frontiers FOR YOUNG MINDS

EARTH AND ITS RESOURCES
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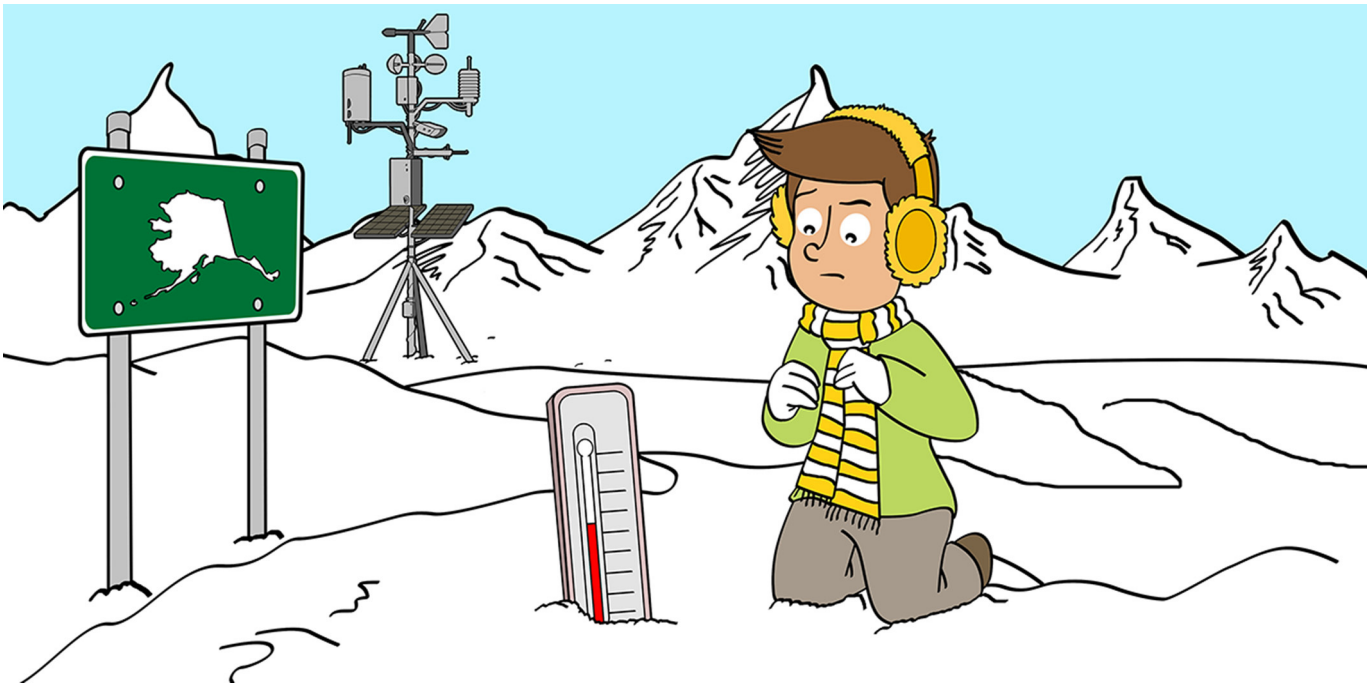

TWO DEGREES MATTERS

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YOUNG REVIEWERS:

ARIA
AGE: 9

MOAB CHARTER SCHOOL
AGES: 11–12

How do you tell if someone is not well? You take the person's temperature. If it is too warm, something is not quite right. We care about how the weather and climate are changing in Alaska's national parks, so we continuously take their temperatures. We have dozens of weather stations in remote locations in the northern Alaska parks that run continuously, powered by the sun. Over the past several years, we found that the air and ground temperatures have been warmer than normal. Plants, animals, and people get used to living in their environments. They thrive within an expected temperature range. Things get out of whack when the environment that organisms are accustomed to changes. In northern Alaska, warming of just a few degrees can cause ice to melt and formerly frozen ground to thaw. Once the ground thaws, the ice changes to water and the landscape changes.

WEATHER AND CLIMATE, WHAT IS THE DIFFERENCE?

We want to know how changes in air temperature impact Alaska's national parks. Alaska's parks are large, and they span several different

Figure 1

Figure 1

Alaska is a large state with large national parks! We took a close look at temperatures in the northern Alaska parks, including the parks in the Arctic and in central Alaska (the parks in light green).

CLIMATE ZONES

Geographical regions based on average temperature and average rainfall.

CLIMATE

The general weather conditions found in a particular place.

WEATHER

The state of the atmosphere at a place and time with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness.

climate zones. When we refer to **climate**, we are talking about the average weather over a long period of time, generally 30 years. To put it in more practical terms, the clothes you decided to wear today are based on the current **weather**. The clothes you have in your closet (sweaters, boots) are based on the *climate* that you live in. The climate varies depending on where you are on Earth. The closer to the north or south pole you get, the less warmth you get from the sun because it is low in the sky. In the middle of the winter near the poles, the sun does not rise at all! As a result, the average temperatures generally get colder as you move away from the Equator. The Alaskan parks we studied are all above 60° north latitude and some are even north of the Arctic Circle, at 66° north latitude (Figure 1). Up here, summers are short, winters are long and cold, and snow blankets the ground for more than 6 months of the year.

OCEANS HOLD THE HEAT

Ocean temperatures are also cooler near the poles. Alaska is a big state surrounded by water, with the Pacific Ocean to the south and the Arctic Ocean to the north. Several of our parks are along the coast and are influenced by ocean temperatures. During the winter months, the Arctic Ocean freezes, and the sea ice keeps nearby lands cool. Along the southern coast of Alaska, the Pacific Ocean remains ice free. This moderates the cold winter months and keeps the temperature of nearby lands warmer.

THE LAND OF SNOW AND ICE

Snow, ice, and frozen ground define these parks. A temperature increase of a few degrees means that snow and ice start to melt. Alaska and other high-latitude environments are undergoing rapid change due to warming temperatures [1]. Alaska's four warmest years on record all occurred between 2014 and 2019. During this period, the ocean temperatures surrounding Alaska were much warmer than normal. This meant that the ice froze later, melted earlier, and was thinner when it was present [2]. Remember that the ice keeps things cool, so when there is no ice, air temperatures are much warmer. Alaska national parks are feeling the heat more than other national parks in the USA [3].

Much of the **Arctic** has **permafrost**, which is ground that is frozen year-round. One of the telltale signs of warming in the Arctic is slumping and oozing ground from thawing permafrost. People have lived in these northern lands for thousands of years. Entire communities are built on frozen ground. As the ground begins to melt, houses and buildings start to sink and fall over. People here hunt (caribou, moose, seals, and whales) and fish (salmon and crab) for food. They use snowmobiles to travel across frozen rivers and the frozen ocean. Without ice, it becomes harder and more dangerous to find food. Everything they hunt for and the way they hunt is based on a cold Arctic.

ARCTIC

The northern most region of the Earth known for its extreme cold climate. An important feature is permanently frozen ground and seasonally varying snow and ice cover.

PERMAFROST

A combination of soil, rocks, and sand that is held together by ice. The soil and ice in permafrost stay frozen all year long.

HOW CAN WE MEASURE CLIMATE CHANGE?

We have weather stations in the Alaska national parks that record data year-round. By collecting data every day, we can figure out the average temperature for the whole year. If we keep collecting data year after year, we can track changes in air temperature, ground temperature, and snow depth over time. It is impossible to have enough weather stations to measure the temperature at every location. So, we have computer models that use math to estimate temperatures where we cannot measure them. The models suggest that the ground temperature is very close to freezing in large portions of the northern Alaska parks [4]. Because the temperatures of the air and the ground are related, we know that warming air temperatures mean the ground is also warming.

But there is another important element to consider—snow! Snow is on the ground for more than half of the year in these parks. By measuring snow depth, we can figure out when the snow arrives in the fall, when it melts in the spring, and how much is on the ground throughout the snow season.

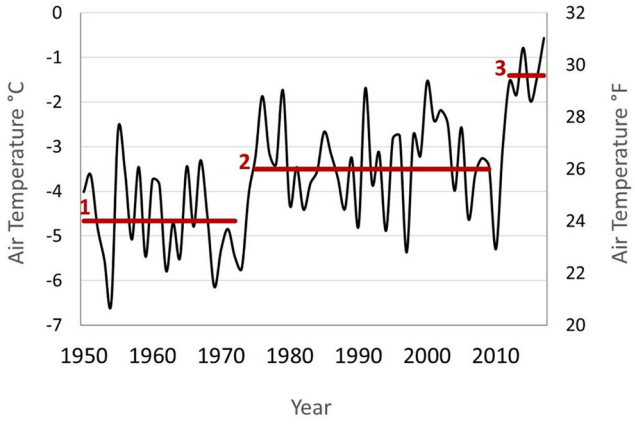

Figure 2

Figure 2

Warming temperatures in northern Alaska national parks over the past 70 years. Notice the cooler period up until the mid-1970s (red line 1), a shift to a warmer period (line 2), and the most recent increase to the warmest temperatures (line 3). The recent 2°C of warming puts the temperature of the northern Alaska parks closer to 0 C or 32°F, the temperature at which snow or ice change to water.

AIR TEMPERATURES ARE WARMING

We found that recent air temperatures in and around the parks are the warmest on record. By looking at the average yearly temperatures over the past 70 years, we can see how much warmer it is now compared to the climate of the past (Figure 2). The average annual temperature in the earlier decades was about −5°C (24°F). Then there was a shift to warmer temperatures in the mid-1970s. Over the next four decades, the average temperature was stable and averaged about −3°C (26°F). That is still cold enough to keep things frozen. But, in 2014, air temperatures increased again by 2°C! This was not a gradual warming, but another sudden upward shift. The average temperature in recent years was about −1°C (30°F), much warmer than it has been in the last 70 years [5]. The temperature increase was not the same in every park. The Arctic parks warmed by almost twice as much as the central Alaska parks.

WARM AIR, WARM GROUND

We found that the central Alaska parks have already started to thaw, even though they have not warmed as much. This is because these parks were warmer to begin with. The permafrost in those parks is relatively warm and already on the edge of thawing. So, when the temperature went up a few degrees, the ground started to melt. We estimate that about one-third of the permafrost in the central parks is thawing now.

The air temperatures in the Arctic parks near the coast warmed the most. The sea ice formed later in the fall and melted earlier in the spring, and the open ocean kept these parks warmer than normal. Even though the ground is colder in the Arctic parks, during this recent warm period some soils rose above the freezing point and started to thaw. At some Arctic weather stations near the coast, permafrost began to thaw. We predict that about half of the permafrost on park lands

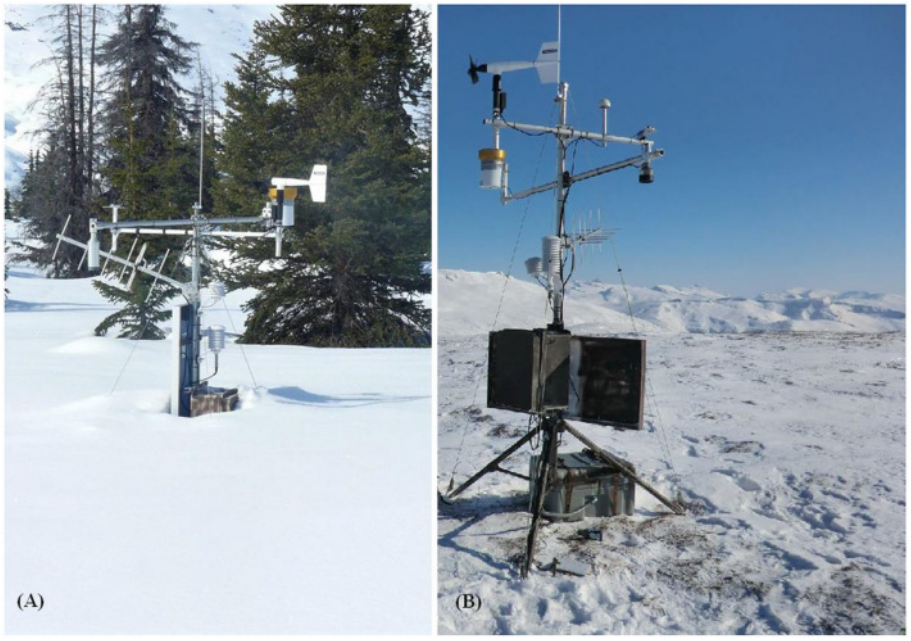

Figure 3

(A) Tebay weather station in Wrangell-St. Elias National Park (in central Alaska) under a deep blanket of snow, and **(B)** Pamichtuk weather station in Gates of the Arctic National Park (an Arctic park) with very little snow. Thanks to the thick, insulating snow layer, warmer winter temperatures at Tebay did not affect the ground temperature nearly as much as they did at Pamichtuk.

near the coast are vulnerable to thawing. This has never happened in modern history.

SNOW MATTERS

Snow covers the ground throughout the winter months and can help insulate it. Where the blanket of snow is deep, the frozen permafrost is protected from warmer winter air. When there is not any snow, the warmer air can warm the ground and cause the permafrost to thaw. This is a slow process that occurs over years and decades. But snow is an important consideration for permafrost stability in a warming climate.

In general, the Arctic parks receive less snow than the central Alaska parks. Also, a lot of snow in the Arctic is blown away by wind. Figure 3 shows a typical mid-winter scene at a central Alaska park and an Arctic park weather station. Since winter air temperatures were warmer and the ground did not have much snow insulation, the ground warmed the same amount as the air in the Arctic parks. By comparison, the ground warmed by only half as much as the air temperatures in the central Alaska parks, where there was more snow.

TWO DEGREES MATTERS

Two degrees of warming means that things have started to melt. The recent warming is particularly troubling in the Alaska national parks where snow and ice are the main features of the landscape. As the

permafrost thaws, the ground sinks, trees tip over, and new ponds form as the ice in the soil melts. Roads get bumpier, and they can be blocked by landslides. More trees and shrubs will grow, and the animals that eat them, like moose and beavers, will become more common. But the Arctic wildlife that has adapted to the cold and snowy climate will not do as well. If the snow arrives later, animals like the snowshoe hare, which turns white to blend in with the snow, will stand out against the bare ground. The snow provides a winter habitat for small animals like Arctic ground squirrels. It also keeps larger animals like bears toasty in their winter dens. Polar bears, like people, need sea ice as a platform to hunt. As temperatures climb above freezing and ice and snow melt, it will impact the entire system of plants, animals, and people in northern Alaska.

Share this story with your friends and family. Let them know that a few degrees of warming *does* matter. Also, tell them that there are things all of us can do to help keep the temperatures of Alaska's parks down. Turn off your computer when you are not using it. Flip the light switch off when you leave the room. Do not leave the faucet running while you brush your teeth. Ride your bike or walk instead of asking your parents for a ride. These are a few simple ways to conserve energy in your everyday life, and they can help make a difference for the future of Alaska's parks.

ORIGINAL SOURCE ARTICLE

Swanson, D. K., Sousanes, P. J., and Hill, K. 2021. Increased mean annual temperatures in 2014–2019 indicate permafrost thaw in Alaskan national parks. *Arct. Antarct. Alp. Res*. 53:1. doi: 10.1080/1523 0430.2020.1859435

REFERENCES

1. Markon, C., Gray, S., Berman, M., Eerkes-Medrano, L., Hennessy, T., Huntington, H. P., et al. 2018. "Alaska," in *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, *Vol. II* (Washington, DC: U.S. Global Change Research Program), 1185–241.
2. Thoman, R. L., Bhatt, U. S., Bieniek, P. A., Brettschneider, B. R., Brubaker, M., Danielson, S. L., et al. 2020. The record low Bering Sea ice extent in 2018: context, impacts, and an assessment of the role of anthropogenic climate change. *Bull. Am. Meteorol. Soc.* 101:S53–8. doi: 10.1175/BAMS-D-19-0175.1
3. Gonzalez, P., Wang, F., Notaro, M., Vimont, D. J., and Williams, J. W. 2018. Disproportionate magnitude of climate change in United States National Parks. *Environ. Res. Lett.* 13:104001. doi: 10.1088/1748-9326/ aade09
4. Panda, S. K., Marchenko, S. S., and Romanovsky, V. E. 2016. *High-resolution permafrost modeling in the arctic network of national parks, preserves and monuments*. Natural Resource Report NPS/ARCN/NRR-2016/1366. Fort Collins, Colorado: National Park Service. Available online at: `https://irma.nps.~ gov/DataStore/Reference/Profile/2237720`.

5. Swanson, D. K., Sousanes, P. J., and Hill, K. 2021. Increased mean annual temperatures in 2014–2019 indicate permafrost thaw in Alaskan national parks. *Arct. Antarct. Alp. Res*. 53:1. doi: 10.1080/15230430.2020.1859435

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ARIA, AGE: 9
I live next to Yellowstone. My dad is a scientist and my mom is a tour guide. We can go into Yellowstone whenever we want!

MOAB CHARTER SCHOOL, AGES: 11–12
We are a unique human sixth grade class in Moab, Utah. We consist of seven students with interests such as rocks, Minecraft, longboarding, cosplay, animals, and dirt biking. Our favorite subjects are math and science and we also like doing community service projects. We enjoy living in and exploring the desert of southern Utah.

AUTHORS

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Ms. Sousanes spent her youth climbing mountains with her dad, which sparked her lifelong interest in the natural world. She studied ecology, biology, and geography in college and graduate school. She got her dream job working for the U.S. National Park Service in 1993, and since then she has studied rivers, geology, soils, permafrost,

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