Trees Measurement, Exploring the Connection between Sunshine and Foliage Varies

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Teacher

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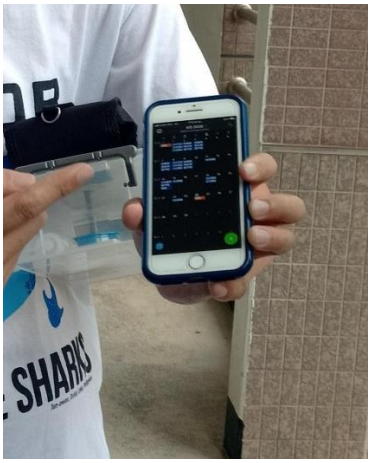
Our Team

National Kinmen Senior High School Taiwan Partnership

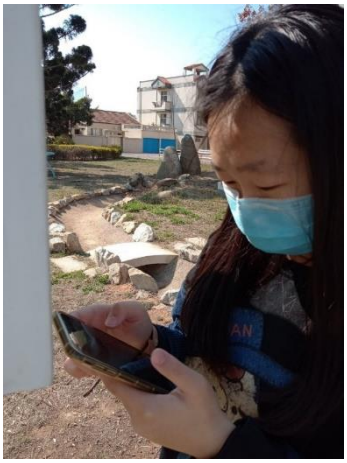
Our Team Photos

The first time our teacher train us



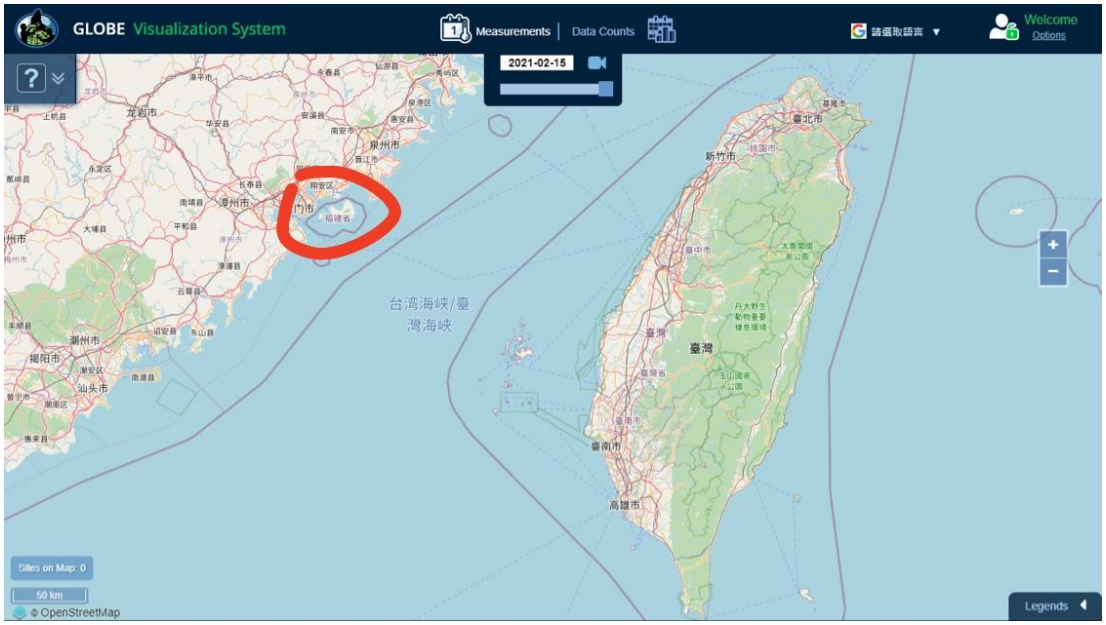
Teacher showed us how, and using what app to do Observations and Record it anytime

Doing Observe

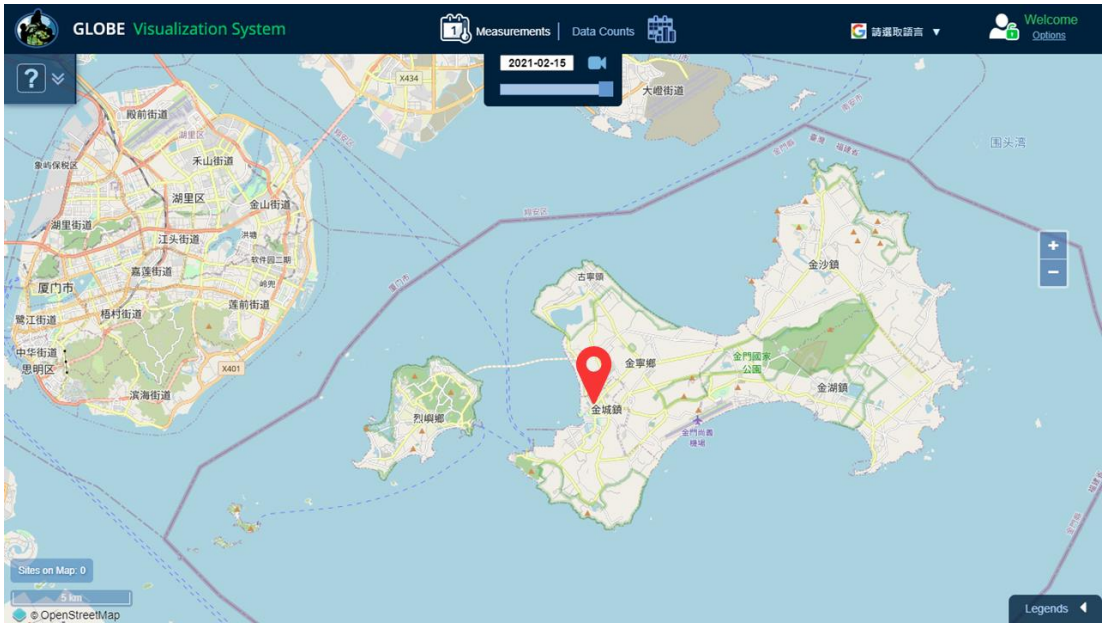


Abstract

The Position of Kinmen



The Position of KMSH (Our School)



One day, when one of our team members walked past the trees in front of a building in school, she immediately noticed the foliage on the tree looked different than before. And our teachers told us it might because of the different directions or angles of the sun shines on the tree.

After that, we confirmed the species of that tree（Pistacia chinensis）. And found the colors of its foliage would change by season to season. We found the phenomenon very interesting, and it led to us decided to investigate into it, hoping to learn more about this situation.

So, this study will be completed by us doing collation of the meteorological data which is collected by our school. We will introduce the weather variations of Kinmen first, then start to explore our interesting observed result of the Pistacia tree discoloration in school.

School Introduction

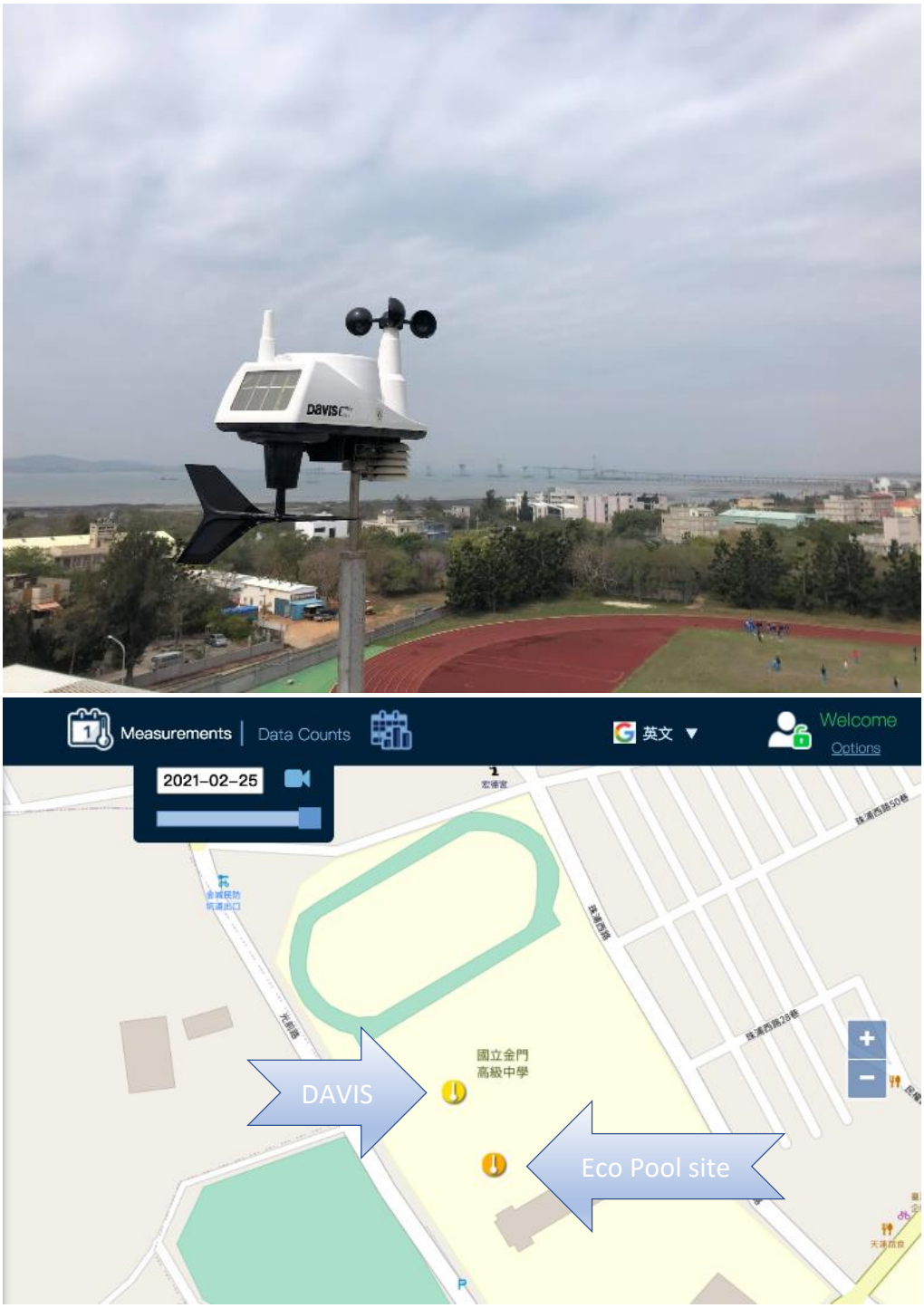
Kinmen, where we live, is an island which is surrounded by sea, has a special geographical location, and lacks water. Here, rainfall and air temperature will change by season. Overall, the precipitation here is basically low throughout every year.

Because of the dramatic climate change, Kinmen also attracts some certain kinds of birds to come to reproduce or to get through winter.

In Kinmen, you can see a variety of ecology.

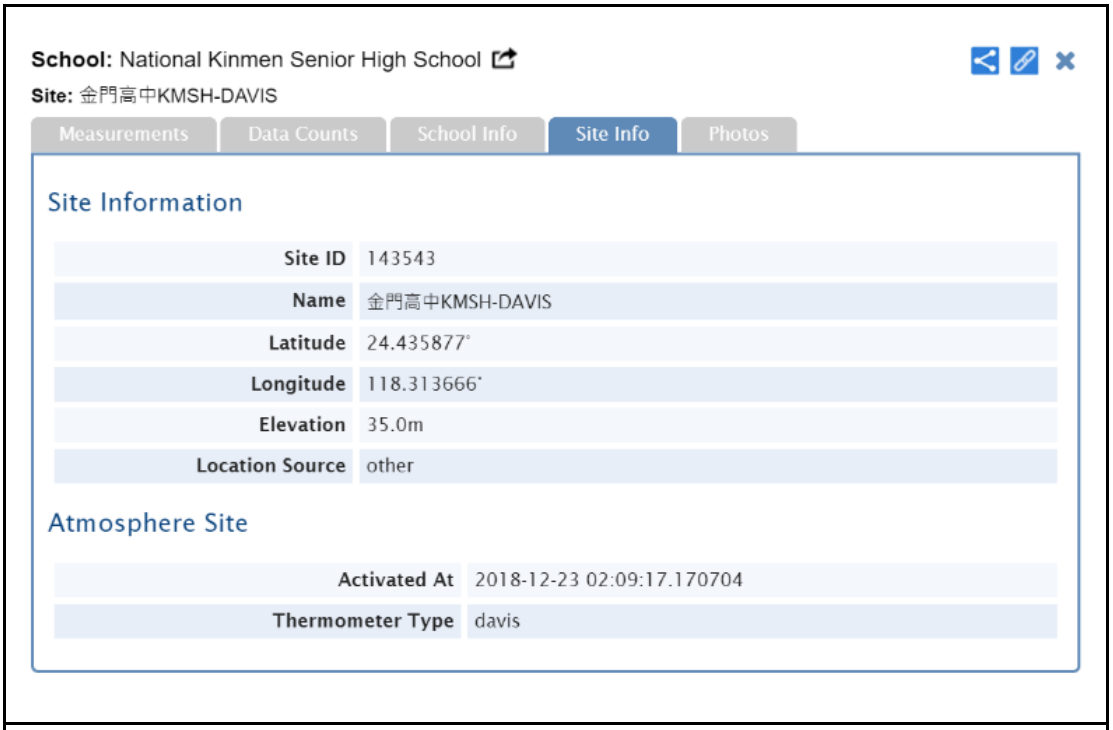
Our school, KMSH (Kinmen Senior High School) is located west of Kinmen Island, longitude and latitude is about (120°,24°). Compared to Taiwan, the cold & hot days here are easier to distinguish. Summer is hotter and wetter while winter is colder and drier here.

Two Data Stations in Our School

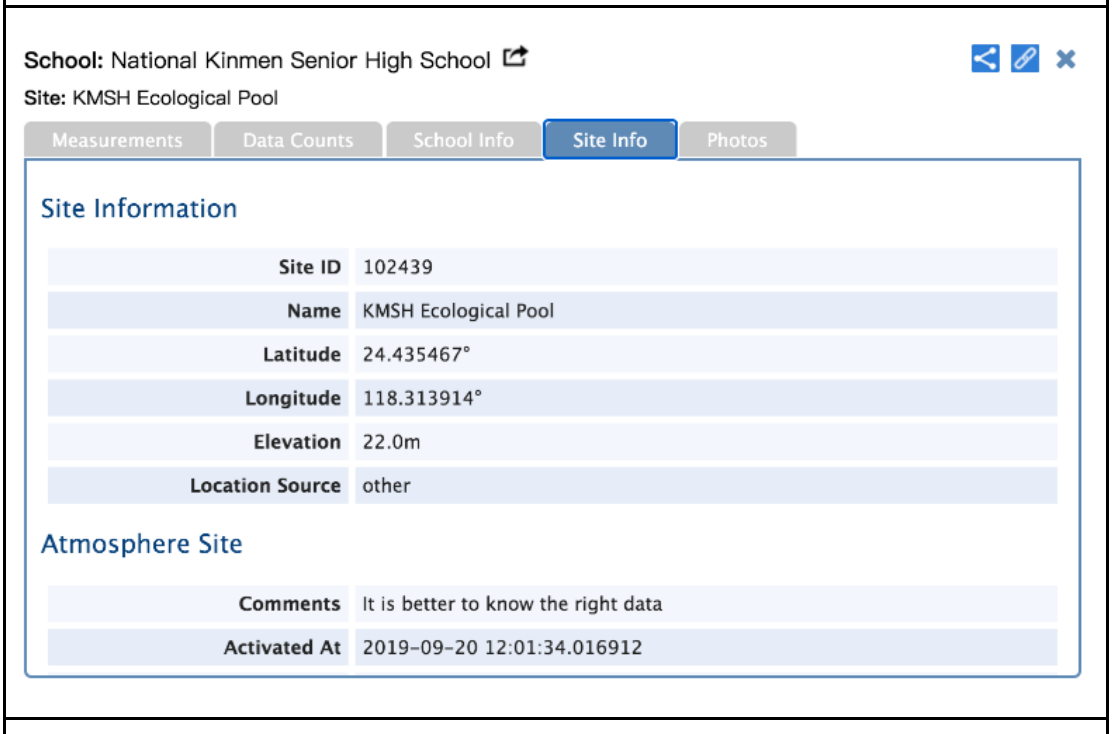


There are two observation stations in our school.

The upward picture is our GLOBE DAVIS automatic meteorological observation station, it is located in the yellow sign on the downward picture, and the orange one is our instrument shelter site.



DAVIS site



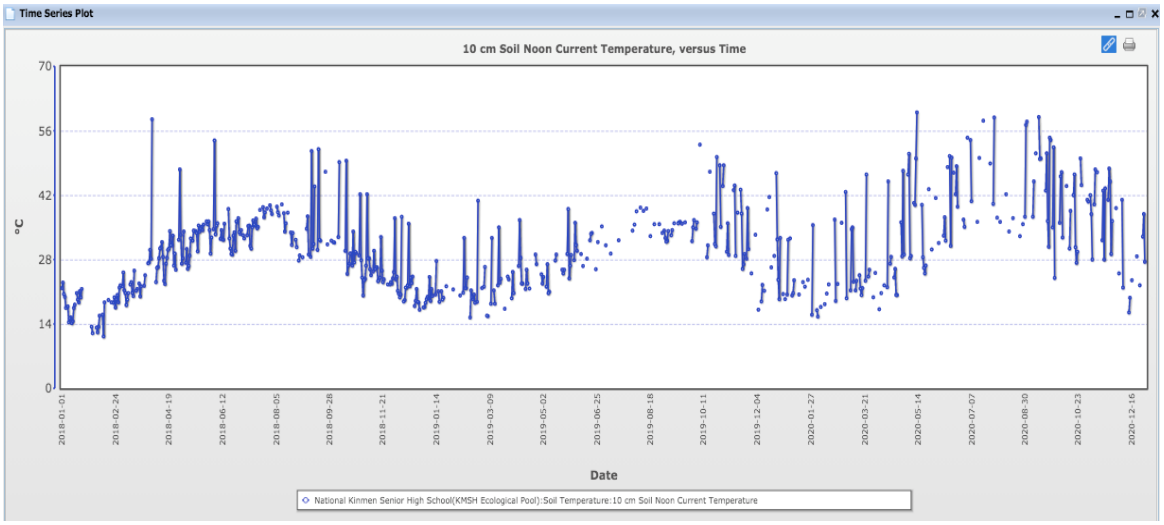
Instrument shelter site

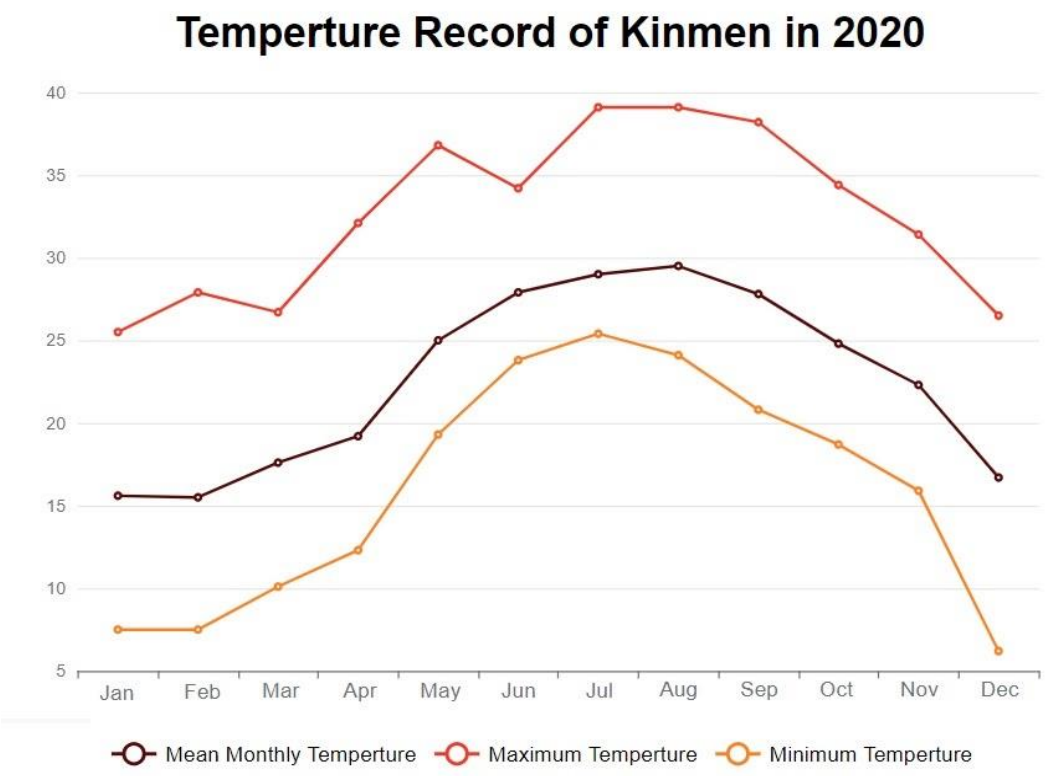
The meteorological data collected by GLOBE DAVIS automatic meteorological observation station on the top floor of the science building in our school will be uploaded to GLOBE website periodically.

One's position is higher and produces meteorological data every day. The other one is near our mesocosm, as contract using, and it is also for the meteorologist-observation volunteers of KMSH doing Data Entry regularly.

School Soil and Air Temperature Records

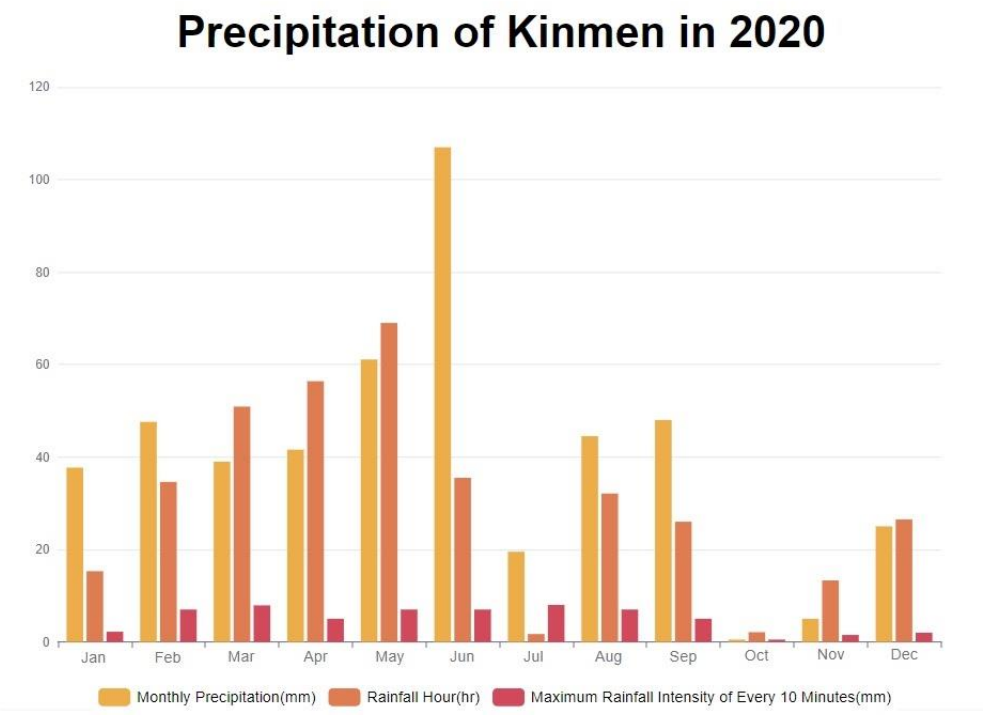
Our school GLOBE Records from 2018-2020（Soil Temperature 10cm）





The above two temperature records (The upward one is from GLOBE data bank, and downward one is the temperature data compiled by Taiwan's climate CWB Observation Data Inquire System for 2020) indicated the climate in Kinmen is hot in summer and cold in winter.

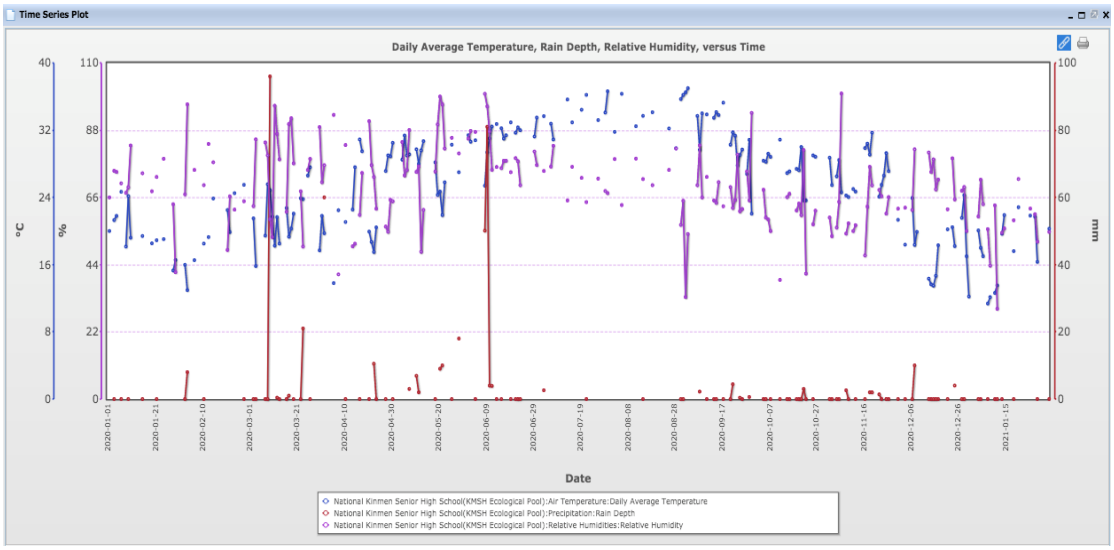
From 2018 to 2020, the highest monthly average temperatures are in August, while the lowest monthly average temperatures are in February. And the four seasons are distinct, that means we can see the seasons' varies obviously by the weather characteristics they have.



Picture above is a histogram of rainfall-related data in 2020

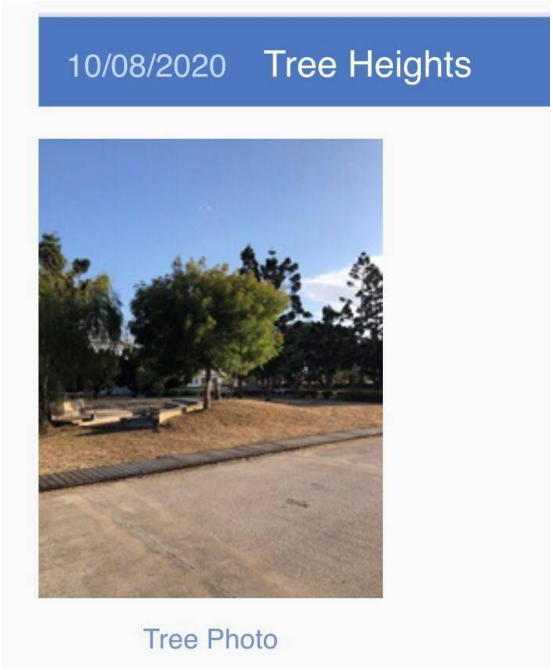
For monthly precipitation, we can know that June has the maximum of total rainfall, whereas October has the minimum. That represents the main rainy season is early summer, and winter is dry, there is little rain throughout the year in addition. For rainfall hours, the greater the rainfall per unit time, the stronger the rainfall intensity would be. It can be seen that, compared with other months, the rainfall intensity in June is always the strongest.

Compared to our school GLOBE data combined temperature, rain depth and relative humidity from January in 2020 to February in 2021, we can find winter is colder, dryer and low humidity. This weather situation may be the reason why the foliage became red.



Temperature (blue), humidity (purple), rainfall (red).

Motivation

	
The whole tree is green in October 2020.	Its phototropic face has started to get red since December 2020.

One day, when we observed the foliage of a tree in our school change its color in different seasons, we found this situation and thought it is interesting. In addition, the tree's red foliage is really beautiful. So, we decided to do research on this point and wonder why the foliage' color would change.

Winter in Kinmen, sun rises from southeast rather than due east. So we make a guess: Sunshine made efforts of the southern foliage of Pistacia chinensis, and it turns to their color are redder. Moreover, the truth says that is correct as well. However, we found that it was not that all the foliage of the tree turned red at the same time, but started to become red at the southeast of the tree. So, we began to think, discuss, and want to explore possible reasons.

At first, we found that the foliage is redder in direct sunlight, but greener on the other side. Then, we started with thinking that the sun shines from different angles and directions, maybe causing the foliage changing color at different speeds.

Research Purposes

1. Try to find out the law of leaves' discoloration of Pistacia chinensis ?
2. Hope to know WHY or WHAT variables would affect the foliage's color change orderly.
3. Want to know why a tree can have the green and the red leaves at the same time.

Research method

1. Using the Internet, relative books or articles and other ways to learn the basic knowledge and geographical distribution, etc. information about Pistacia chinensis.
2. Then search for GLOBE data bank or other kinds of meteorological records and discover the variables that causes the vary of the foliage.
3. At the same time, do more observations for the tree which discolor the most obvious, that is the Pistacia tree.
4. In the end, discuss and analyze the conclusion of our questions.

Methods and Materials

Software:

(1) Microsoft Office

(2) MS Paint

Hardware:

(1) Computers and Phones

(2) Infrared Thermometer

(3) Barometer

(4) Instrument Shelter and Relative Measuring Instruments

Research Process and Results

Facing North（2020.12.25—2021.03.05）

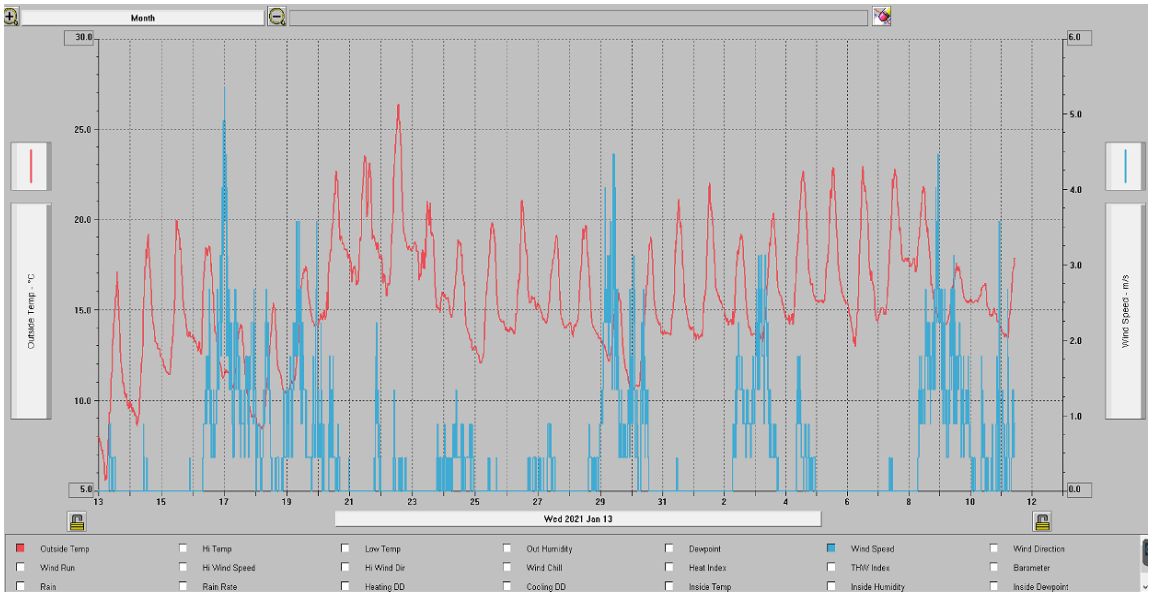
Date /Time	Picture	Date /Time	Picture
2020 12/25 12:36 p.m.		2021 01/07 12:24 p.m.	
2021 01/14 12:25 p.m.		2021 01/21 15:19 p.m.	

Date /Time	Picture		
2021 01/28 14:03 p.m.		2021 01/29 14:09 p.m.	
2021 02/08 13:51 p.m.		2021 02/15 14:12 p.m.	

Date /Time	Picture		
2021 02/18 14:19 p.m.		2021 02/23 12:24 p.m.	
2021 02/24 12:37 p.m.		2021 02/26 12:38 p.m.	

Date /Time	Picture		
2021 03/05 12:36 p.m.		2021 03/06 14:17 p.m.	

By observing the pictures of 1/14、1/28、1/29、2/8 and 2/15, we found the foliage fall faster than usual during those days. We checked climate data which is collected by GLOBE DAVIS automatic meteorological observation station in our school (pictured below), we learned that when these photos were taken, it seemed to be in the middle of the time between pictures when strong wind comes, and it results in this condition.



temperature (red), wind speed (blue).

Facing South（2020.12.27—2021.03.05）

Date /Time	Picture		
2020 12/27 11:00 p.m.		2020 12/28 12:26 p.m.	
2020 12/29 12:34 p.m.		2020 12/30 12:24 p.m.	

Date /Time	Picture		
2020 12/31 12:28 p.m.		2021 01/04 12:08 p.m.	
2021 01/05 12:30 p.m.		2021 01/06 12:06 p.m.	

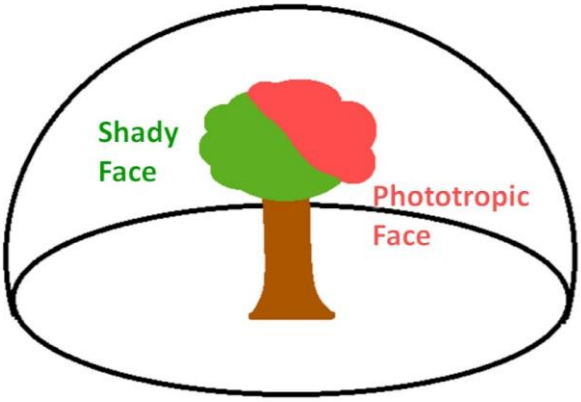
Date /Time	Picture	Date /Time	Picture
2021 01/07 12:46 p.m.		2021 01/08 12:29 p.m.	
2021 01/11 12:41 p.m.		2021 01/12 12:30 p.m.	

Date /Time	Picture	Date /Time	Picture
2021 01/13 12:27 p.m.		2021 01/14 12:24 p.m.	
2021 01/15 12:40 p.m.		2021 01/28 14:05 p.m.	

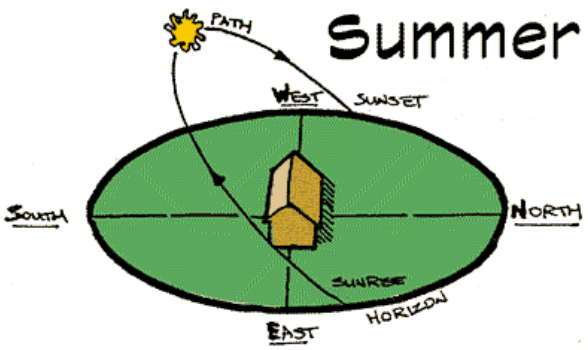
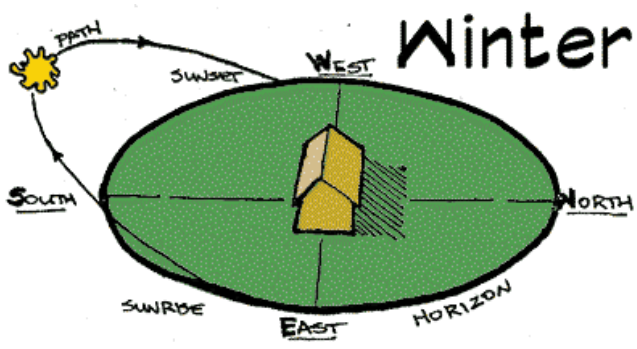
Date /Time	Picture			
2021 01/29 14:10 p.m.		2021 02/08 13:52 p.m.		
2021 02/15 14:11 p.m.		2021 02/18 14:20 p.m.		

Date /Time	Picture			
2021 02/23 12:25 p.m.		2021 02/24 12:38 p.m.		
2021 02/26 12:38 p.m.		2021 03/05 12:37 p.m.		

We have taken pictures of the tree for a long time. First of all, we found that foliage became red from the phototropic face of the sun, then the red color spread to the opposite side (the shady face).



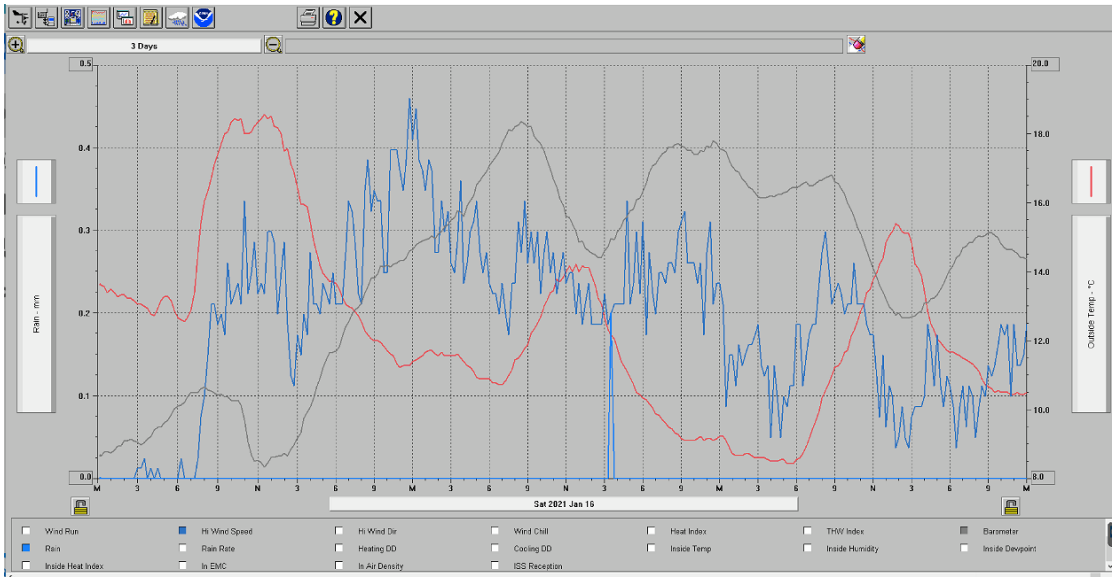
Since we searched the information about foliage discoloration of Pistacia chinensis, we learned the dryer weather would cause the foliage turn red. So we can know that the foliage got red more easily in winter. Furthermore, we also can observe that connection between section trees and the solar declination.

	
Solar declination in summer is bigger. The sun shines from right above easier than winter.	Solar declination in winter is smaller. The phototropic face of the tree is more easily at the side than summer.

The two pictures above are took from:
https://kknews.cc/zh-tw/news/on8rj45.html

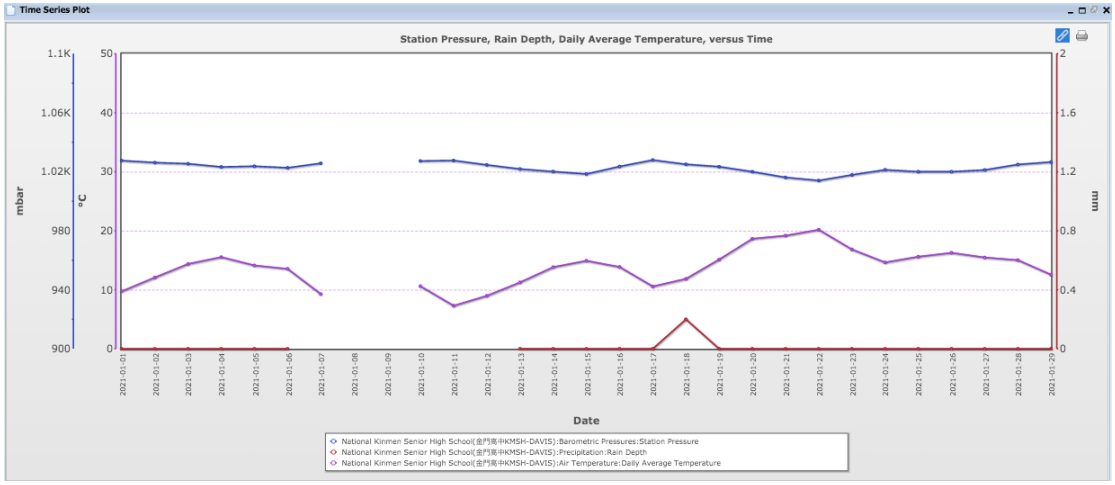
In addition, we also found the situation that the Pistacia tree kept falling foliage since January, and it seems to be affected by the weather conditions, too.

Much foliage fell obviously around January 20, 2021. We think that it was affected by the previous strong wind. Furthermore, according to the data information of January 16th to 19th, which are collected by GLOBE DAVIS automatic meteorological observation station in our school. (Pictured below) We can see there was a front coming in the morning on January 17th, 2021. It resulted in atmospheric pressure and wind speed rise → the temperature drops, and the frontal rain drops, causing much foliage to fall.



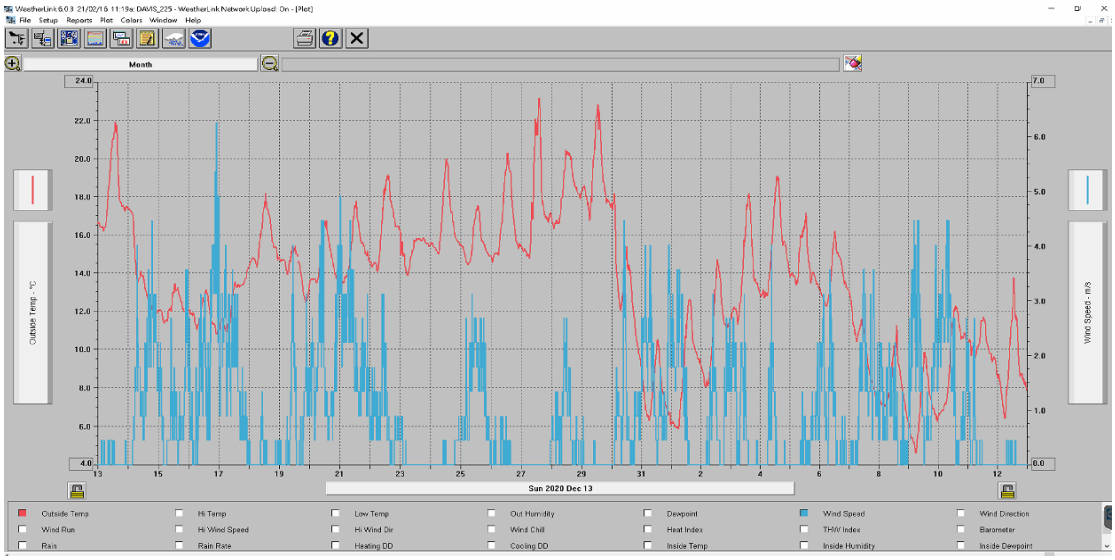
Rainfall(blue), outside temperature(red), high wind speed(light blue), barometer(gray)

By picture below (data from our school DAVIS PC), it can be seen that the above condition on January 17th.



Station pressure(blue), rain depth(red), daily average temperature(purple)

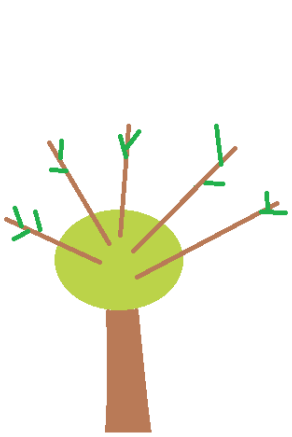
Data below says that the wind is strong from 12/13 to 1/13, but the foliage likely did not fall a lot. Maybe our guessing of "the toughness of the foliage is related to the color" is true. The weather became cold obviously on January 1st, and then the foliage turned into red very quickly. The foliage fell off as soon as the wind blew. Luckily, the intensity of wind in January was very different, which means this may be a new discovery.



Outside temperature(red), wind speed(blue)

So far, we observed that if the foliage color is yellow, it will fall more easily than the foliage in other colors.

Through the observations these days, our team observed the sharp top of the branches was leafing new green leaves. Then our teacher told us it might be affected by the sun. We think the sun is very interesting!



Discussion

The tree which we are going to study is Pistacia chinensis. We have observed it for a long time and found that its leaf color would change regularly.

The trees start to grow the red leaves from spring to summer, then they turn to green. When Pistacia tree's leaves are going to fall, around autumn, the leaves turn back to red, and they start to fall when winter comes. Because the Pistacia tree is a semi-deciduous plant, it will be "half" leafless, but will not all fall in early spring.

The form below is the phytochromes that affects the color of the plant we verified:

Pigment	**Its original color**	**The color it shows**
Chlorophyll	Green	Green
Anthocyanin	Red, purple, blue	Red, orange, pink, blue-purple
Xanthophyll	Light yellow	Yellow, light yellow
Carotene	Yellow	Yellow, orange-red
Tannin	Tan	Tan, dark brown

The color of Pistacia chinensis is affected by a kind of Anthocyanin, which is stored in the vacuole of leaves' cells.The purpose of why Anthocyanin appears in plants is to protect the plant against the damage of ultraviolet light. In addition, Anthocyanin absorbs ultraviolet light better than chlorophyll.

Then, what is the connection between Anthocyanin, air temperature and the foliage color? In the process of the leaves wilting, the ability of leaves to deliver nutrients to itself gradually declines, and Glucose, Xanthophyll and Carotene stay last, which are more durable than Chlorophyll and less prone to deteriorate. The Glucose and Xanthophyll contained in the leaves of some certain plants will produce Anthocyanins slowly after they are shone by the sun, and Anthocyanins are the reason for their leaves’ redness.

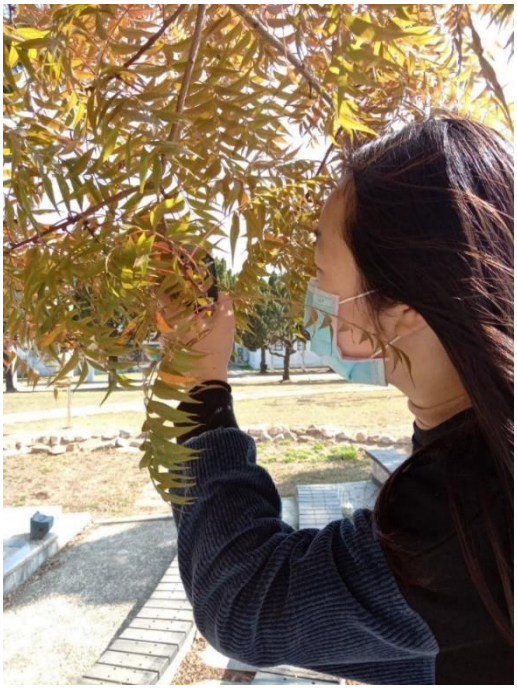
And we speculated most of the plants are greener in summer is because the ambient air temperatures are not conducive to the formation of any kinds of Anthocyanin, and the high temperature in summer will also speed up the decomposition of Anthocyanin, giving rise to plants to return to the green color that dominated by chlorophyll.

The opposite of stated above, the low temperature in winter can promote the synthesis of Anthocyanin in plants. More Anthocyanin can provide more calories to the plants, keeping them warm. When the proportion of Anthocyanin in trees increases, the color of the leaves will also turn red.

Because the sunshine can help form the Anthocyanins, the leaves are redder in places with strong sunlight. And what is the connection between Anthocyanin, humidity and the foliage color?

Water (H2O) is one of the raw materials photosynthesis will need, it will affect the guard cells' stomata in plants open or close, and affects the plants absorb carbon dioxide (CO2). We speculated the high rainfall and humidity result in the photosynthesis of the leaves stronger, and the amount of chlorophyll gets higher as well. When winter comes, the drier weather causes the amount of chlorophyll to get lower, bringing about the leaves' color of Pistacia trees becoming red, that is the color of Anthocyanin.

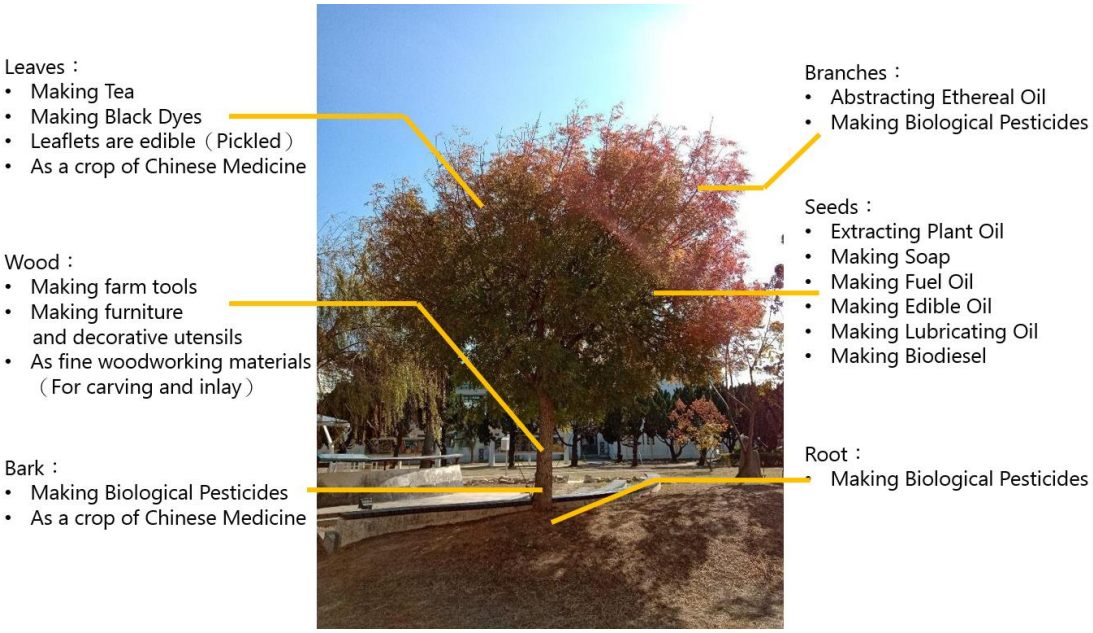
Unifying all the information above, we thought that the leaves on the Pistacia phototropic side are particularly red may be affected by the sunshine. However, if the leaves' surface temperature on the phototropic face is higher than the shady face of the leaves, it will not be conducive to the formation of Anthocyanin. When we feel stuck on this point, our teacher suggested we can go measure the surface temperature of the green and red leaves on the spot.



After we measured the surface temperature of the red leaves on the phototropic face and the green leaves on the shady face, we found their deviations are less than 1°C, so we think the main reasons that affect the leaf colors are probably humidity and the sunshine.

Outlook

1. The use of Pistacia chinensis



Picture above says some uses of a Pistacia tree. In America, semi-deciduous plants are often planted as street trees to make the city look more beautiful.

In fact, Pistacia is also a tough plant. It can survive in many environments polluted by sulfur dioxide, hydrogen chloride or soot. Therefore, Pistacia chinensis is a beneficial and harmless plant for humans. We hope that more people can learn about this plant through our report.

2. Our thinking and outlook

By the pictures that were taken for a long time, we found the foliage began to get red from the phototropic face of the sun. Therefore, we speculated: when most of the foliage is going to be green, the rest of foliage on the phototropic face of the sun may be the last turn into green. But when we tried searching for the relative information that we need, we immediately realized few people observing the difference, it led to us could not find any pictures, information or other evidence previously. In light of the fact that we do not have meteorological observation records in summer now, we are wondering: is the foliage really starting to get green from the phototropic face?

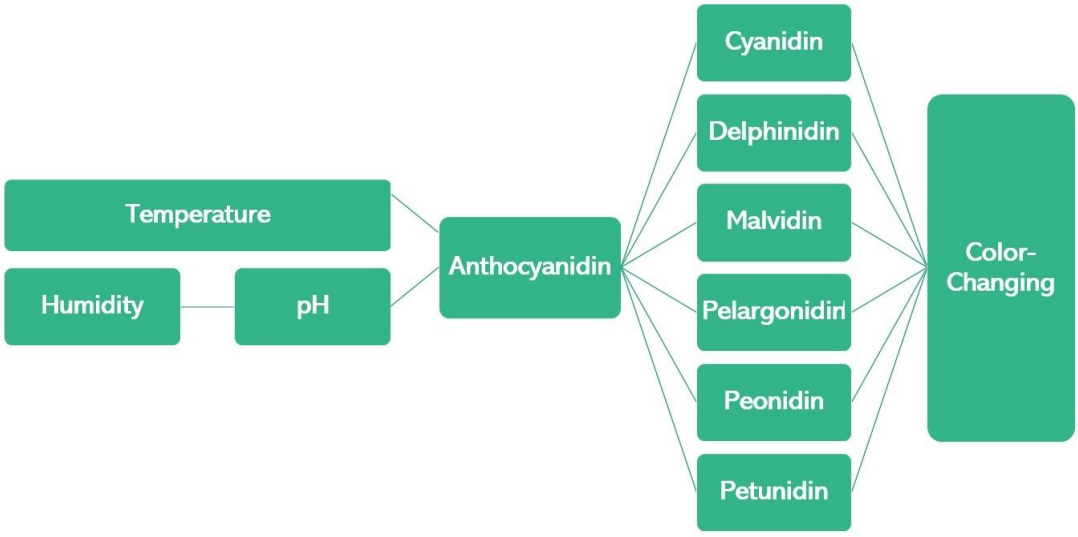
In summary, we have reached a consensus: Maybe we have to continue observing. As a result, we also decided next year, when our data bank accumulates a great amount that allows us to do more exploration, we are going to attend 2022 IVSS

again, doing the extended study about this foliage-color-change situation. Perhaps we can use some foliage and do some scientific experiments, learning whether the sunshine, air temperature, humidity or other variations will affect it or not.

Conclusion

The Pistacia's leaves color is changed by Anthocyanin, and the reason for Anthocyanins' amount to change is air temperature; the reason for Anthocyanin's color to change is pH, and pH is affected by humidity (the higher humidity, the lower pH). So we found that the Pistacia's leaves are affected by the rainfall and ambient air temperature in winter, they are less and redder than usual, and where there is more sunshine, the leaves' amounts are more and redder.

Sum up other possible influencing factors as shown in the figure below.



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6. NOAA（Climate Prediction Center）https://ssur.cc/nPKTa
7. GLOBEhttps://www.globe.gov/