How Does Temperature Affect the Snowpack Depth

By the Middle School Science Students
James Smith, Mylee Johnson, Peyton Hilty, Josh Olson, Carlyann Anvil, Lyra Abruska
Mrs. Faith Lussow and Mrs. Gwen Diltz

Knik Charter School

Wasilla, Alaska USA
11/15/23 - 2/29/24

Table of Contents

Abstract

This report investigates the relationship between snowpack depth and air temperature. Our class became aware of the importance of a good layer of snowpack to insulate plants like berries that have been traditional foods of our ancestors and us. We are concerned that with Global Climate Change, that the change in temperature can affect the snowpack covering these plants. We used the GLOBE Current Air Temperature Protocol, and the GLOBE Solid Precipitation Protocol for the Snowpack and Snowfall Data. We also used data from NOAA taken at the Palmer Airport, AK. Our results showed that the snowpack depth did vary according to the air temperature, and there were other factors that affected the snowpack depth like the wind blowing the snow away and drifting. When the air temperature was above 0℃, it could melt the snow, causing the snowpack level to decrease. It could also rain if the temperature is above 0℃ which could cause the snowpack level to decrease. When the air temperature goes below 0℃, the melted snow can freeze, which can make the snowpack level decrease. The decrease in the snowpack level and the ice forming could be harmful to berries and other plants. We also found that there were 88 days below 0℃ and 32 days above 0 °C. The data shows the average temperatures for each month: November, 2023 was -0.95℃, December, 2023 was -8.51℃, January, 2024 was -10.32℃ , and February,2024 was -5.69℃.

Introduction

We acknowledge the Dena'ina people, on whose traditional lands we live and operate. We also acknowledge all Indigenous people of Alaska. Thank you for your past and present stewardship of the waters, plants and animals.

Our school is called Knik Charter school and our grades are Kindergarten to 12th grade. We are in the Matanuska-Susitna Borough School District in Wasilla, Alaska.

The Dena'ina people called this land "Benteh" which means "Among the lakes." Local traditions say there was a large Indian village, known for always having trout, silver, and red salmon. It was between a few good fishing lakes that were connected by a small stream. (Shem Pete's Alaska: The Territory of the upper cook inlet Dena'ina By James Kari & James A. Fall.)

The Vickaryous family from Minnesota was one of the 203 families of the Matanuska Valley Colony Project that came to Alaska in 1935. They made a dairy and potato farm called Cottonwood Farm. Our school is on the land that was once a potato field and is close to their original Colony House.

The Mat-Su Borough is surrounded by the Alaska Mountain Range, Chugach Mountain Range, and the Talkeetna Mountain Range. There are two major glacial-fed rivers in our valley, the Matanuska River and the Susitna River. The closest body of water to us is the Cook Inlet which is 50 km (about 30 miles) away.

Figure 1. Google Earth image of Mat-Su Valley showing the surrounding mountains, rivers and the Cook Inlet. 4/20/24

Figure 2. Google Earth image of Knik Charter School located in Wasilla, AK. 4/20/24

Our school is surrounded by mountains, lakes, small farms, a lumber yard/construction site, and a neighborhood. Our school has portables which look like army camps. There is a big building and a greenhouse called the Benteh STEAM Academy, right next to the portables. It used to be a commercial greenhouse. The portables are surrounded by asphalt (roads), gravel, plants, bushes, and small trees. There is also a diesel shop near our school. At the front of the school there is a pile of dirt and sand. We are right next to the Palmer Wasilla Highway.

Our study site, Knik Nuviya, is at Latitude 61.34 N and Longitude 149.24 W . “Nuviya” is the Inuit word for “clouds”.

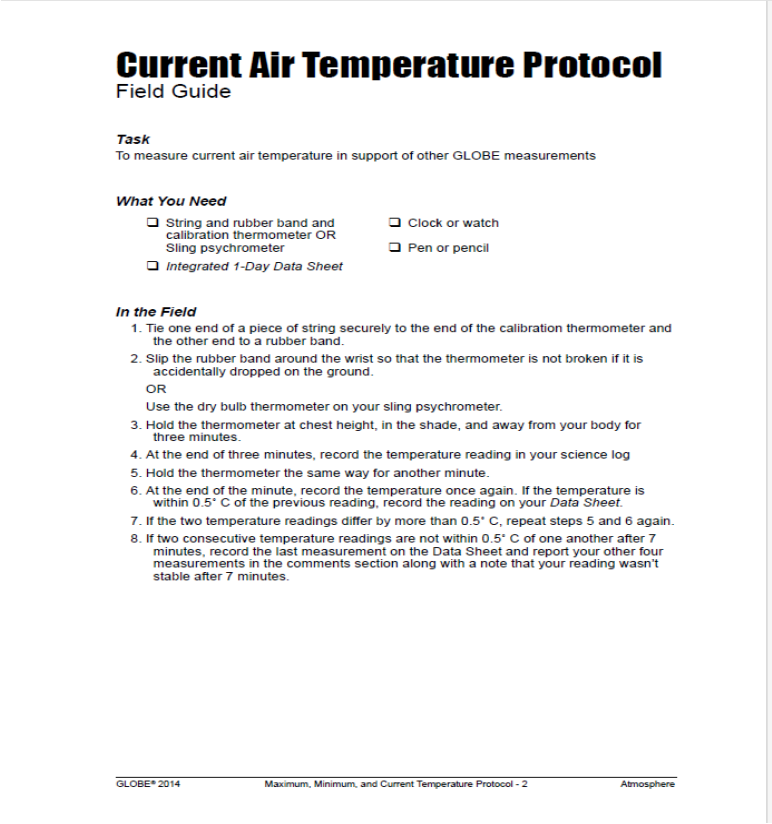
Figure 3. Knik Charter School Campus showing the three sites used to measure snowpack and snowfall data. Photo courtesy of Bre Wong and Kevin Lytle, Benteh STEAM Academy 4/5/24

Research questions

- How does temperature affect the snowpack depth?
- What was the average temperature each month?
- What was the average temperature of the warm days (above 0°C)?
- What was the average temperature of the cold days (below 0°C)?
- How cold or warm was it overall?

Methods

We used the GLOBE Current Air Temperature Protocol with an alcohol thermometer, and the GLOBESolid Precipitation Protocol for the Snowpack and SnowFall Data.



Current Air Temperature Protocol
Field Guide

Task
To measure current air temperature in support of other GLOBE measurements

What You Need

- ❑ String and rubber band and calibration thermometer OR Sling psychrometer
- ❑ *Integrated 1-Day Data Sheet*
- ❑ Clock or watch
- ❑ Pen or pencil

In the Field

1. Tie one end of a piece of string securely to the end of the calibration thermometer and the other end to a rubber band.
2. Slip the rubber band around the wrist so that the thermometer is not broken if it is accidentally dropped on the ground.
   OR
   Use the dry bulb thermometer on your sling psychrometer.
3. Hold the thermometer at chest height, in the shade, and away from your body for three minutes.
4. At the end of three minutes, record the temperature reading in your science log
5. Hold the thermometer the same way for another minute.
6. At the end of the minute, record the temperature once again. If the temperature is within 0.5° C of the previous reading, record the reading on your *Data Sheet*.
7. If the two temperature readings differ by more than 0.5° C, repeat steps 5 and 6 again.
8. If two consecutive temperature readings are not within 0.5° C of one another after 7 minutes, record the last measurement on the Data Sheet and report your other four measurements in the comments section along with a note that your reading wasn't stable after 7 minutes.

GLOBE® 2014 Maximum, Minimum, and Current Temperature Protocol - 2 Atmosphere

Figure 4. GLOBE Current Air Temperature Protocol.

Solid Precipitation Protocol

Field Guide

Task

Measure the amount of new snow that has collected on your snowboard.

Measure the total depth of snow on the ground.

Obtain samples of new snow and snowpack for pH measurement.

Obtain samples of new snow and snowpack to determine the water equivalent.

Prepare the snowboard to collect more snow.

What You Need

- ❑ A meter stick (or a longer measurement pole if snow accumulates to more than a meter in depth
- ❑ Snowboard
- ❑ A straight-sided container
- ❑ The overflow tube from your rain gauge
- ❑ Two clean sampling jars with covers for the pH samples
- ❑ A container for the snowpack rain equivalent sample
- ❑ Something flat and clean to slide under inverted containers
- ❑ *Integrated 1-Day Data Sheet*
- ❑ Pen or pencil
- ❑ Labels for snow samples

In the Field

1. Insert the measuring stick vertically into the snow until it rests on the ground. Be careful not to mistake an ice layer or crusted snow for the ground. Read and record the depth of the snowpack.
2. Repeat the measurement in at least two more places where the snow is least affected by drifting.
3. Report all three of these numbers as the total snowfall. If the snowpack is so small that a depth cannot be read, record the letter "T" (for trace) for total snowpack.
4. After a new snow has fallen on earlier snow, gently insert the measuring stick vertically into the snow until it touches the snowboard. Read and record the depth of new snow. If no new snow has fallen, record 0.0 as the depth of new snow.
5. If there is new snow, take at least two more measurements at different spots on the snowboard.
6. Report these numbers as the depth of new snow. If the snowfall is so small that a depth cannot be read, record the letter "T" (for trace) for new snow. If the snow on the snowboard has been disturbed before you can take an accurate measurement, report "M" for missing.
7. Record the number of days since the last reading of snow on the snowboard.

GLOBE® 2014 Precipitation Protocols - 9 Atmosphere

Taking Samples for the Lab

8. After you have measured the depth of new snow on the snowboard and of the snowpack, take a straight-sided container (such as the overflow tube from the rain gauge), and hold it straight up and down over the snowpack, well away from the snowboard. Choose a place where the snow has not been disturbed. Push the container down until it almost touches the ground.
9. Slide something flat and clean under the container just above the ground and turn the container right side up. Be sure not to lose any snow.
10. Save this sample in a clean container, cover it, label it "snowpack pH".
11. Take the overflow tube from the rain gauge, and hold it straight up and down over the snow away from the snowboard. Choose a place where the snow has not been disturbed. Push the tube down until it touches the ground.
12. Save this sample in your tube or another container, cover it, label it "snowpack rain equivalent".
13. Hold a straight-sided container straight up and down over the snowboard. Push the container down until it almost touches the board's surface.
14. Slide something flat and clean under the container just above the board and turn the container right side up.
15. Save this sample in a clean container, cover it, label it "new snow pH".
16. Hold the overflow tube from your rain gauge straight up and down over the snowboard. Push the tube down until it touches the board's surface. Slip something flat under the tube and turn it right side up OR hold the tube to the board and flip the board and tube over. Be sure not to lose any snow.
17. Save this sample in your overflow tube or another container, cover it, label it "new snow rain equivalent", and take it inside with you.
18. Once you have taken your samples, place the snowboard on top of existing undisturbed snow. Push the snowboard gently into the snow so that its surface is even with the surface of the snow. Place a flag or other marker nearby to help you locate the snowboard after the next snowfall.
19. Take your labeled samples inside to melt and measure.

GLOBE® 2014 Precipitation Protocols - 10 Atmosphere

Figure 5. GLOBE Solid Precipitation Protocol

Materials

- Centimeter/Meter Stick
- Notebook and Pencil
- Laminated Particle Board "snow board"
- Alcohol Thermometer
- Orange markers for "snow board"

Figure 6. Measuring snowpack 2/18/24

To measure our snowpack, we went into the back of the school yard where we had placed our "snowboard." We bring our meter stick, notebook, and a pencil. We measure the snow with the meter stick in three spots and record the measurements. We also took the air temperature in Celsius degrees. When we got the measurement we would write it down on the whiteboard in the classroom. We have class on Mondays, Tuesdays, and Thursdays only. Sometimes our teacher would take measurements when we did not have class.

Figure 7. Third site looking South on 2/18/24

Figure 8. Third site looking East on 2/18/24

Figure 9. Third site looking North on 2/18/24.

Figure 10. Third site looking West on 2/18/24.

Figure 11. Third site showing snowboard, orange markers, shovel, meter stick, PVC tube, and bucket used to collect snow data on 2/18/24.

Results

How does the temperature affect the snowpack depth?

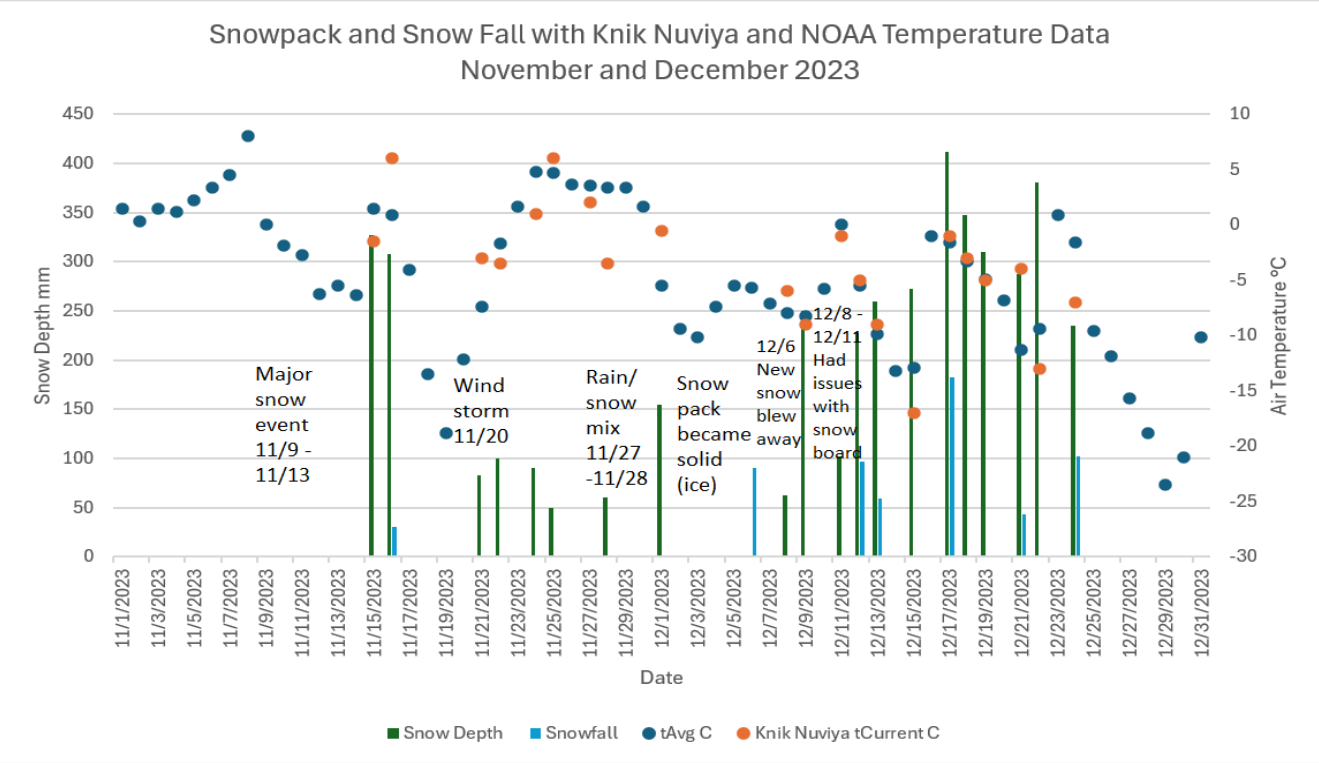


Figure 12. This graph shows how the temperature affects the snowpack in November and December, 2023. It shows the average temperature tAvg from the NOAA data at the Palmer Airport and the temperature data that we measured tCurrent.

Our teacher started measuring the snowpack for us on November 15, 2023 after a big snowstorm. School was canceled from November 9 to November 13.

There was a windstorm on November 20 and school was canceled on November 21. It was too windy to go outside on November 20. The snow blew away and drifted a lot. Our teacher measured the snowpack on November 21.

It got warmer and started to rain on November 27. We could not really measure the snowpack from November 28 to December 6 because it was ice. It got warm and the snow melted then it got cold and it all turned to ice. The new snow blew away before we could measure it on December 6.

We set the snow board up on December 7. The elementary student played with the snow board and moved it around. We did not get the new snow. We moved the snow board to a second site.

There was a blizzard and a windstorm on December 10 and 11. We could not find where the snow board was. We did not mark it very well. We got a new snow board and put it at a third site.

We had Christmas Break from December 22 to January 8 where we did not measure the snowpack. Our teacher measured the snow for a couple of days during the break.

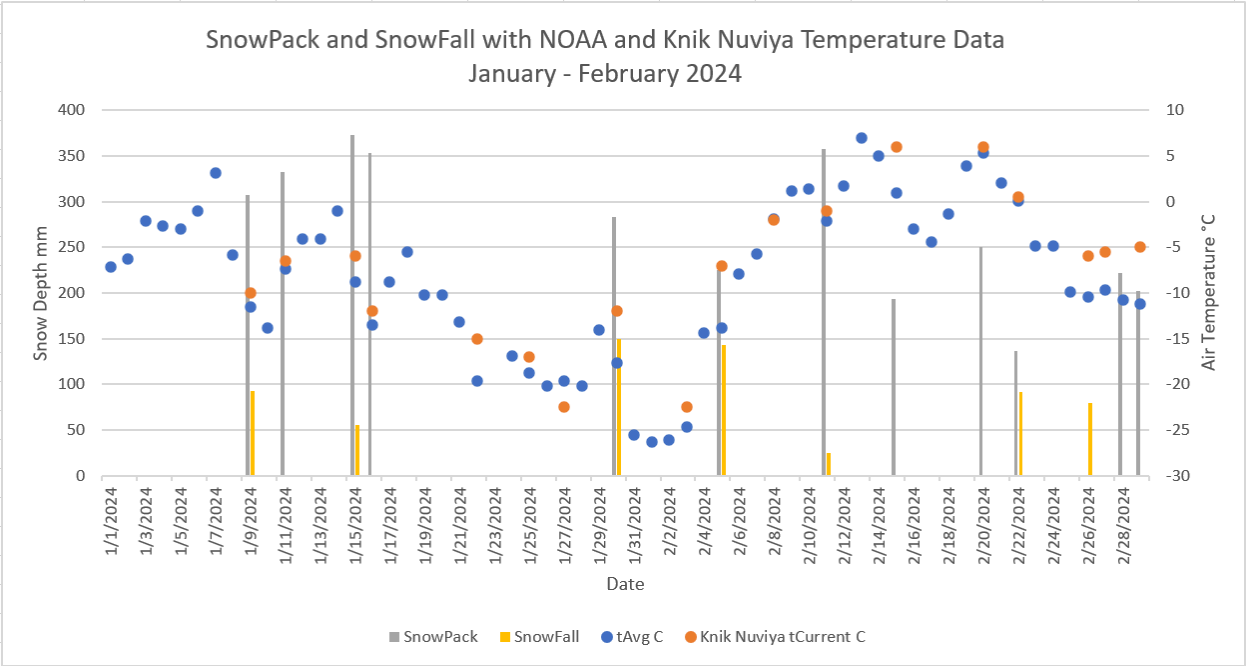


Figure 13. This graph shows how the temperature affects the snowpack in January and February 2024. It shows the average temperature tAvg from the NOAA data at the Palmer Airport and the temperature data that we measured tCurrent.

We had some problems with measuring the snowpack because there was a lot of ice at the bottom. It was hard to get the ruler all the way down to the ground. We did not take measurements from January 17 to January 30 because our teacher was sick. We noticed that it had not snowed but the snowpack depth went down between January 15 and January 30. It got cold and then snow compacted.

We noticed that even though it snowed on January 30 and February 5 that the snowpack depth went down. It could be because it was really cold for a few days and the snow compacted. It was -22℃ on February 3. Or it could have been because where we measured the snowpack it was uneven. There are snow drifts from the wind.

It got warm and the snow started to melt on February 14. It was 6℃.

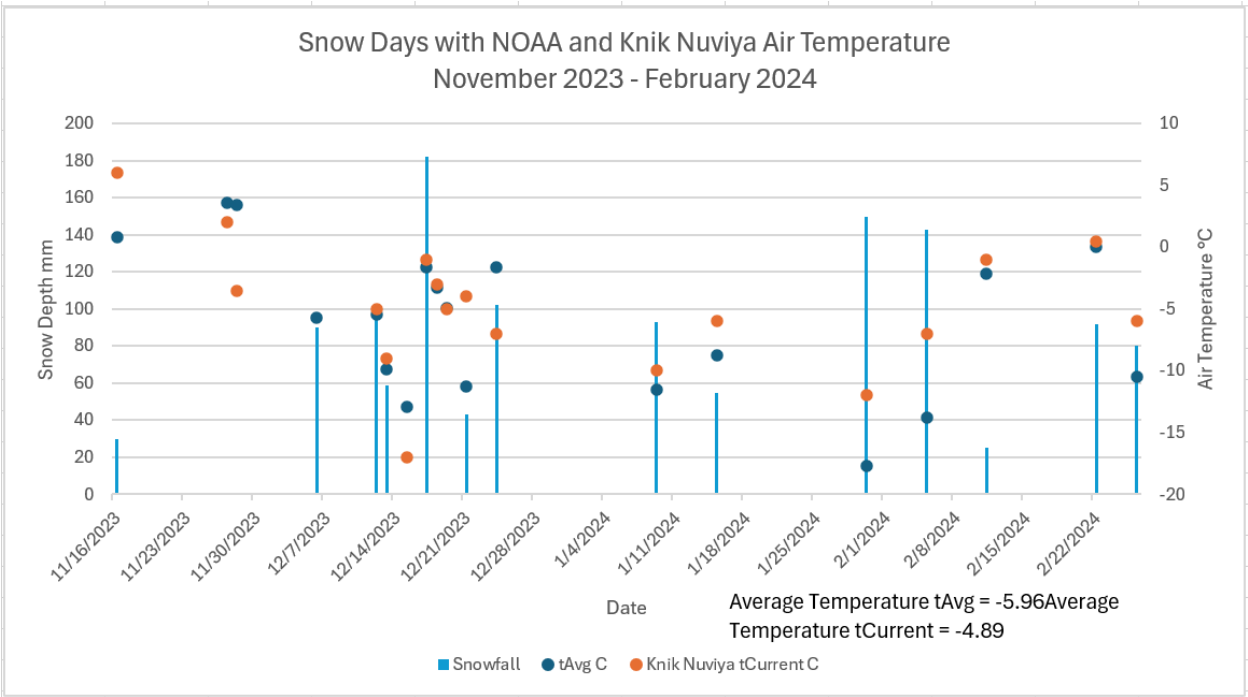


Figure 14. This graph shows the effect of temperature on new snowfall.

We noticed that it has to warm up in order for it to snow. The range of temperature that we measured (tCurrent) on days that it snowed was 6℃ to -12℃. The temperature average that we measured (tCurrent) on the days that it snowed was -4.89℃.

What was the average temperature each month?

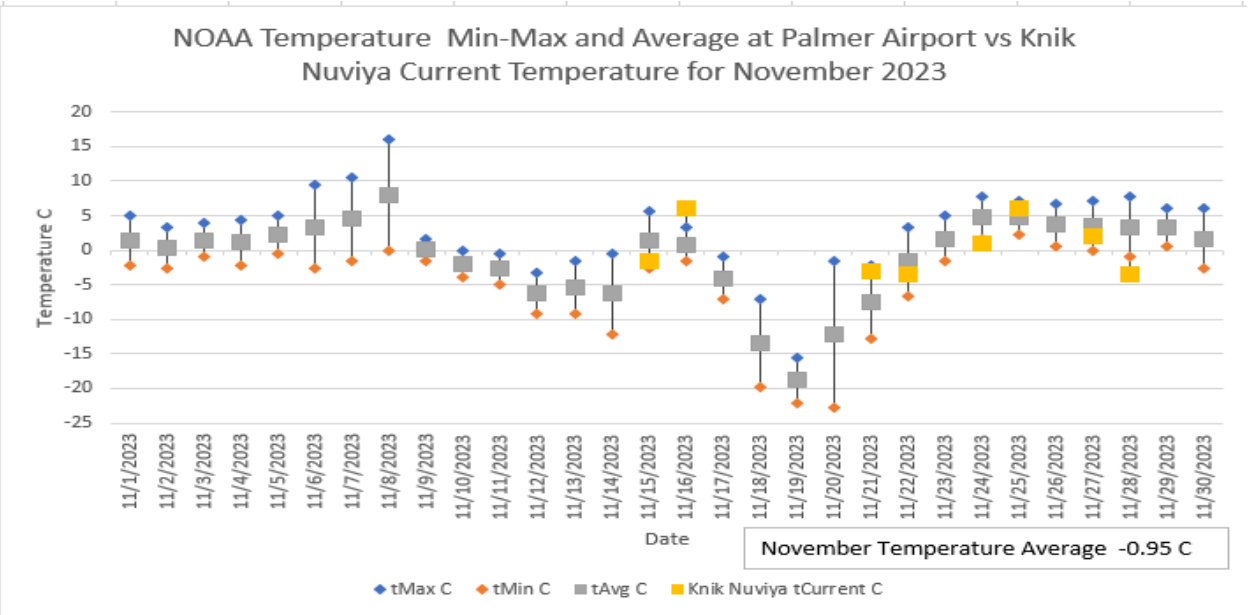


Figure 15. The average temperature for November, 2023 according to the data from the Palmer Airport tAvg was - 0.95℃

We decided to find data from somewhere that was better to show the average temperature per month because our data was not continuous. We found maximum (tMax) and minimum (tMin) temperature data for the Palmer Airport from NOAA using the codap.concord.org graphing tool. We had to calculate the average (tAvg) temperature because it was not listed with the other temperature data on codap. We added our data to the graph so we could compare and see if our measurements were off or not. We used this equation to calculate the average temperature: Arithmetic mean = $\frac{x_1 + x_2 + x_3 + \ldots x_0}{n}$

Figure 16. Google Earth image showing the distance of 13.2 km (8.2 miles) between our school and the Palmer Airport (PAQ). 4/20/24

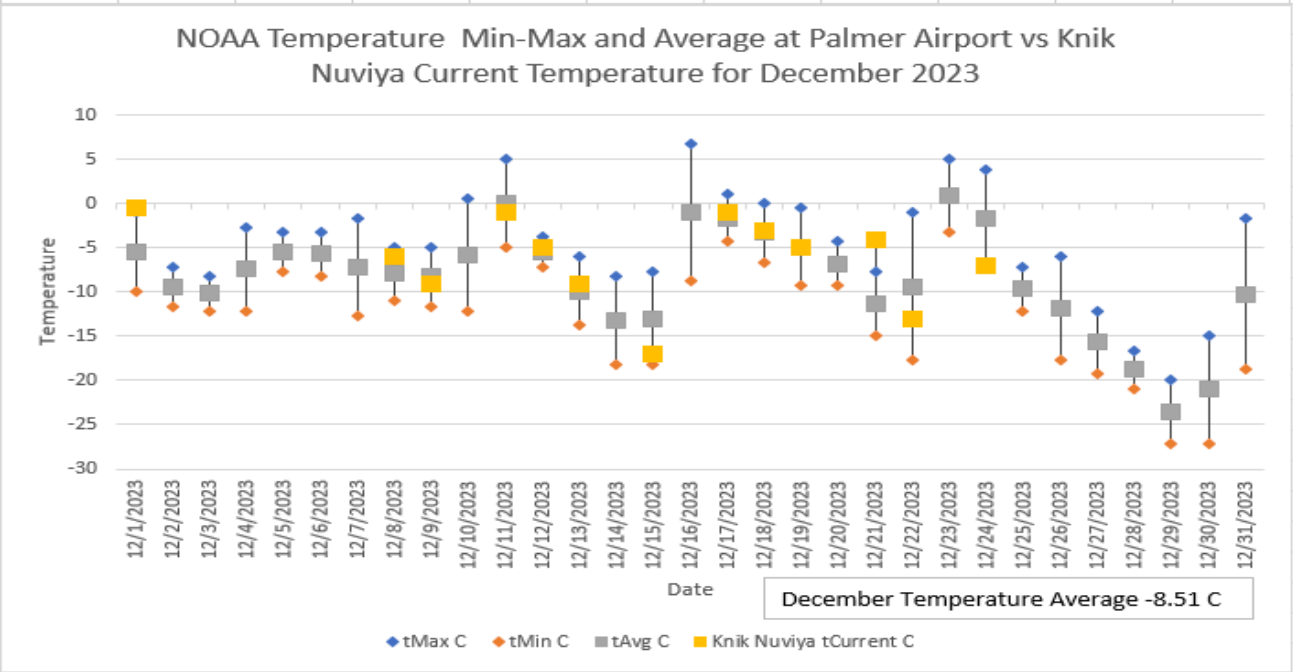


Figure 17. The average temperature for December, 2023 according to the data from the Palmer Airport tAvg was - 8.51℃.

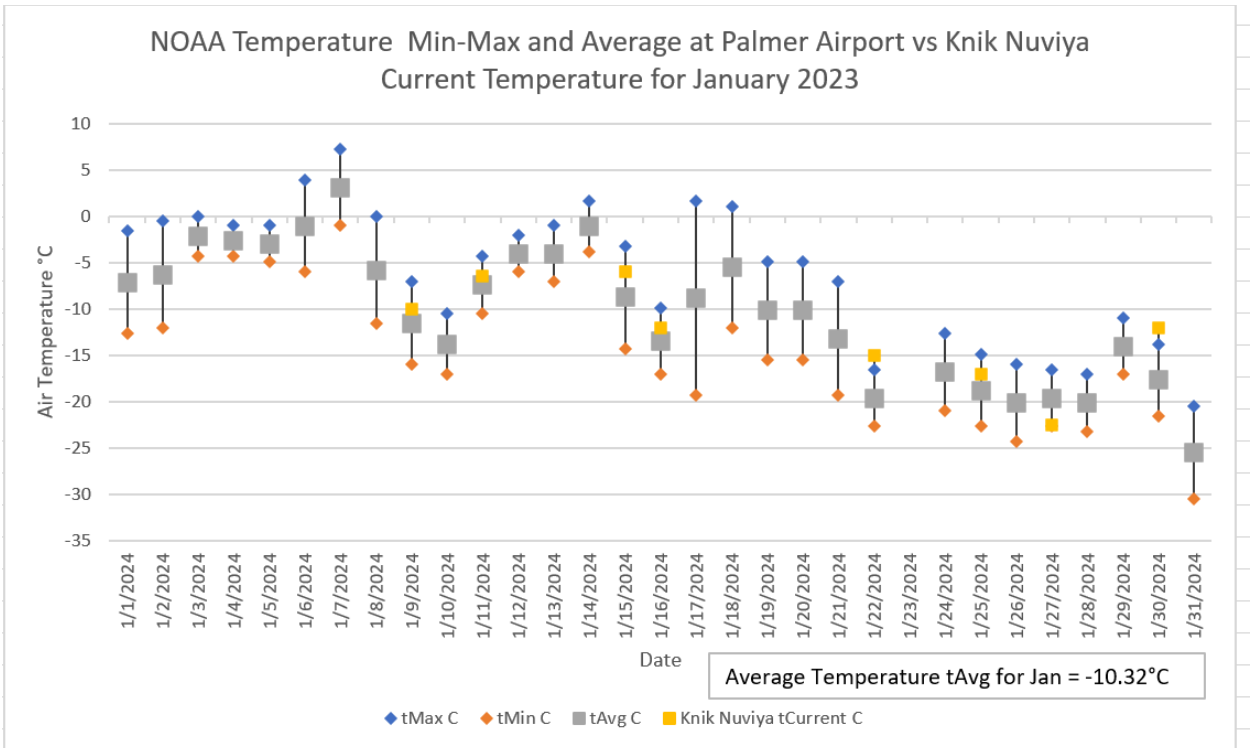


Figure 18. The average temperature for January, 2024 according to the data from the Palmer Airport tAvg was - 10.32℃.

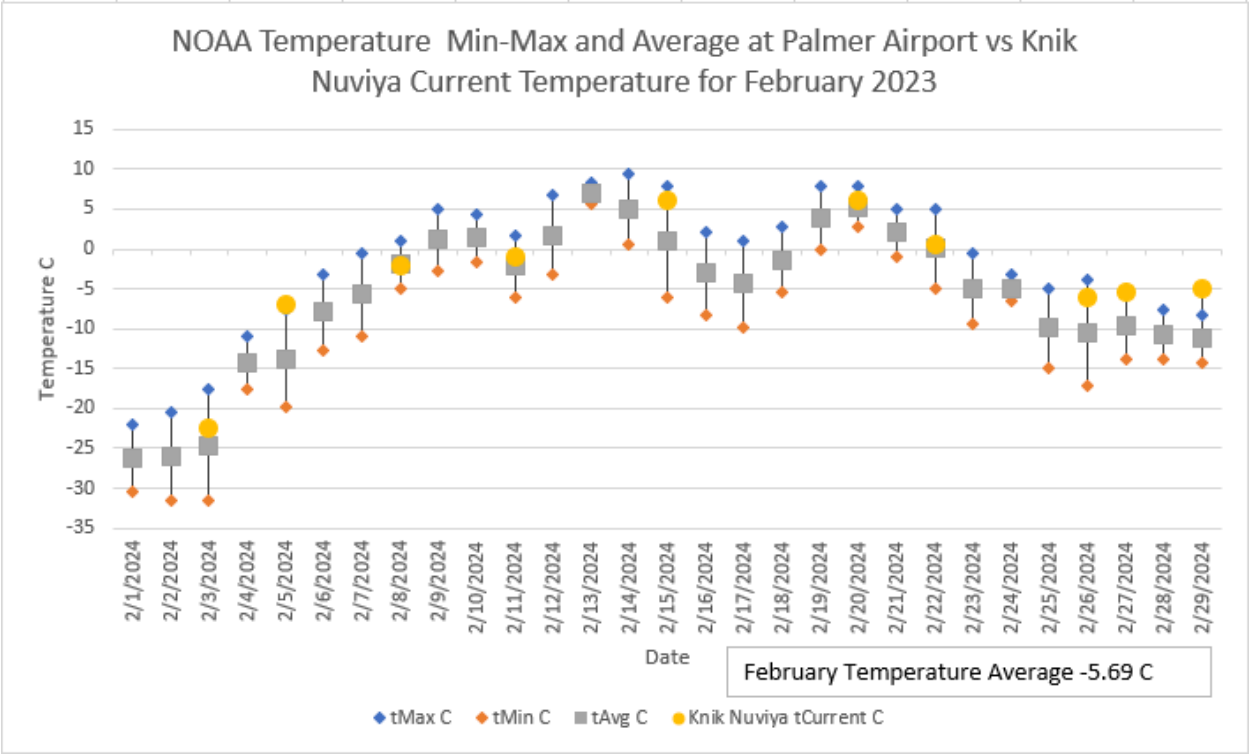


Figure 19. The average temperature for February, 2024 according to the data from the Palmer Airport tAvg was - 5.69℃.

What was the average temperature of the warm days (above 0℃)?

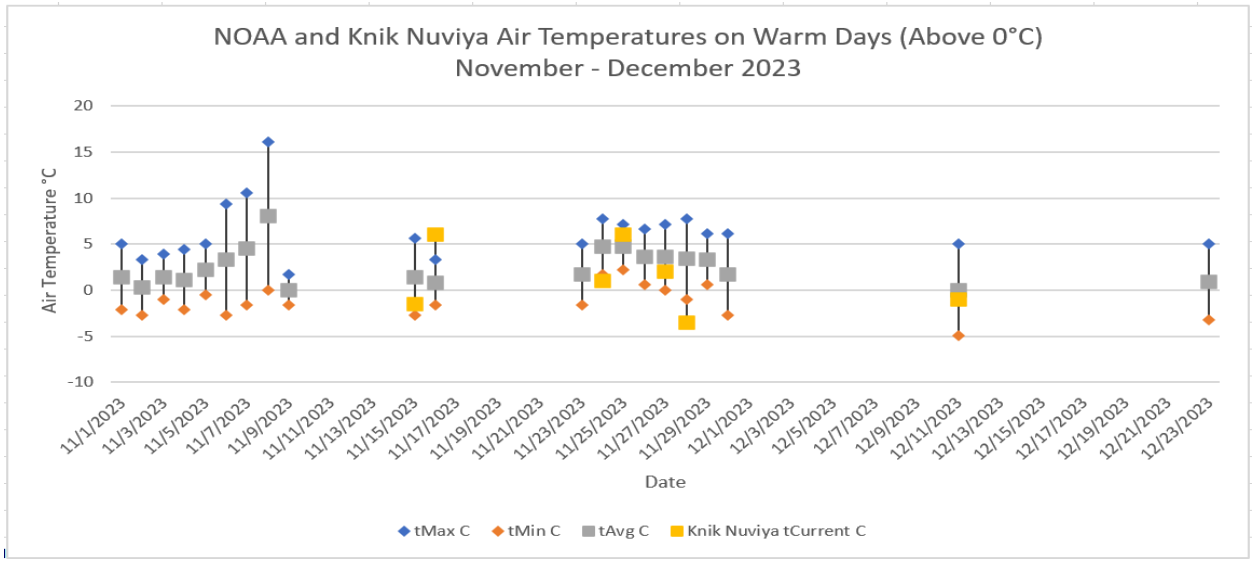


Figure 20. This graph shows the temperatures on the days tAvg was above 0℃ for November and December, 2023.

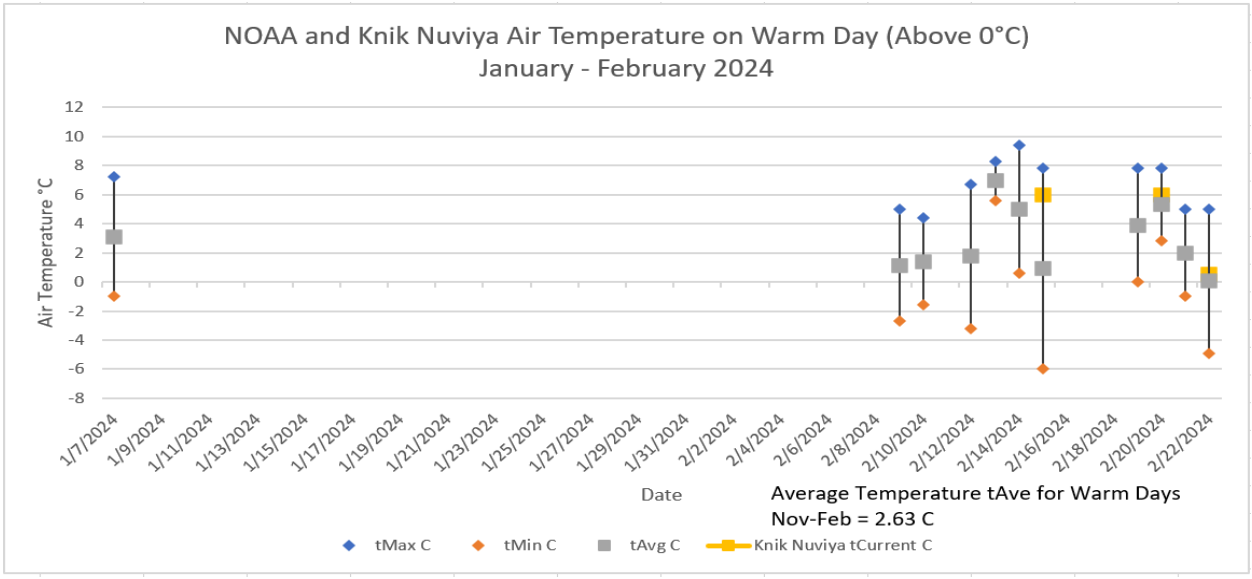


Figure 21. This graph shows the temperatures on the days that tAvg was above 0℃ for January and February, 2024.

The average temperature for the warm days from November, 2023 to February, 2024 using the average temperature that we calculated from the NOAA data at the Palmer Airport tAvg was -2.63℃.

What was the average temperature of the cold days (below 0℃)?

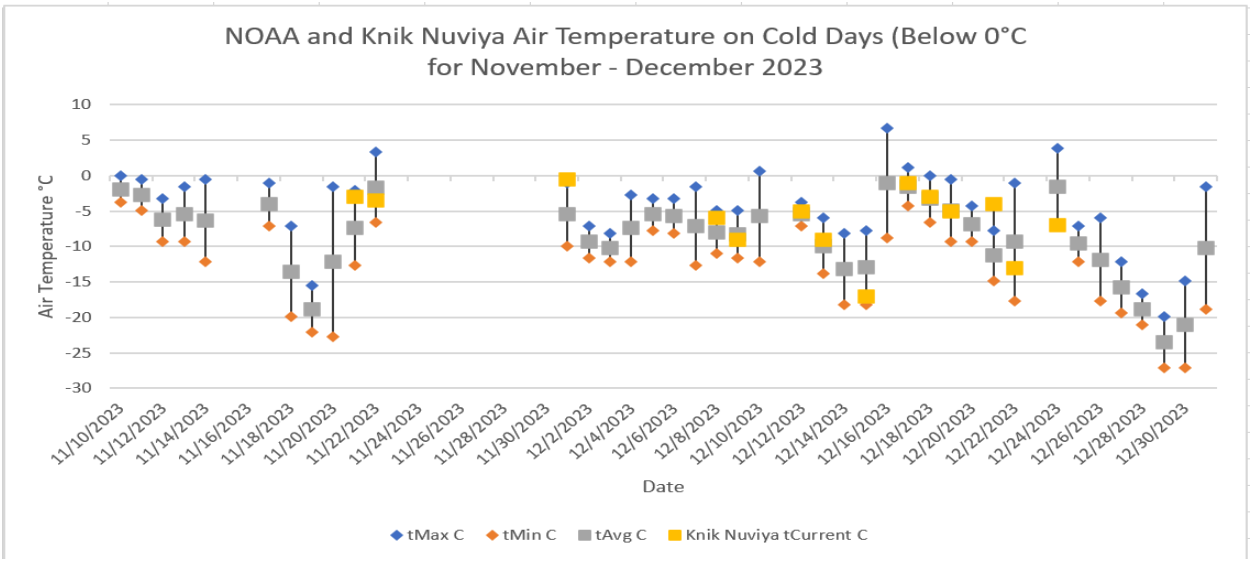


Figure 22. This graph shows the temperatures on the days that tAvg was below 0℃ from November to December, 2023.

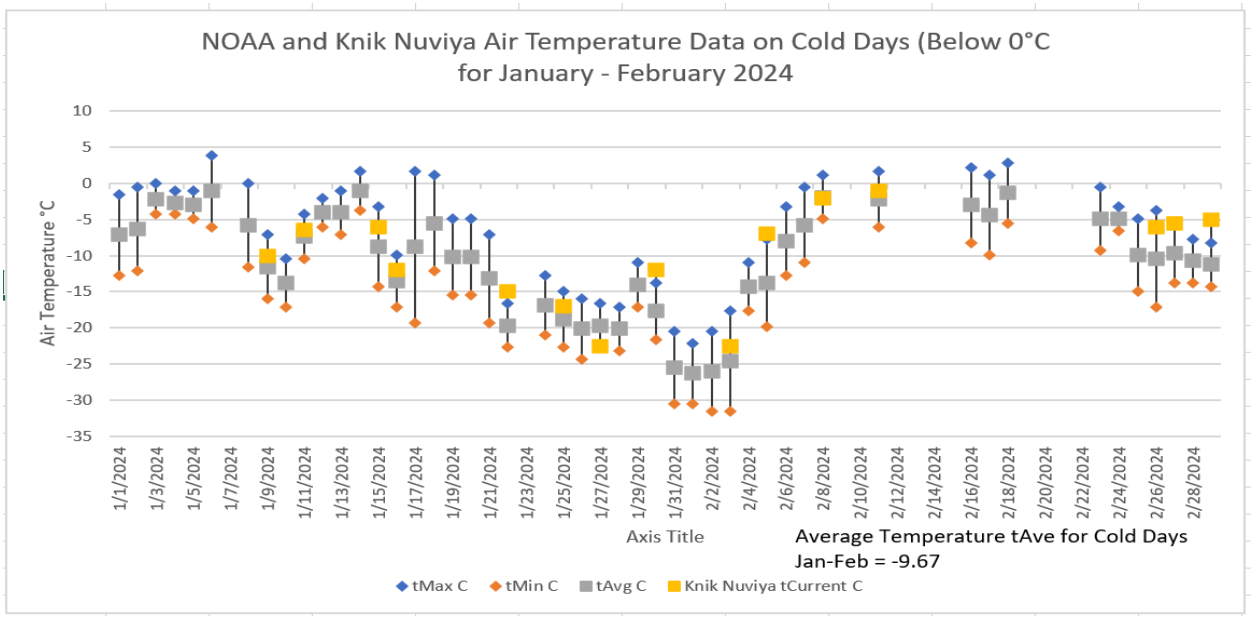


Figure 23. This graph shows the temperatures on the day that tAvg was below 0℃ from January to February, 2024.

The average temperature for the warm days from November, 2023 to February 2024 using the average temperature that we calculated from the NOAA data at the Palmer Airport was -9.67℃.

How warm or cold was it overall?

There were 32 days that tAvg was above 0℃ and 88 days that tAvg was below 0℃.

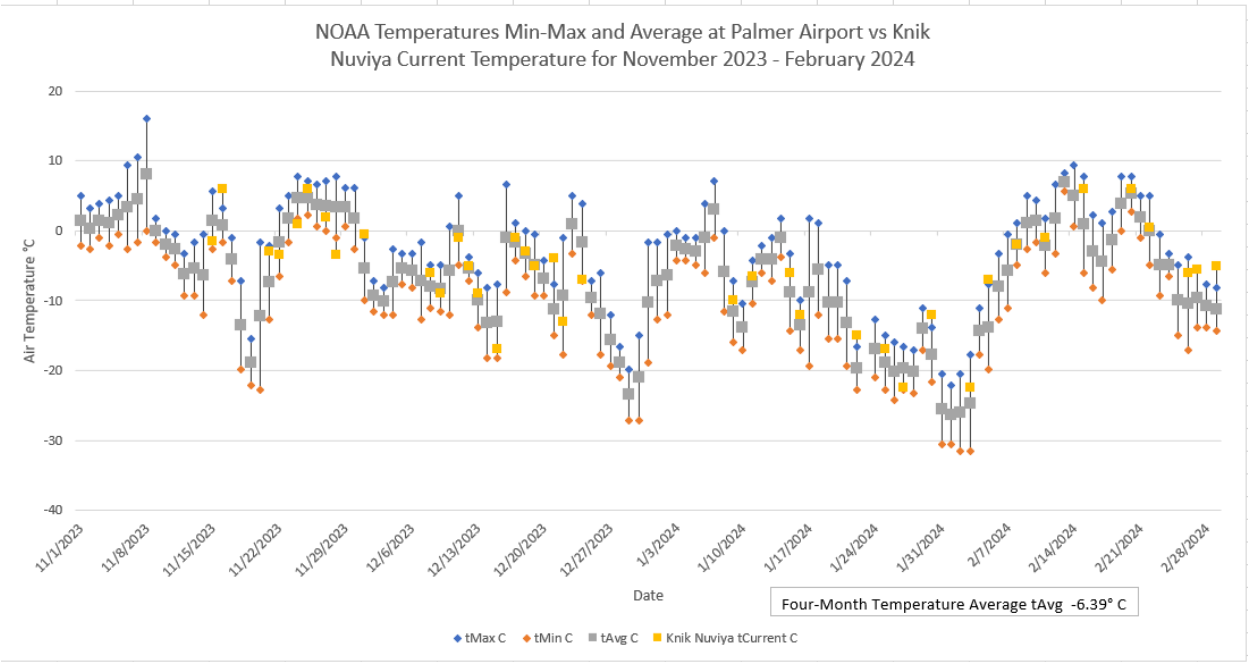


Figure 24. This graph shows the NOAA temperature data from the Palmer Airport and the temperature measurements we took tCurrent from November, 2023 to February, 2024.

We calculated the average temperature from the Palmer Airport tAvg for all of November to February and it was -6.39℃. Our data and the data from the Palmer Airport shows that three times from 11/1/23 to 2/14/24 the temperature fluctuated from close to 10℃ to below -20℃ and back close to 5℃.

Conclusion

In conclusion, temperature did affect our snowpack levels. When it is warm, and above freezing, the snowpack melts and decreases. But when it is cold, and it is below freezing the melted snow freezes into ice and decreases or compacts the snowpack. If it snows, the snowpack increases. Also, it has to warm up in order for it to snow. It is very windy at our location, so it blows the snow all over and our snowpack decreases and changes the snowpack level.

The data shows that on days when the temperature is higher it melts the snow or it rains, causing the snowpack to decrease, but on days when the temperature is lower

it snows during the times when usually it would rain and it doesn't melt as much which results in higher snowpack levels.

Windy days had an effect on our data because when we went to take data the wind just blew it off the board before we got data. There were two severe wind storms and heavy snow and the wind moved the snow everywhere, decreasing the snowpack level and making the snowpack uneven due to drifting.

We did not get very accurate measurements of the new snowfall so we could not determine the total snowfall for the months we measured the snowpack and snowfall because we are missing too much data. According to the National Weather Service, on 4/21/24, Anchorage, AK received 132.6 inches, or 3368.04 mm, of snow since July 1, 2023, tying for the second snowiest season on record. Anchorage is about 64.4 km (40 miles) from Wasilla.

From November 1st 2023 through February 29th, 2024 the temperature was mostly below zero. There were 88 days below 0℃ and 32 days above 0 °C.

The data shows the average temperatures varied throughout November and February. November was -0.95℃, December was -8.51℃, January was -10.32℃ , February was -5.69℃. Our data and the data from the Palmer Airport shows that three times from 11/1/23 to 2/14/24 the temperature fluctuated (cycled) from close to 10℃ to below -20℃ and back close to 5℃.

Discussion

We believe that to improve our data we should have had a designated spot away from the playground and construction. We could put something like a sign saying do not remove the snow board or Don't Touch it and educate the Elementary kids to not touch the equipment. It also might have helped if we had notified the rest of our school and site what we were doing and had other students help with collecting data.

Maybe, if more people were involved we could have collected more data since our science class only meets three times a week. The wind is part of our area so an accurate part of our data and "missing" data.

We could use different equipment for measuring the snowpack. We did break two rulers and we had a difficult time making sure we were at the ground because of a hard ice layer.

The school was doing construction and that disrupted our research (that is why we don't have anything in March). We would have March researched if it was not for the reconstruction part of our school.

We also had difficulty getting to the snowpack board because it got blocked by the plowers moving the snow and we couldn't get to it that well. So we got the snowboard and moved it over a little so we didn't have to go through the plowers stuff. Telling plowers to leave a little spot in between the snow hills would make it easier to access the board.

We decided to find data from somewhere that was better to show the average temperature per month because our data was not continuous. We found maximum (tMax) and minimum (tMin) temperature data for the Palmer Airport from NOAA using the codap.concord.org graphing tool. We had to calculate the average (tAvg) temperature because it was not listed with the other temperature data on codap. We added our data to the graph so we could compare and see if our measurements were off or not.

Possible suggestions and extensions for further study could be to look at historical snowpack and temperature data and compare it to our findings. Also we collected data for the liquid equivalent of the snowpack and snowfall and we could

analyze that to see what effect the liquid content of the snow has on the snowpack depth.

Our class became aware of the importance of a good layer of snowpack above the roots of plants like berries that have been traditional foods of our ancestors and us. We are concerned that with Global Climate Change, that the change in temperature can affect the snowpack covering these plants. We went on two field trips to pick blueberries and high bush cranberries. We even extracted seeds from the blueberries. Our results showed that the snowpack depth did vary according to the air temperature, and there were other factors that affected the snowpack depth like the wind blowing the snow away and drifting. When the air temperature was above 0℃, it could melt the snow, causing the snowpack level to decrease. It could also rain if the temperature is above 0℃ which could cause the snowpack level to decrease. When the air temperature goes below 0℃, the melted snow can freeze, which can make the snowpack level decrease. The decrease in the snowpack level and the ice forming could be harmful to berries and other plants.

Resources

AK Berry Futures_Blueberry_10.24.23_2.pdf

Kar, James I & Fall, James A. (2016) Shem Pete's Alaska: The Territory of the upper cook inlet Dena'ina Revised Second Edition. Fairbanks, AK. University of Alaska Press.

Frontiersman Obituary Rose Marie "Tiny" DePriest (Vickaryous)
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.frontiersman.com%2Fobituaries%2Frose-marie-tiny-depriest%2Farticle_d9b49bea-863e-11ed-8523-4f8f06145d39.html&psig=AOvVaw2WbSB2pqL8q10ouSgPyHf5&ust=1714100295518000&source=images&cd=vfe&opi=89978449&ved=0CAcQrpoMahcKEwj49uLLr9yFAxUAAAAAHQAAAAAQBA
Figure 1. 4/20/24 retrieved from
https://earth.google.com/web/@61.44497393,-149.75792177,-0.18843066a,58205.52711188d,30.00000337y,0.00001076h,0t,0r/data=MikKJwolCiExakFfMTBnQTFIMlNyaVdORTVleHFvdi1ZaGs0N2NSOUQgAToDCgEw
Figure 2. 4/20/24 retrieved from
https://earth.google.com/web/@61.5889476,-149.35013264,104.32101381a,5990.13893121d,30y,0h,0t,0r/data=MikKJwolCiExakFfMTBnQTFIMlNyaVdORTVleHFvdi1ZaGs0N2NSOUQgAToDCgEw
Figures 6 - 11. 2/18/24 taken by Mrs. Faith Lussow
Figure 16. 4/20/24 retrieved from
https://earth.google.com/web/@61.58918647,-149.21422355,79.75356347a,22799.81620132d,30y,0h,0t,0r/data=MikKJwolCiExN1RQdkVZLWNYQWVYUUxFTzlCY2xFR3Mtc1I2YW1TeEkgAToDCgEw
GLOBE Current Air Temperature Protocol and the GLOBE Solid Precipitation Protocol 4/20/24 retrieved from GLOBE.gov
NOAA weather at Palmer Municipal Airport: tMin,tMax retrieved from
https://codap.concord.org/app/static/dg/en/cert/index.html
Anchorage snowfall total 4/21/24 retrieved from weather.gov/arh/climate?wfo=afc

Acknowledgements

Mr. Isaac Martin, English teacher at Knik Charter School
Bre Wong and Kevin Lytle, Drone Class instructors at the Benteh STEAM Academy
Christi Buffington and Tori Brannan, Science Education Specialists at the International Arctic Research Center at the University of Alaska, Fairbanks