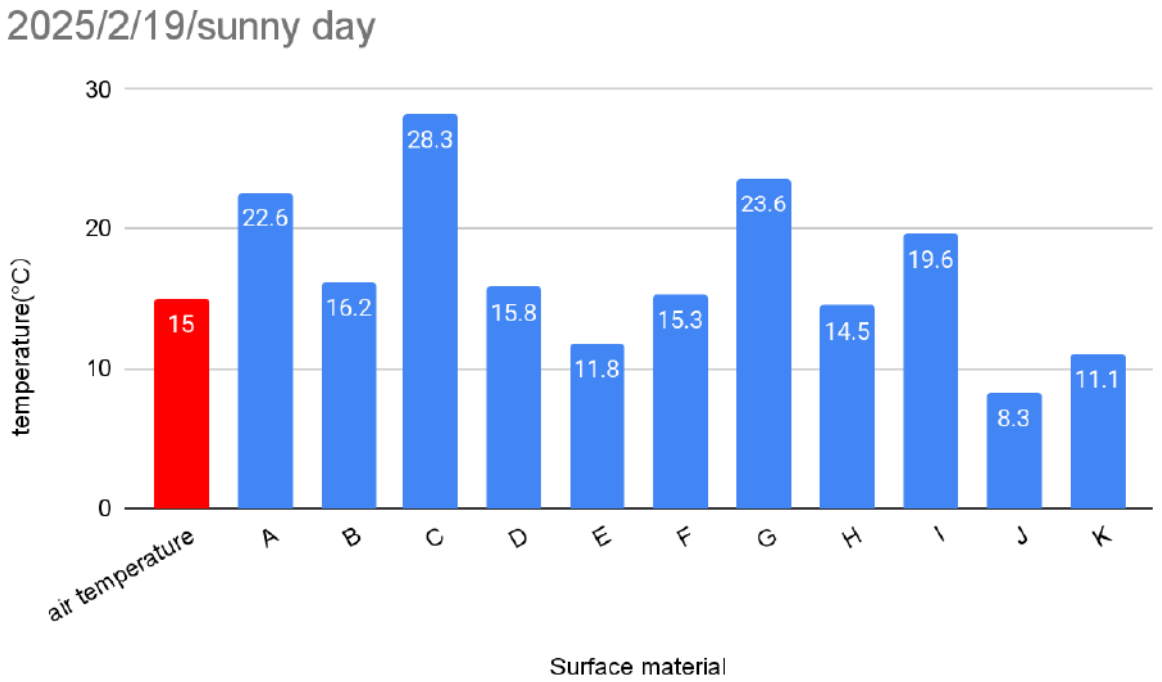
Day15：2025.2.12　　Weather：Rainy　　Air temperature：14°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
unmeasured	15.5	unmeasured	14.9	13.2	13.3	unmeasured	16.1	unmeasured	13.4	12.8



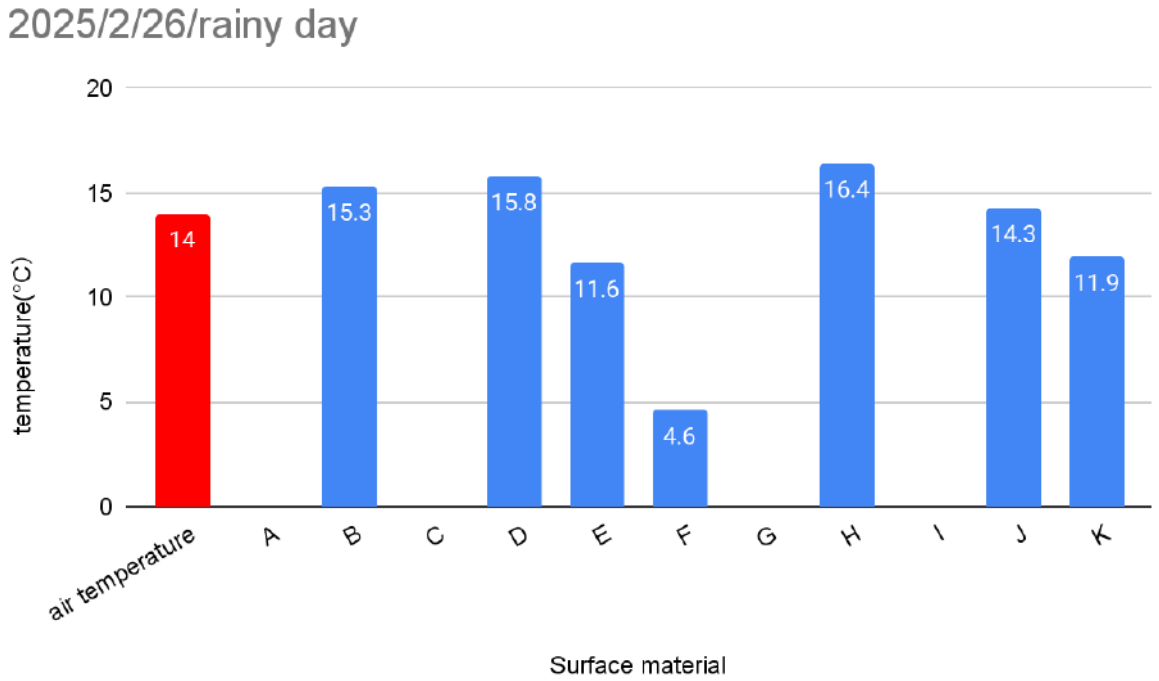
Day16：2025.2.19　　Weather： Sunny　　Air temperature：15°C

A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
22.6	16.2	28.3	15.8	11.8	15.3	23.6	14.5	19.6	8.3	11.1

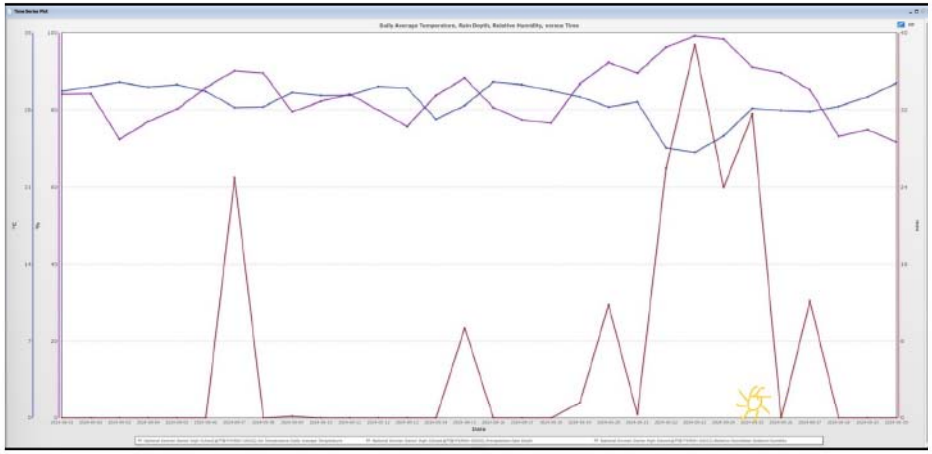


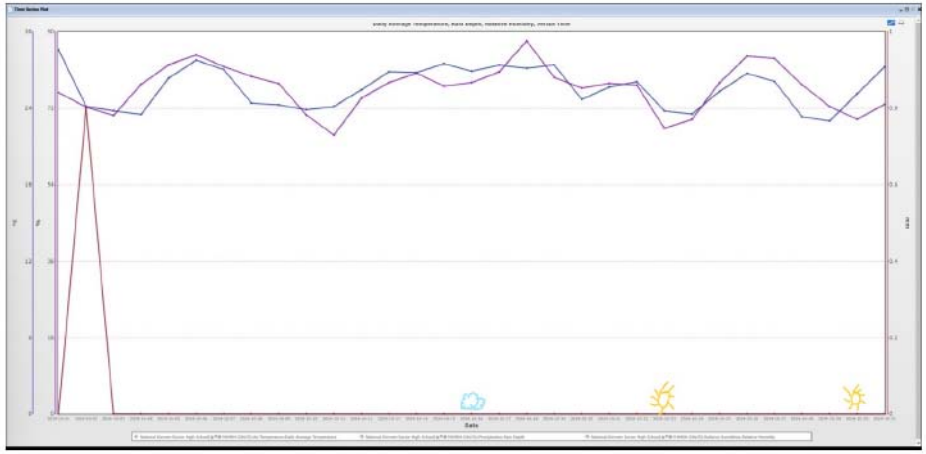
Day17：2025.2.26　　Weather：Rainy　　Air temperature：14°C

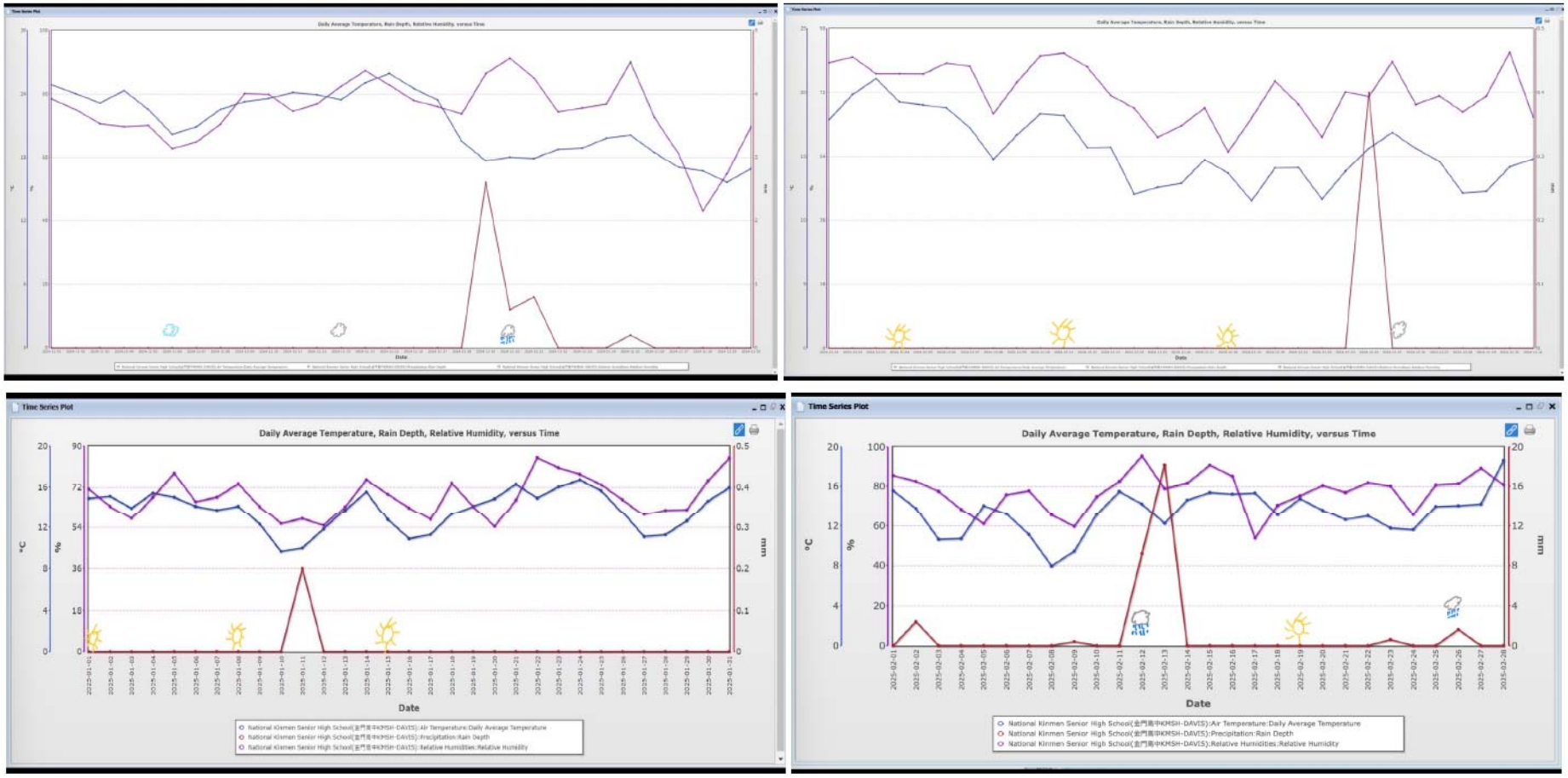
A	B	C	D	E	F	G	H	I	J	K
Concrete floor(exposed to sunlight)	Concrete floor(in the shade)	Grass(exposed to sunlight)	Grass(in the shade)	Pool	Metal sheet	Green PU running track(exposed to sunlight)	Green PU running track(in the shade)	Red PU running track(exposed to sunlight)	Red PU running track(in the shade)	metal flagpole
unmeasured	15.3	unmeasured	15.8	11.6	4.6	unmeasured	16.4	unmeasured	14.3	11.9




晴天 Sunny
雨天 Rainy
陰天 Overcast
多雲 Cloudy

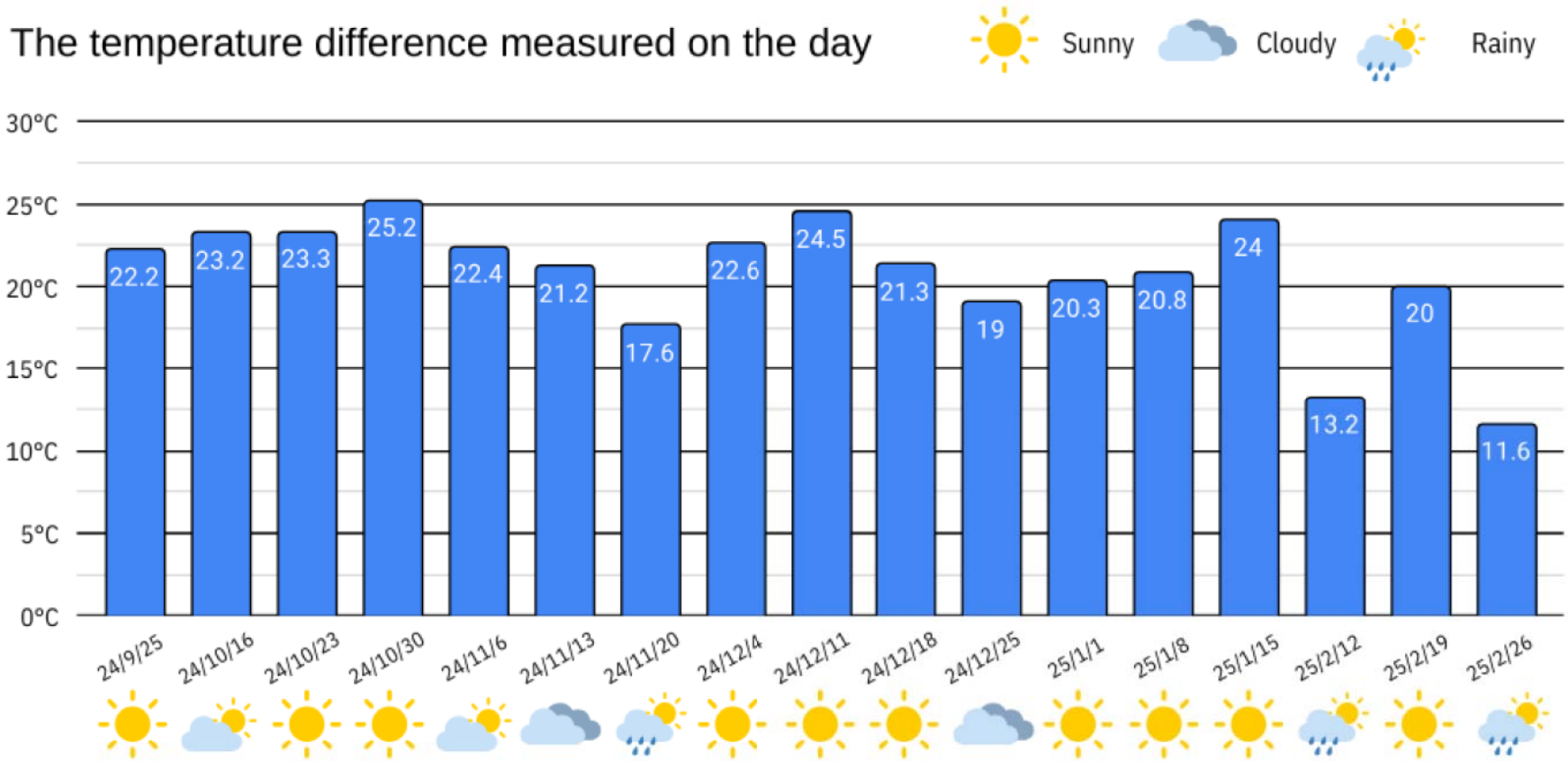






We asked the teacher to retrieve data from the automated weather station at Kinmen High School, including temperature, humidity, and rainfall, and then mark the dates we observed with a graphical representation.

Discuss


The temperature difference measured on the day
Sunny
Cloudy
Rainy
30°C
25°C
20°C
15°C
10°C
5°C
0°C
22.2
23.2
23.3
25.2
22.4
21.2
17.6
22.6
24.5
21.3
19
20.3
20.8
24
13.2
20
11.6
24/9/25
24/10/16
24/10/23
24/10/30
24/11/6
24/11/13
24/11/20
24/12/4
24/12/11
24/12/18
24/12/25
25/1/1
25/1/8
25/1/15
25/2/12
25/2/19
25/2/26

Based on the chart and measurement methods, We can find that the temperature difference between different materials measured by the :laser thermometers varies significantly in different weather conditions. The data shows that the three smallest temperature differences recorded on the day occurred during rainy weather. This could be attributed to environmental conditions on rainy days, such as thicker cloud cover and higher humidity, which result in less variation in surface temperatures across different materials, thereby reducing the measured temperature differences.

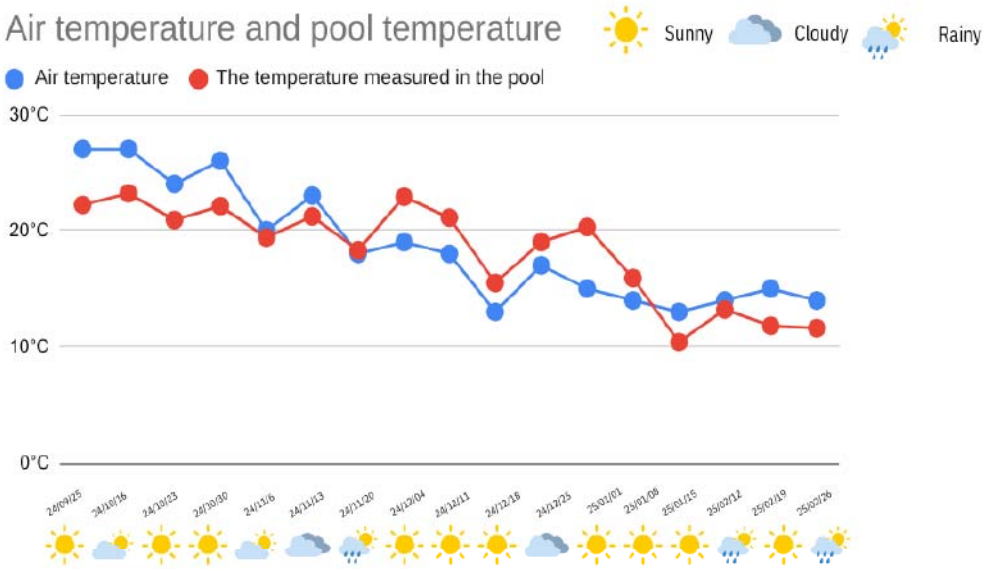
In addition, temperature differences on cloudy days were also relatively small, while sunny days exhibited the largest temperature differences. This could be because, on sunny days, direct sunlight causes greater discrepancies in the heat absorption and dissipation capacities of different materials, leading to more pronounced temperature variations measured by the infrared thermometer. On cloudy or rainy days, weaker sunlight reduces surface temperature changes across materials, resulting in smaller measured differences.

From this data, it can be inferred that weather conditions significantly affect the surface temperatures of different materials. In particular, on sunny days, the heat absorption and dissipation characteristics of various materials increase the temperature differences, while on cloudy and rainy days, environmental factors minimize these differences. These findings are valuable for understanding the thermal conductivity properties of materials under different climatic conditions.

Further analysis reveals notable differences in the temperature responses of various ground materials in high-temperature environments. For instance, the PU track, due to its heat retention capacity and low reflectivity, has a surface temperature significantly higher than the ambient temperature during sunny midday. In contrast, grass and concrete surfaces exhibit relatively smaller temperature differences. The high-temperature characteristics of PU tracks may impact the safety and performance of athletes during training. Therefore, it is recommended that athletes avoid prolonged training on PU tracks during high-temperature periods and consider alternative surfaces such as grass or other cooler materials.

This study provides a reference for the design of sports venues. Future research could explore optimized ground material designs to enhance the comfort and safety of sports environments, thereby better protecting athletes' health and performance.

- We found that air temperature affects the pool.



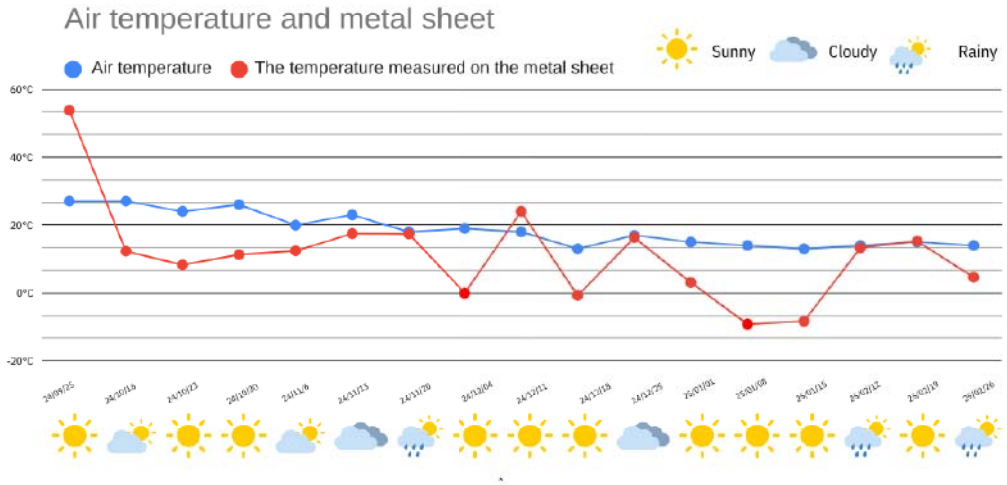
The chart shows a certain correlation between pool temperature and air temperature, but the changes in pool temperature are smaller in magnitude and exhibit a lag effect. On sunny days, air temperature is relatively high, while pool temperature remains stable, indicating that water has a high specific heat capacity, which slows both the heating and cooling processes.

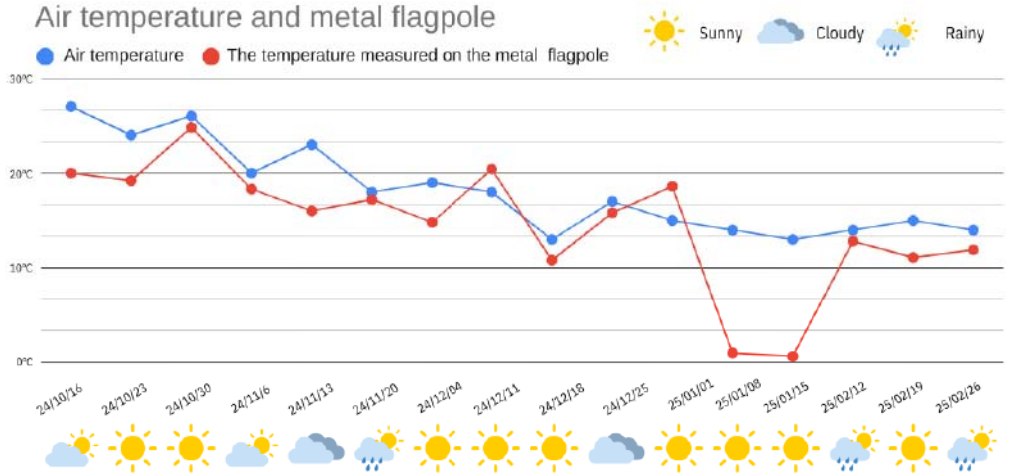
During sunny periods, air temperature typically rises, and pool temperature gradually follows suit. However, after cloudy or rainy weather, air temperature drops more rapidly, while pool temperature decreases more moderately, demonstrating a lagging cooling effect. This may be because the pool absorbs a significant amount of heat, allowing it to maintain a relatively stable temperature even as air temperature declines. Additionally, consecutive sunny days can accumulate heat, sustaining higher pool temperatures in the short term, whereas cloudy or rainy weather reduces sunlight and increases precipitation, leading to a more noticeable drop in pool temperature.

Overall, pool temperature is primarily influenced by air temperature, but weather conditions (such as sunlight and precipitation) also affect its variation trends.

Long-term observation of the interaction between these factors can help improve the accuracy of pool temperature predictions.

- Metal surfaces such as metal sheet and flagpoles conduct heat quickly, which may result in uneven surface temperatures. Additionally, their reflective properties can affect the accuracy of temperature measurements taken with an infrared thermometer.





Our measurement of metallic materials was initially driven by curiosity. Based on common understanding, metals have a relatively low specific heat capacity. Thus, we anticipated larger temperature fluctuations during measurements. However, the data did not align with our expectations. We found that on sunny days, the temperature readings of metal plates were less stable, while the temperature changes of metal flagpoles were relatively smaller. This phenomenon could be attributed to the reflective properties of metal surfaces. The smoother surface of metal panels exhibits strong sunlight absorption and reflection capabilities. Under intense sunlight, the surface temperature may rise rapidly due to the absorption of radiant heat, causing infrared thermometers to record readings higher than the actual ambient temperature.

On cloudy or rainy days, or in low-temperature conditions, the measured temperature of metal plates was sometimes lower than the ambient air temperature. This could be due to the rapid heat dissipation properties of metal surfaces. These findings suggest that infrared thermometers may produce significant measurement errors on metallic surfaces under varying weather conditions.

Infrared thermometers are highly susceptible to the material properties of the object being measured, especially when measuring metal surfaces. The readings are often influenced by environmental lighting. For instance, metal temperatures measured under strong sunlight tend to be overestimated, whereas measurements in low-temperature or cloudy conditions are often underestimated.

In conclusion, when using infrared thermometers to measure metal temperatures, factors such as material, environmental conditions, and reflectivity can introduce errors. For high-reflectivity metals in particular, it is essential to account for these factors and make appropriate adjustments. Alternatively, using contact-based temperature measurement devices, such as thermocouples, to directly measure the surface temperature of metals may provide more accurate results than relying on infrared thermometers.

Conclusion

Preliminary results indicate that the red PU track surface reaches the highest temperature on sunny days, with a temperature difference exceeding 15°C compared to the ambient air temperature. In contrast, the temperature difference for grass surfaces is relatively smaller but still higher than expected under direct sunlight. On cloudy days, the temperature differences among the three surface types decrease significantly, demonstrating that weather conditions have a notable impact on temperature variations. Therefore, temperature differences can be used as a preliminary indicator to assess the weather conditions.

Bibliography

GLOBE visualize data

https://vis.globe.gov/GLOBE/