LOOKING FORWARD LOOKING BACK

Building Resilience Today

Community Report

Kwigillingok, AK

August 26-27, 2019

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APIA
ALEUTIAN PRIBILOF ISLANDS ASSOCIATION

AK CASC
Alaska Climate Adaptation Science Center

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ACKNOWLEDGEMENTS

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Lewis Amik III, Darrel John, Gary Evon, and Gavin Phillip
Kwik Incorporated - Willie Atti

This report describes the results of a community visit to Iliamna that included multiple meetings. The Looking Forward, Looking Back: Building Resilience Today (LFLB BRT) project leaders would like to thank the community partners, community leaders, and community meeting participants for their participation and contribution to this project and for sharing their knowledge and wisdom. We would also like to thank them for their time and support during the community visits and meetings that were central to the success of this work.

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COMMUNITY DESCRIPTION*

Kwigillingok is located in the lower western shore of the Kuskokwim Bay near the mouth of the Kuskokwim River that empties into the Bering Sea in the Southwest region of Alaska. Kuigilguq is the Central Yupik name for the village, which translates as, One Without a River, and has a marine climate. It lies 77 miles southwest of Bethel and 388 miles west of Anchorage. The 2018 population is 381. The Moravian Church established there in 1920 and the village was first recorded on an Alaskan map in 1927. The Native Village of Kwigillingok is the federally recognized Tribe and the local governing entity. Kwigillingok Tribal Council actively maintains their local language by regularly conducting their meetings in Yupik. Kwik Incorporated is the local corporation established under the Alaska Native Claims Settlement Act.

Commuting to other villages is by plane, boat, snow machines, as there are no connecting roads to surrounding communities. The mail is delivered daily weather permitting; the groceries and other necessities are delivered by plane and air cargo planes. Fuel and other large items are transported by barge from Seattle, but most barge services do not have regular schedule services to the villages, and only come to the village if they are bringing freight. Subsistence hunting, fishing and gathering way of life, the marine and land mammals, water fowl, fish and vegetation are harvested from the ocean, rivers and the land. There are a few who travel out of Kwigillingok to hunt for moose, caribou or marine mammals that are not available in our area. With a warming climate Kwigillingok is experiencing permafrost thaw, increased storm surge flooding, a decline of sea ice, and extreme heat events which directly and significantly impacts food security, human health and safety, infrastructure stability and the practice of Yupik traditions and a perpetuation of local cultural knowledge.

*Compiled from L. Amik's draft community description during the LFLB BRT Intensive Work Session, March 5, 2020. Anchorage, AK and the State of Alaska Division of Community and Regional Affairs Community Database Informational Portal

PROJECT DESCRIPTION

The Alaska Climate Adaptation Science Center (AK CASC), in partnership with the Aleutian Pribilof Islands Association (APIA), designed the Looking Forward, Looking Back: Building Resilience Today (hereafter 'BRT') project as a series of trainings and workshops with tribal community leadership and members. The overarching goal of the project was to collaboratively develop the Indigenous knowledge and western science knowledge for adaptation planning. We worked with five community teams consisting of up to four leaders from communities that chose to participate in the project: Iliamna, Kotlik, Kwigillingok, Quinhagak, and St. Michael. Community teams were developed through the application process and the project duration. Community teams were encouraged to have involvement from multiple governing bodies within the community that could include the Tribal Council, the city government, and the village corporation. The project title, with its references to the future (Looking Forward), past (Looking Back), and present (Building Resilience Today), refers to the idea that adaptation planning relies on all three perspectives. Equally important, however, is the dialogue to exchange past and present information, context, and what we expect in the future. Accordingly, two training sessions held at the International Arctic Research Center in Fairbanks, Alaska at the beginning and near the end of the project were developed to provide community team interaction with each other and with university and federal science partners. The project team also traveled to the partner communities and held a series of onsite events with community members to document locally-relevant information and share climate science tailored to the needs and conditions of each community. This report represents the community information shared during those onsite events. The Meeting Announcement (page 5) shows the date and description of the outreach events.

The purpose of these events was to: 1) facilitate mapping of a Traditional Use Area to refine an area for climate projections; 2) construct current and past seasonal Subsistence Calendars to identify important species and times of the year; 3) document Indigenous and local knowledge from current community members about environmental changes they have observed over their lifetimes; and 4) assist with documenting what the community perceived to be climate-related issues through photos and interviews. The agenda of the visits was co-produced with the community team. In each community, the community team and the project team co-hosted an open-to-the-public meeting and met with various groups. The community team advertised the meetings by posting community fliers, making announcements on the community radio, and reaching out to individuals that would contribute to the engagement discussions. Each community meeting focused on activities to develop seasonal Subsistence Calendars, map Traditional Use Areas, and document observed environmental changes. Community members spent time at stations dedicated to each of these activities working with project team members. The project team also met with various groups of individuals that included village corporation, tribal council, and city representatives where additional information about observed environmental changes was gathered. This community report presents some of the information developed in these activities.

MEETING ANNOUNCEMENT

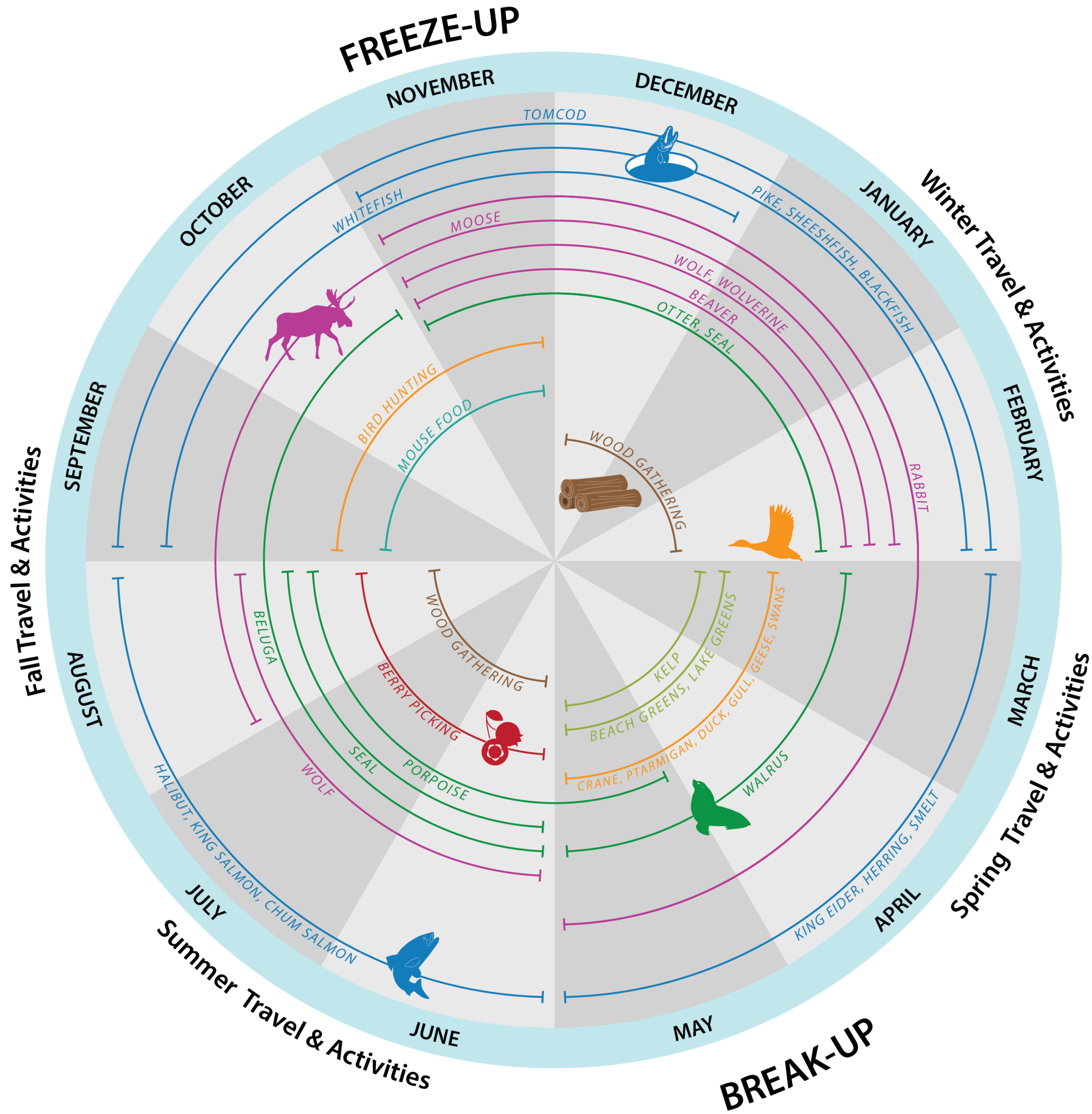
CLIMATE CHANGE IN KWIGILLONGOK

Share your experiences.

A team of Kwigillongok community leaders, along with the Aleutian Pribilof Islands Association and the Alaska Climate Adaptation Science Center, invites you to attend a series of community events on **August 26-28th** to discuss climate change impacts and gather information on changes to local lands, waters, and fish and wildlife. We will also explore adapting to change through traditional knowledge and practices in the community.

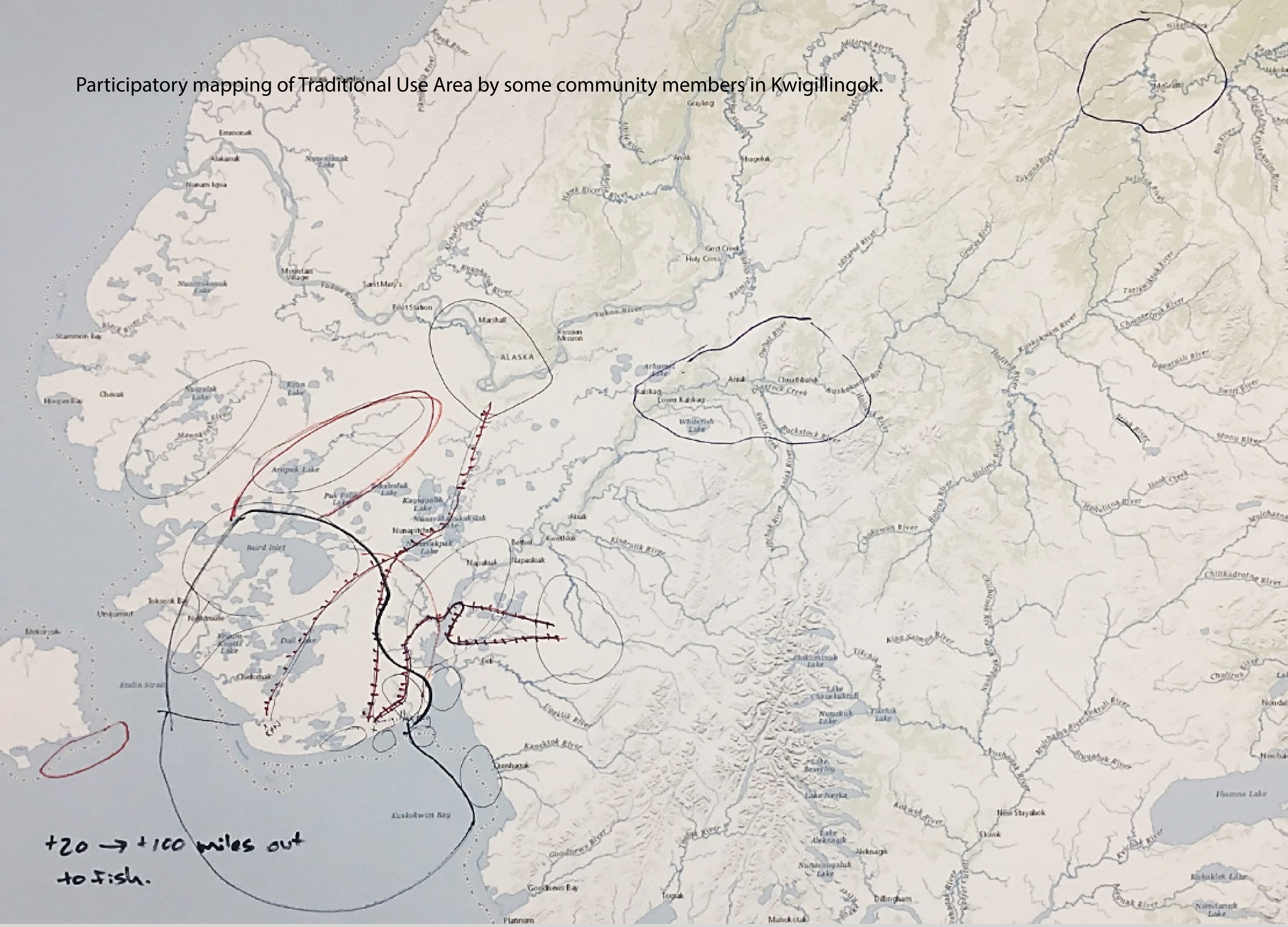
Schedule

Event	Time & Location	Description
Work Session with Local Community Team	August 26th, 10 A.M-12 P.M. Location	Review Training One draft report and evaluation feedback.
Meet with Village Corp Land Committee	August 26th, 1:30-3:30 P.M. Location	Visiting partners and community team meet with the village corp.
Community Meeting	August 27th, 7-9 P.M. Location	Hear about future climate change impacts projected for the Y-K area and share information on community change.
Mapping Exercise, Voluntary Interviews, and/or Focus Groups	August 27th, 1-4 P.M. Location	Meet informally with visiting partners one-to-one or in small groups to document any information related to land use and current change.



SUBSISTENCE CALENDAR

At the Subsistence Calendar station participants worked on two separate sheets of paper to list the many plant, marine mammal, fish, bird and animal species they rely on and harvest. One list focused on the current subsistence species while the other list focused on subsistence species in the past. After the list of species had been completed, participants then placed the species on a circular calendar during the time of year the species were harvested. In order to document observed changes, participants were asked to list past and current subsistence hunting or gathering practices, identifying any observed changes in the arrival, harvesting or hunting time of key species. This exercise provided an opportunity to recognize the variety of species that each community depends on and has concerns about. Participants also had further opportunities to share brief stories and observations of change.



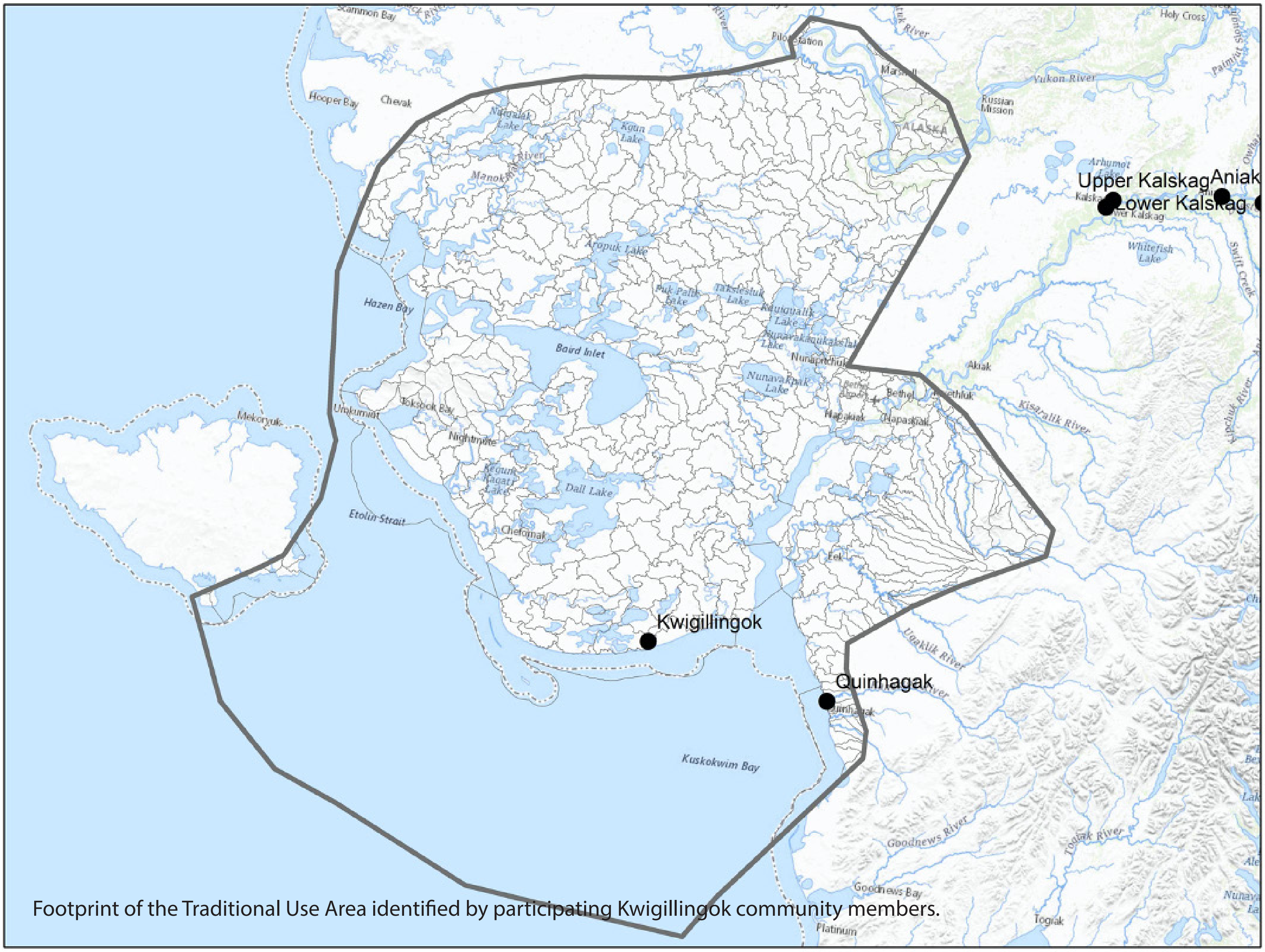
Participatory mapping of Traditional Use Area by some community members in Kwigillingok.

KWIGILLINGOK COMMUNITY MAP

A meeting with members of the Native Village of Kwigillingok, Kwigillingok Village Council, Lands Council and Kwik Incorporated.

Each Alaska Native community in Alaska historically had a Traditional Use Area, or traditional territory, prior to the 1971 passage of the Alaska Native Claims Settlement Act (ANCSA). Alaska Native communities still have common use areas that may be based on current land use and ownership, or historical land use. For this exercise, we asked communities to identify these areas. In addition, we asked communities to identify anywhere they traveled by foot, boat, ATV, or snow machine for purposes beyond subsistence that included potlatches, basketball tournaments, and other travel.

At the Traditional Use Area activity station, the project team provided the community teams and participants with large scale maps of the land and area around their villages (United States Geological Survey topomaps) and various colored markers. Working in their teams, they identified a use area by drawing directly on the large paper maps. Each community constructed their own legend that described the map they drew. The project team then used these maps to develop detailed regional climate projections for each community. Many communities identified general subsistence areas and routes taken to access these areas and other communities.



Footprint of the Traditional Use Area identified by participating Kwigillingok community members.

DIGITIZED COMMUNITY MAP

The community members outlined a Traditional Use Area during community meetings. Areas and trails were drawn on a printed USGS map. These were transferred to a digital representation using computer Geographical Information System (GIS) software (ESRI ArcMap within the GIS). A 'footprint' of the area was also created that encompassed the entire Traditional Use Area. Participants have a digital version of their Traditional Use Area for future purposes. These digitized 'footprints' were then used to refine the spatial extent of the climate projections averaged for the region of interest.

Windmills in Kwigillingok.

ENVIRONMENTAL OBSERVATIONS

During the public community meetings and the smaller group meetings during the community visits, participants were asked if they had observed any environmental changes throughout their lifetime. These observations were documented and attributed by the project team during the community visit. After the community visit, project team member Ryan Toohey (AK CASC) organized observations into themes by one or more topics (traditional methods, subsistence, weather and climate, etc. – see below, pages 10-14) using a process called 'coding'. The same observation could belong to several different themes as long as it pertained to the theme in some way. These themes were developed from the observations so that community members could quickly find Indigenous and local knowledge that pertained to a certain subject. The community teams reviewed and agreed on these themes when they reviewed the draft documented observations during the second team training (see Project Description above, page 3).

Notes on observations were taken rapidly by hand in a necessarily informal form and were reviewed and appoved by the community. In the interest of preserving the words of the community as closely as possible to this original form, editing in the following section was kept to a minimum and only utilized to preserve space and increase readability.

Permafrost thaw has led to coastal erosion in Kwigillingok.

QUESTIONS/RESOURCES REQUESTED

Community members raised the following questions.

How is climate change going to impact infrastructure?
Where should relocation should occur? - Willie Atti
What's causing global warming?
There is concern about plastic in the ocean.
There is concern about Fukushima.
There are reports from northern friends of seals dying, birds dying. What's causing these die offs?
What is Kwig going to be like in the near future? - RJ
Example: village wanting to relocate? We've already moved further away from the coast.
How will the land change in the future?
How can we integrate these changes into the school curriculum so they can be prepared?

Community members requested the following resources.

We need guidelines/procedures around climate change and food security
Land ownership map would be useful for decision-making - RJ
If conditions get worse, what plans can we use to protect the general public? - Darrel T

OBSERVATIONS

Climate & Weather

- Since the 1964 earthquake, climate and water conditions have been slowly changing. There are shorter winter periods with more floods. The ground is going to change too. - David
- One mile north, a lake sunk along with the land - RJ & David
- There have been lots of changes. It's warming up. There is more moisture in the winter time and warming up in January. Its not safe to travel. We did not go as far. I usually trap, but creeks were open. Same for in the spring-time with logging. This past winter was worse for traveling. We often travel at night. One person died and fell into the creek. The Kuskokwim ice was not good. Sea ice went out too early. Each year there is less and less ice. - Johnny Friend
- 1 week was hotter than normal in Kwig. A hot day was in the high 90's. - Emma Oscar
- Warmer mild winters make cold temperatures feel really cold. My mom told me to gather more than usual because things are changing so much. Things are dying. - Emma

Ice

- Freeze up has been later. There is more time for walrus harvest and seal. - Lewis
- Used to have thick ice, now it's completely different. Not getting thick Ice. - RJ
- Kuskokwim River does not freeze that much anymore. It used to freeze 4-6 ft thick. It used to have ice jams. The ice jams were better to create more driftwood for sending it down the river. - Willie Atti
- The sloughs used to have solid ice, but now they are open throughout the year. There is more warmer weather in the winter. - David
- Thickness of ice on coast has decreased, no shore ice, its not piling up any more. - Willie Atti
- You can see the ocean water open through all the year. - David
- Used to ice skate in early October. - Andrew
- Ocean ice conditions are not as thick. It makes seal hunting more difficult. Some seals have left or don't come any more. - Darrel

Rain

- We had a wet August. A couple of years ago, August through November was rainy while November through February had less precipitation. - John C and Darrel T

Seasons

- Winters already seeing changes. Winters are shrinking, shortening. - RJ
- Elders used to say winters will not be like this in the future. - RJ
- More warmer weather in the winter. - David

Vegetation

- No spruce trees in the past, but there are some now. - RJ

Water

- Lakes are draining. Creeks are forming. - Willie
- Lakes drain out-related to permafrost, land changes, the ground around it also falls. - RJ
- Spawning grounds are low on water. High water temperature this summer killed eggs and fish. - Willie Atti
- More ponds are drying. Now, storm surge flooding happens every year. - Darrel

Flooding

- The heart of the village use to be south near the coast. Now, its migrating north. The area in front of the school with normal high tide, now gets submerged. - Willie
- In 2016-2017, residents from downtown were evacuated to school because of flooding. - Lewis
- High tide overflows now, even when its clear and calm. Water used to stay on ground for awhile. Now stays for only a few days then soaks into the ground. - David Johns
- There are shorter winter periods with more floods now. - David

Land

- Earthen mounds are disappearing. The high ground is sinking. Its happening at a really fast rate. Its happening regionally. Permafrost is melting. I am personally considering relocation. - Willie Atti
- One mile north, a lake sunk along with the land. - RJ & David
- The coastline has lowered. We used to not be able to see boats from very far out. Now, we can see them at the coast. Moose too! - RJ
- Recently, a wedding guest returned to Kwig that was born and grew up here. She thought the land has fallen. - Lisa
- Ground is going to change too. - David

Erosion

- Monitoring erosion at barge landing, Kwig Inc Store, north of HD 2020 light poles. - Darrel

Subsistence

- We used to get wood there (Yukon River), now we go way up Kuskokwim. Not getting as much drift wood. - RJ
- There are huge die offs now for fish, birds, and seals. - Darrel

Salmon

- Its affecting fishing on the Kuskokwim River. There is no more commercial fishing. The spawning grounds are low on water. High water temperature this summer kills eggs and fish. - Willie Atti
- Quinhagak had some fish kills. - Jon Carter
- Floating fish on Kusko from mouth to Tuluksak: Salmon (reds), whitefish. - Andrew
- Kuskokwim river channels have changed with more mud flats now. Fish were easier to catch in the past. Now, we have to travel 20-100 miles. Fish and Game closing periods are hard. Old ocean river channels are changing. - Willie Atti

Other Fish

- We used to cache tomcods for the winter. Now, there are less tomcods and more smelts (both tomcods and smelts are anadramous). - Andrew

Caribou

- There used to be lots of caribou (1917), but not anymore. - Darrel and Emma

Birds

- Ptarmigan should be gathering at the mouth of the Kuskokwim River right now to migrate. They are not there anymore. Alaska Fish and Game are studying the declining ptarmigan. Climate Change might be the cause. Radio collars are no good for the ptarmigan. Their feathers are too fragile. Feathers will break when it gets to cold. - Johnny Friend
- Sea gulls die off across the river this year. - Emma Kiunya
- No more good ground to hunt black brant, white fronts, king eiders: no more ice so no more places to hide. Used to see ptarmigan much, may not see them anymore - Darrel
- Less reliance on eggs. - RJ

Seals

- Ocean ice conditions are less thick, so seal hunting is more difficult. Some seals have left or don't come any more. There are three types of seals we're not getting anymore due to lack of ice. - Darrel

Walrus

- In 2016 and 2018, Walrus dominated spring season. This year, they dissappeared when the ice drifted away. - Darrel and Emma

Traditional Methods

- The hunting/harvesting system given to us by our Elders has greatly changed. We need to keep one part, we need to hunt when things are there. - RJ
- Johnny Friend's father's generation learned from (and perhaps did themselves) using entirely traditional equipment. The rate of change in hunting practices may have changed rapidly both with the climate and with the access to different tools. As a result, people now have a completely different range of travel and usual resource use.
- When the animals show up, you get them. If fish too late, then point to weather. - Traditional Knowledge
- Our Elders talked about changes before passing away because they knew the changes by observing; never used to believe then but now I do: waterfowl, big game, sea mammals, and fish. - Johnny Friend
- "We used to wear seal mukluks (points to over-the knee height), now we can wear tennis shoes all year long". People used to make mink, beaver, muskrat parkas and used to wear seal skin mittens over gloves. Also changing in transportation. - Emma
- Too hot for seal hat this year. Darrel

Infrastructure

- We need to jack up houses more often now. We need to wait till the winter time. - Lewis
- Really slow process for relocation, and relocating homes to tribal land. - Lewis
- He jacks his house up about 2 feet each year in the fall when the ground freezes up, and by the end of spring it sinks when the ground thaws. - Johnny Friend
- Here, foundations, church, and pads sank further in. We got a FEMA grant in 2018, but not enough capacity for heavy equipment operation and maintenance. We need new equipment too: a bull dozer D6/D9 dozer. - Darrel T

Fire

- Small tundra fires have occurred around Kwig. - Lewis and JC

Adaptations

- Husband wanted to buy snow machine. She thinks not as much snow anymore, ATV better. - Lisa

Riverine erosion monitoring in Kwigillingok.

Permafrost

- When he was a child, he could dig down about 30cm in the summer and find permafrost. Now, it is much deeper. - Johnny Friend

Miscellaneous

- Lewis does not agree with ALFRESCO. He thinks the area NW of Baird Inlet will not have spruce like the projections say. He thinks it is too high/dry and in any case there are no spruce there now, just birch. - Lewis Amik

A community meeting in Kwigillingok discussing climate scenarios and projections.

SNAP ONLINE TOOLS

Overview

The second Fairbanks training (see project description, page 4) introduced community teams to online climate information tools developed by The Scenarios Network for Alaska and Arctic Planning (SNAP) at University of Alaska Fairbanks, where the training was held. The goal of these sessions was to introduce community team members to how they might use these tools to develop information for their planning efforts and to learn more about potential impacts in their regions. For this report, the region around each community was considered and a specific narrative for that region was developed to illustrate the potential changes and impacts indicated by each tool. The following pages illustrate the results from each tool for Kwigillingok.

To explore how climate change might affect you, use the SNAP web tools at https://www.snap.uaf.edu/tools to get a hands-on, user-friendly overview of how climate change may affect regions or resources of concern to you. Many of these tools were introduced during the BRT Training 2 in Fairbanks. All of them can be freely shared. The summaries below help explain f the results from each tool for Kwigillingok.

Questions & Feedback

SNAP is always seeking feedback about the usefulness of our online tools, and about the way we share climate change information. As you read through this document and explore these online tools, it may help to keep following questions in mind – and to think about how your feedback might help us improve:

1. How do changes in average temperatures affect your experience on the land in both the short-term and the long-term? Are short-term effects such as extremely hot days more important, or are long-term trends such as loss of permafrost and river ice more important?
2. What effects that you are experiencing can be linked to changes in vegetation? Which aspects of climate (e.g. hotter summers, fewer cold winter days, drying soils) do you think are most important in causing these changes in vegetation?
3. Is loss of sea ice important to your community? Directly, or only indirectly? What do you think would happen if sea ice almost entirely disappeared in the Bering Sea?
4. What would you like to measure and track in your community (e.g. water temperature, berry crops, dates of seasonal events, numbers of animals sighted) in order to get better data on climate change?

About SNAP

The Scenarios Network for Alaska and Arctic Planning (SNAP) is a climate change research group in UAF's International Arctic Research Center (IARC). Since 2007, SNAP has used climate data to create and share ideas of what a future Northern climate could look like. SNAP works with people, communities, and organizations to plan for a changing climate. To learn more about climate models, methods and projects in Alaska, visit SNAP's website at www.snap.uaf.edu. Some of these data were used to create climate projections for the BRT project.

SNAP

Community Climate Charts

https://snap.uaf.edu/tools/community-charts

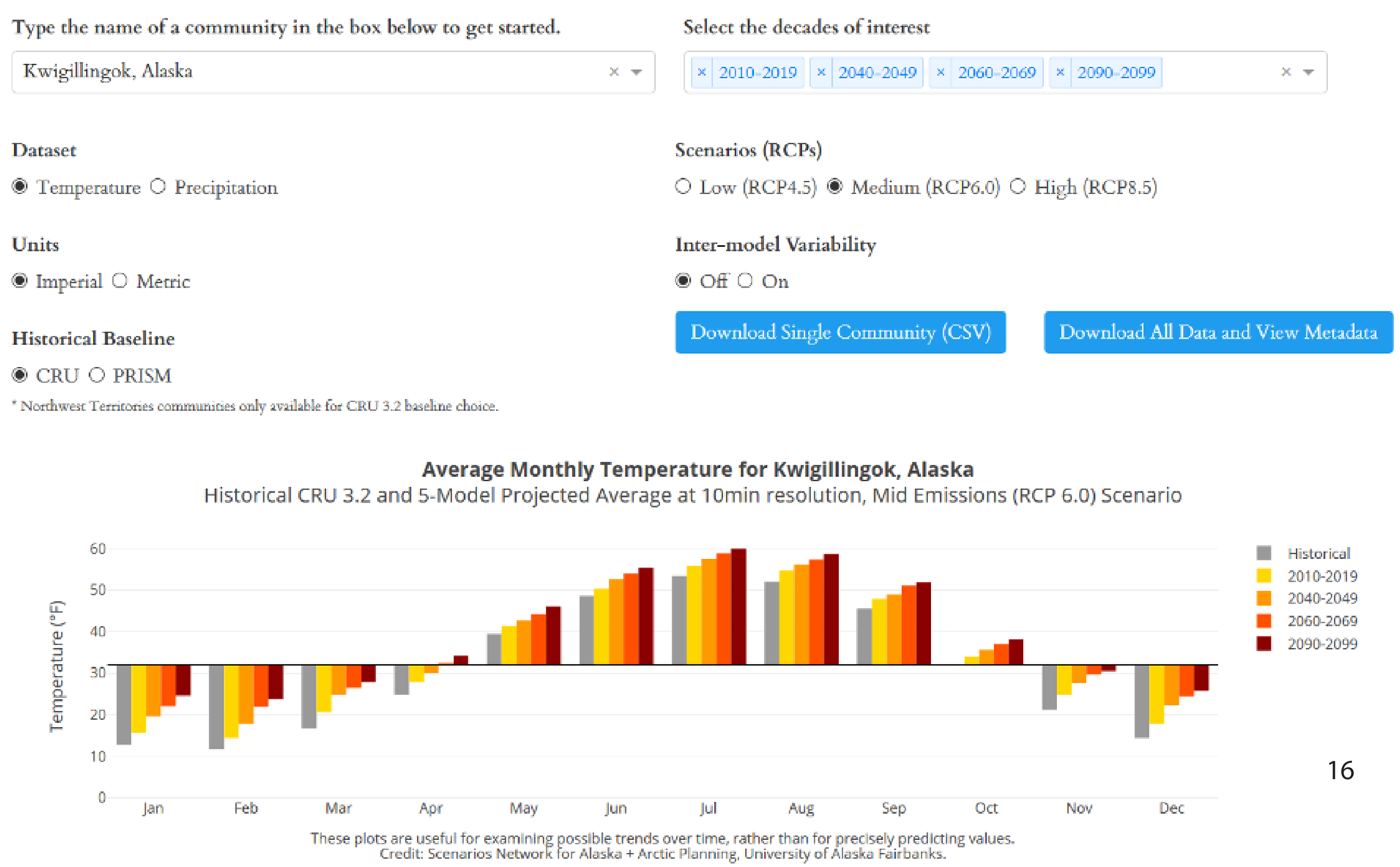
The Community Climate Charts tool allows users to select their own community, and view a graph of temperature or precipitation projections by decade, as compared to historical baseline values. In this case, Kwigillingok has been selected, and the graph shows temperature for the past, for the approximate present, and for future decades.

Note that overall changes in temperature tend to be greatest in winter, but shifts in fall and spring freeze and thaw may prove to have the greatest impacts. For example, although historically the month of April had average temperatures well below freezing, by the end of this century April is projected to average well above freezing.

Connections to changes described in Kwigillingok BRT community meetings and activities:

- Freezup is getting later, shorter winters, less ice, thin ice, limited time for seal and walrus, travel is more dangerous, shift from snowmachines to ATVs

CRU (Climatic Research Unit, University of East Anglia, UK) and PRISM (http://www.nacse.org/prism/) refer to historical climate estimates made using weather station data and computer modeling of what climate would be between weather stations. RCPs refer to pathways of future climate that would likely occur under different concentrations of greenhouse gases (see page 22 for explanation).



Community Permafrost Data

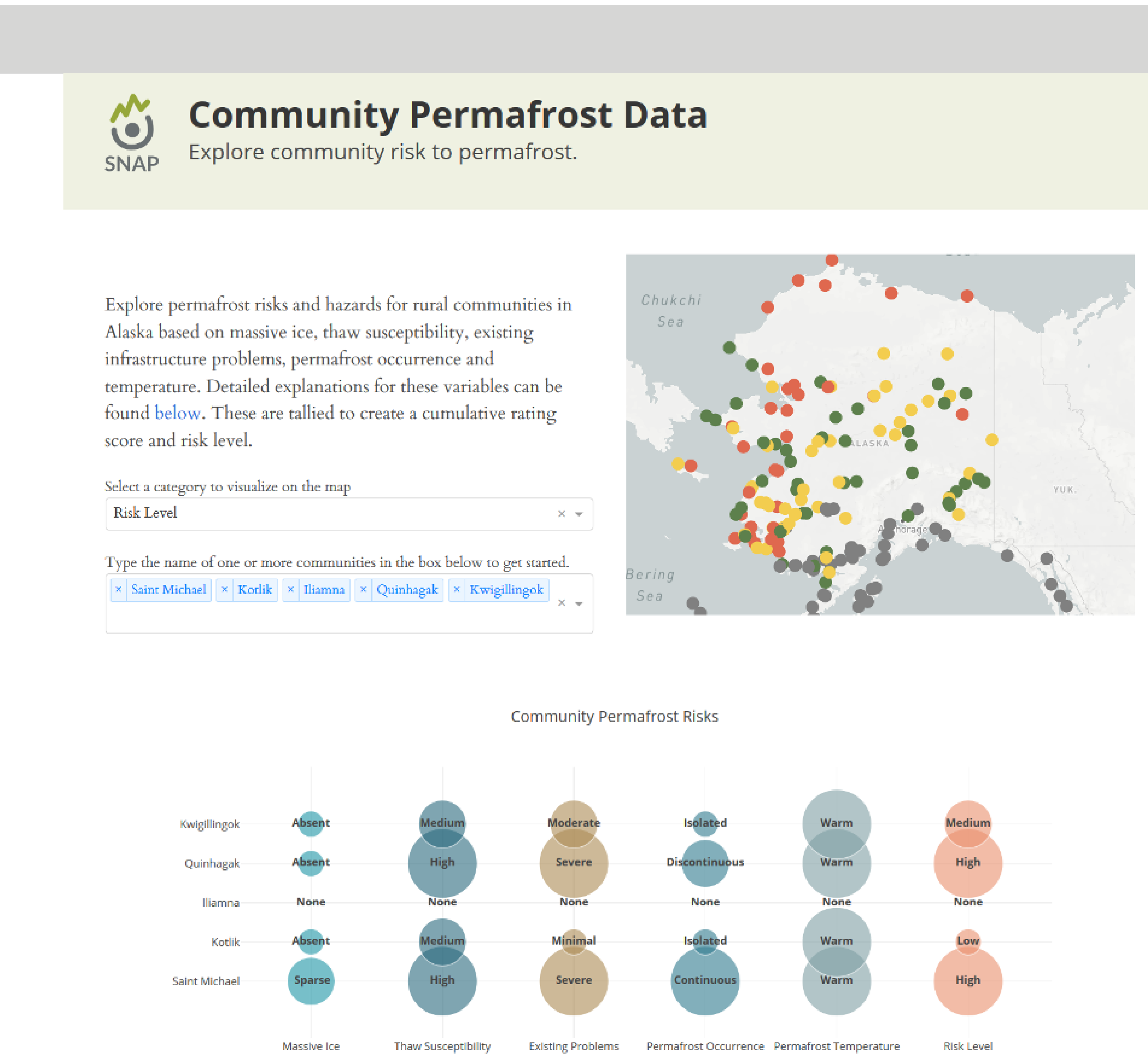
https://snap.uaf.edu/tools/permafrost

The Community Permafrost Data tool allows users to select one community or multiple communities, and to see relative conditions for several permafrost characteristics including: massive ice, thaw susceptibility, existing problems, permafrost occurrence, permafrost temperature, rating score, and risk level. Here, the project team selected all the communities that participated in the BRT project so that community team members can see the differences.

Note that variables are linked. For example, where permafrost has already been lost, risks are generally considered lower than where active loss is occurring. In Kwigillingok, overall risk level is ranked as "medium". Discontinuous permafrost is present, but has already become isolated. Remaining permafrost is warm and at great risk of thaw in the near future. The community risk level for Kotlik indicates the tool characterizes existing problems as "moderate" compared to some of the other communities in the project.

Connections to changes described in Kwigillingok BRT community meetings and activities:

- Flooding, erosion, permafrost loss, ground sinking, earthen mounds disappearing, houses sinking.



Historical Sea Ice Atlas

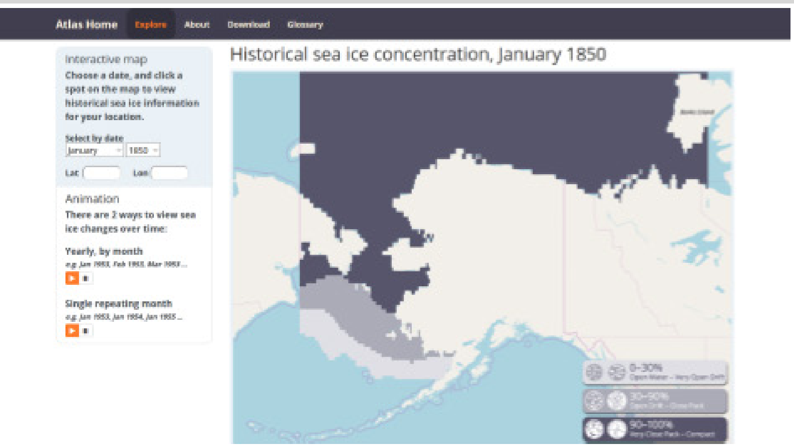
http://seaiceatlas.snap.uaf.edu/explore

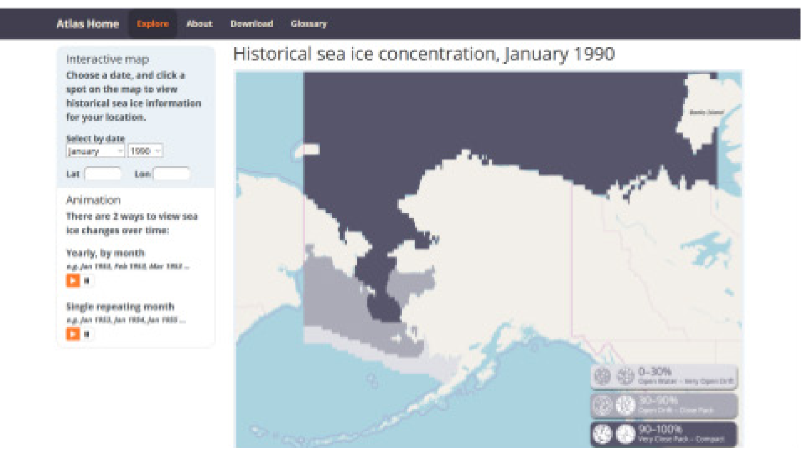
The Historical Sea Ice Atlas online map and animation tool shows historical sea ice for any month of any year from 1850 to the present. It can be animated to show change over time by month or by year. This tool does not provide future projections, but can be a useful visualization for showing trends that are expected to continue.

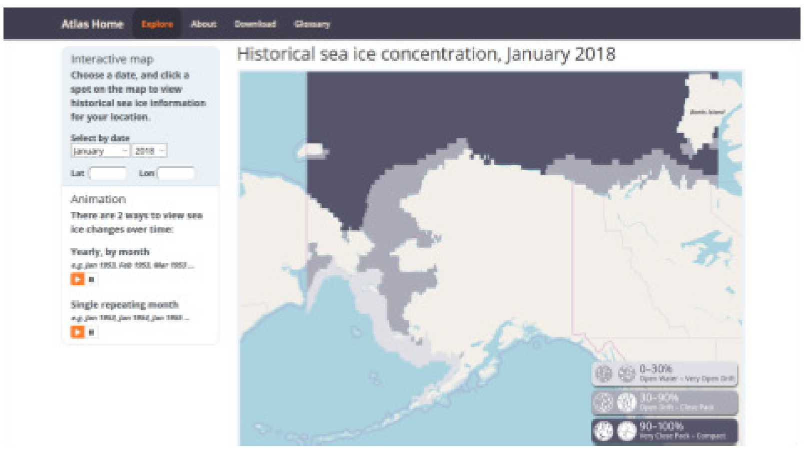
As shown in the figure and supported by local observations and memories, ice coverage used to be consistent, decade after decade. Declines started in the 1970s, and have continued thereafter. Around Kwigillingok, areas that reliably had substantial or total ice coverage are now seeing poor ice coverage or open water. Seasons are becoming shorter in both spring and fall. Shorter ice seasons disrupt many species and many traditional activities.

Connections to changes described in Kwigillingok BRT community meetings and activities:

- Warmer water killing eggs and fish, no more commercial fishing.







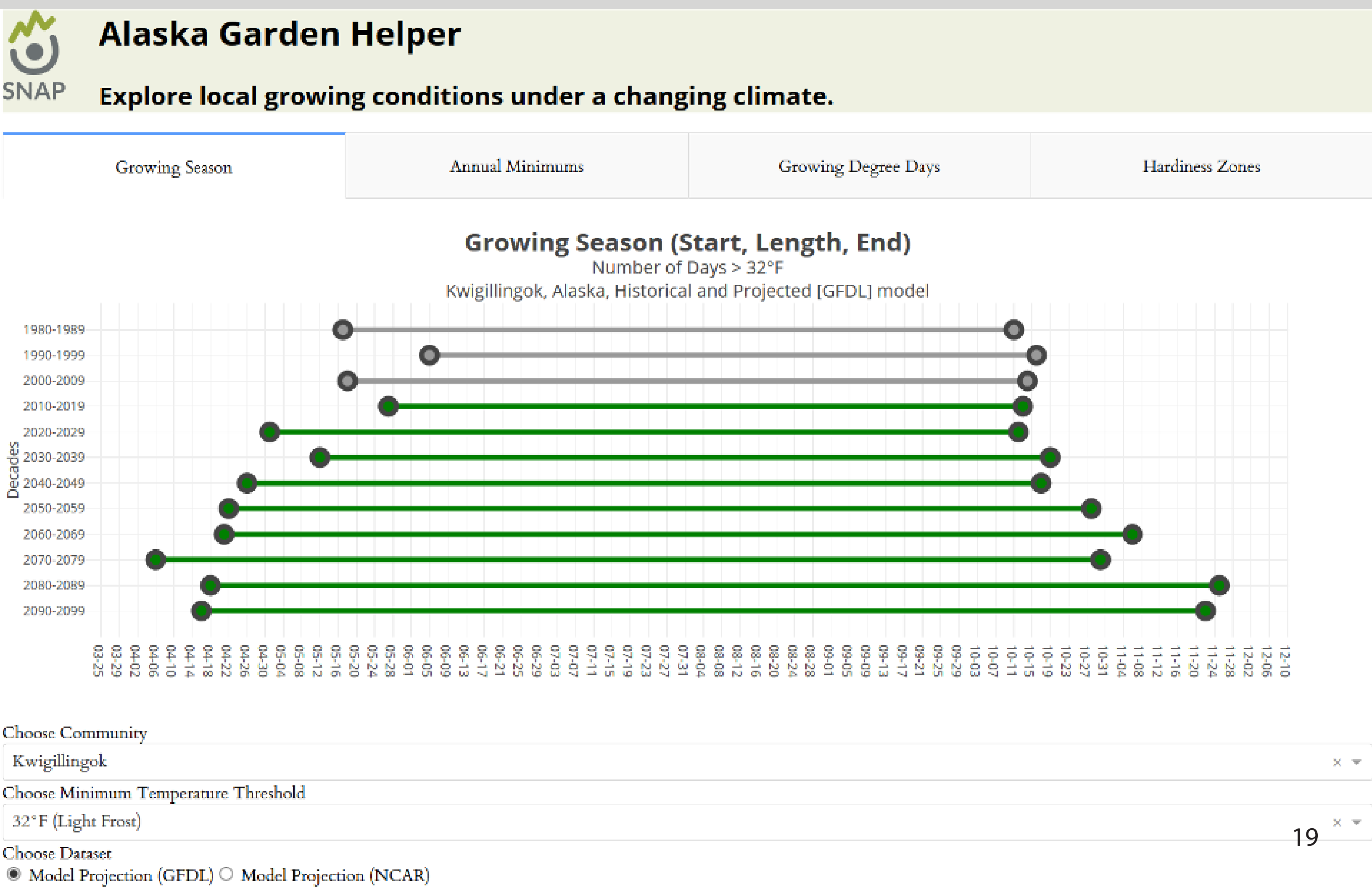
Alaska Garden Helper

https://snap.uaf.edu/tools/gardenhelper

Though designed for gardeners and farmers, this Alaska Garden Helper tool provides useful projections of warm season length and extreme winter cold – variables that also affect natural ecosystems. Longer summers, hotter summers, and loss of limiting cold in winter can greatly change the plants and animals on the land and in the water – changes that community members are already reporting in Kwigillingok.

Users can select their community and can choose from several tools and temperature thresholds, including 28°F, 32°F, 40°F, and 50°F. Each selection will generate a new graph.

Summer season length in Kwigillingok, as measured by the precise dates of last frost and first frost, will continue to be highly variable, since a difference of one degree can register as a large shift. However, on average the summer season will expand greatly into the shoulder seasons. Coldest winter temperatures will become much warmer, as shown by the "Annual Minimums" and "Hardiness Zones" tabs within this tool.

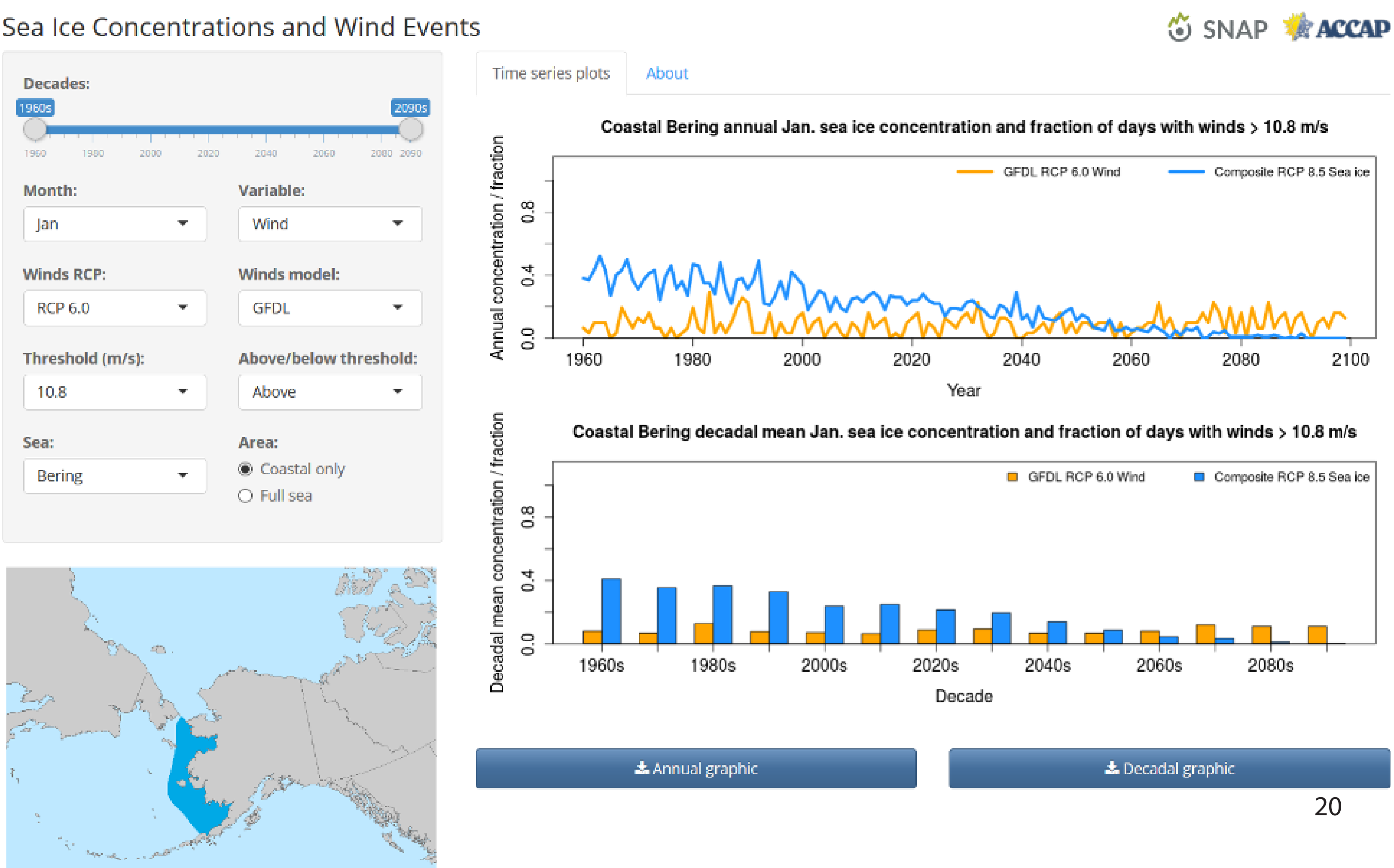


Sea Ice and Wind

https://://uasnap.shinyapps.io/sea_ice_winds/

This Sea Ice and Wind tool explores the interactions of wind and ice. Users can select a sea – in this case, the Bering Sea – and generate graphs for selected months and time periods.

Outputs for wind are highly variable, and may not indicate clear patterns of change, but outputs for ice show obvious severe declines, ongoing and into the future. These results are averaged across the area of the Bering Sea shown in the map, and thus are not specific to any one community. However, with normal variability in winds and wind events, loss of ice can lead to severe erosion throughout coastal regions.



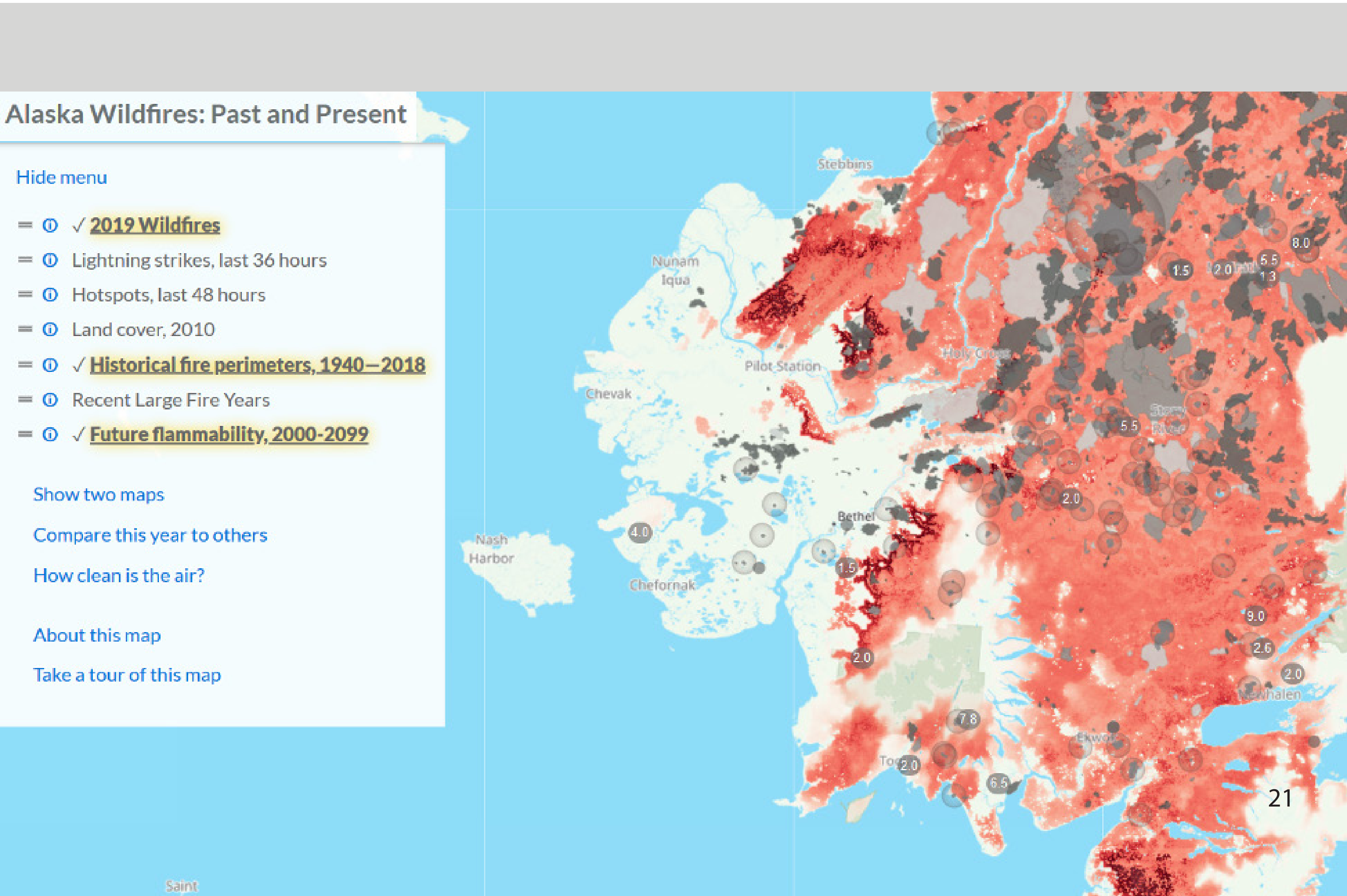
Wildfire in Alaska

http://mapventure.org/#/map/fires

This Wildfire in Alaska map tool explores past and future fires statewide. The map is zoomable, and offers multiple features that can be turned on or off.

The map below shows eighty years of past fire scars, shown as gray patches. The summerfires of 2019 are shown as small gray circles. Note that many 2019 fires occurred in areas much farther southwest and much closer to the coast than typical historical fires. This map also shows modeled future flammability, with darker reds indicating larger changes in future flammability. See page 45 for traditional use area scenarios for changes in flammability. Due to hotter temperatures and expansion of shrubs and trees, flammability is spreading closer to areas such as Kwigillingok that have little or no history of fires.

Smoke from fires can affect areas that are not themselves on fire or fire-prone. Thus, an increase in fires – particularly fires that are relatively close -- can affect the health, activities, and quality of life of community members in Kwigillingok.



CLIMATE CHANGE AND IMPACTS PROJECTIONS

Overview

In each community workshop, we reviewed potential future climate conditions and some changes in the environment that we would expect from those conditions. These future conditions are called "scenarios" because we don't know exactly what the weather and climate will be like, so we look at a range of possibilities from some warming to more warming. We also use two time ranges for these futures, 2040-2069 and 2070-2100, because different climate effects might take different lengths of time to happen. We learned in the Fairbanks trainings how scientists use complicated computer climate models to work out what the climate might be and how it affects fire, plants, and permafrost. We also learned that there are a lot of these models, and while all of them are scientifically reasonable, the future climates they project vary. So we also use the average of five different climate models for future climate scenarios. For the fire, land, and permafrost changes, two different climate models (a warmer one and one with less change) were used. At the community visits, we brought maps of these changes for the region and talked about them with community members.

For temperature, precipitation, and snow, the historical and future climate used to map changes came from University of Alaska Fairbanks Scenarios Network for Alaska and Arctic Planning (SNAP). Climate models simplify the real world, and this computer version of the world can be too simple for community planning because the model can only see detail for larger areas (like a square with 50 or more miles on a side). The climate for this project has been mapped to smaller areas (like squares less than a mile on a side). This information is available for five climate models that work well in the Arctic – they describe sea ice and the atmosphere in ways that look like historical weather we know occurred.

The average changes from these five models are shown for two futures: one where there is moderate warming, but eventually it slows down because of less coal, oil and gas use (which cause an increase of climate warming gasses in the atmosphere) and one where there is higher warming that continues to increase. These are called "representative concentration pathways" or RCPs for short - RCP4.5 is medium warming and RCP8.5 is higher warming. Lower rates of warming are possible with large changes in global policy and changes in coal, oil, and gas use, but we are currently heading for the moderate or high warming future so we did not choose a low warming scenario (RCP 2.6). The climate changes in the maps are compared to the 1970-1999 historical climate. The numbers in the upper left of each map page are the scenario averages for the four panels over the community-defined Traditional Use Area.

During the Fairbanks training we talked about when climate models do a pretty good job and when and why they are more uncertain. The scenarios that result in the maps in the next section address three main kinds of uncertainty. Using several climate models accounts for differences in climate models. Using a medium warming future and a high warming future addresses the uncertainty in how much change from climate warming gasses we think may happen. Using thirty-year averages decreases the effect of warmer or cooler, wetter or drier decades that happen for natural reasons. Together, these three things (using 5 climate models, using a medium and high warming scenario, using multiple decades) give us a more reliable range of future climates we can expect.

Permafrost futures (average yearly ground temperature at 3 feet deep) were available for two climate models under an older scenario (called A1B), which is in between the medium and high warming futures for the climate, fire, and land changes. The fire and land changes were available for two climate models used to provide temperature and precipitation to a land model that simulates vegetation and fire under the higher warming future.

Specific questions about any of the projections mapped here? Contact Jeremy Littell, Alaska Climate Adaptation Science Center, jlittell@usgs.gov. Further details on variables can be found in the SNAP data archives:

http://ckan. snap.uaf.edu/dataset

Kwigillingok projected climate changes and impacts

For the near future, about 2040-2069, Kwigillingok Traditional Use Area average annual temperatures are expected to increase +5.9 °F under medium warming and +7.7 °F under higher warming compared to 1970-1999. For the later future, about 2070-2099, Kwigillingok average annual temperatures are expected to increase +7.6 °F under medium warming and +11.3 °F under higher warming compared to the period 1970-1999. Warming will probably be greater in autumn and winter than spring and summer. Annual average precipitation (rain and snowfall) is expected to increase about +17% under medium warming and about +21% under higher warming for the near future 2040-2069 relative to 1970- 1999. Annual average precipitation is expected to increase about +19% under medium warming and about +33% under higher warming for the later future 2070-2099 relative to 1970-1999.

Precipitation increases will probably be greater in autumn and winter than spring and summer. However, in northern forests like those in Alaska, it has been found that about 15% more precipitation is needed to keep up with the increase in water demand of about 2 degrees °F. So it is possible that even with more rainfall, water in plants during the warm season could decrease because precipitation increases would not be enough to keep up with the amount of water the heat can evaporate from the land and plants.

For 2040-2069, the amount of water available in April 1 snowpack (October to March snowfall water) is expected to decrease 5% under medium warming and decrease 14% under higher warming, compared to 1970-1999. For 2070-2099, the amount of water available in April 1 snowpack is expected to decrease 11% under medium warming and 31% under higher warming, compared to 1970-1999. Averaged across the Kwigillingok region, average winters are still expected to be snow dominant for the 2050s, which means that snowmelt will still usually be the main driver of streamflow responses. However, by the 2080s, rain and snow mixed will become more common in the southwest YK delta, including Kwigillingok, and more winters than in recent times could have a shorter snow season or more mixed rain and snow. Some areas of permafrost might stay until the 2050s under a lower warming climate model (called ECHAM5), but decrease under all other scenarios.

Areas to the north and east of Kwigillingok become good for spruce growth, mostly in places that were shrub tundra. More spruce growth is expected under the moderate climate model (called CGCM3) than the warmer climate model (called CCSM4). Future computer model land changes suggest spruce could become more common to the northeast of Kwigllingok. In the north central part of the region, some shrub tundra and birch/willow/alder forest may become grass tundra for the warmer climate model. Fire could become more common in the higher elevation areas northeast of Quinhagak and to the north and northeast of Kwigillingok. Some decrease in fire is projected in the far northeast part of the region for the moderate climate model under both moderate and high warming scenarios. Changes in vegetation are new kinds of plants growing where different plants used to be. These changes happen as new areas become good for plants, either because the climate is better for them or after fire or other disturbance. Both models project large landscape changes to the north, near the Yukon River and north east of Quinhagak.

Descriptions of variables

Temperature

Annual averages (12 months) as well as four seasons (Spring – March to May; Summer – June to August; Autumn – Septem¬ber to November; Winter – December to February). Maps (pages 27-31) show "deltas", or future projected changes, in surface air temperature from climate models compared to the same historical months or three-month seasons. The mapped changes are averages of 5 climate models and are displayed for two time periods as well as for both moderate and high warming scenarios.

Precipitation

Annual totals (12 months) as well as four seasons (Spring – March to May; Summer – June to August; Autumn – September to November; Winter – December to February). Maps (pages 32-36) show future percent change in precipitation (rain and snow) projected by climate models compared to the same historical months or three-month seasons. The mapped changes are averages of 5 climate models and are displayed for two time periods as well as for both moderate and high warming scenarios.

Snowfall, or snowfall water equivalent

Maps (page 37) show future percent change in total snowfall derived from climate model projections compared to the same historical months or three-month seasons. The mapped changes are averages of 5 climate models and are displayed for two time periods as well as for both moderate and high warming scenarios.

Snow Index

October to March amount of total precipitation that is snowfall, measured by the amount of water it contains. These are displayed as a percent; a value of 55% would mean that 55% of the total precipitation falls as snow between October and March. 55% means that 55% of the precipitation was snow, while 45% was rain. Values greater than 40% are snow dominated; values between 10% and 39% are transitional; values between 0% and 9% are rain dominated.

Ground temperature at 1m (3.3ft) depth

Annual average ground temperature at 1 meter (3.3 feet) deep in the ground. This is an index of permafrost stability or thaw. The colder it is, the more likely permafrost is to persist. Near freezing (0 °C or 32 °F), the permafrost is more likely to thaw. Above freezing, it is unlikely to persist into the future.

Changes in fires per century

The times an area burned under simulated historical (1901 – 2000) conditions is compared to the number of times an area burned under simulated future (2001-2100) conditions. Numbers over 0 mean an increase in fire (e.g., 2 would mean a doubling of fire frequency); numbers less than 0 mean a decrease in fire.

Changes in vegetation per century

The times the dominant vegetation in an area changed under simulated historical (1901 – 2000) conditions is compared to the number of times vegetation changes under simulated future (2001-2100) conditions. Numbers over 0 mean an increase in landscape change (e.g., 2 could mean a change from shrub tundra to spruce followed by a change to deciduous forest).

Descriptions of variables (Continued)

Current probability of permafrost

This map shows the current probability that the area has permafrost under it. Darker blue indicates a higher probability of permafrost.

Thermokarst predisposition

Thermorkarst occurs where permafrost thaws and causes the ground to slump or cave in. Dark blues indicate areas where a model designed to predict thermokarst potential indicates it is likely. **If the graphic is absent, the model indicated no thermokarst predisposition in the region, so the map was not printed.**

Change in months of reliable snow

For this map, a month with "reliable snow" was defined as a month where, on average, more than 70% of the precipitation arrived as snow. The historical (1970-1999) months of reliable snow were compared to the future (2040-2069) months of reliable snow for RCP 8.5 (higher emissions), and the change calculated as future minus historical.

Map picture file abbreviations

All maps in this file are also in a folder with each map by itself. There are "small" maps that you can use in Word or PowerPoint (or other software) documents for reading. There are also "big" high resolution maps that could be printed off as posters or zoomed in on the screen and keep higher detail. The file names are abbreviations– here is what they mean:

dPann – change in annual (January to December) precipitation
dPdjf – change in winter (December, January, February) precipitation
dPjja – change in summer (June, July, August) precipitation
dPmam – change in spring (March, April, May) precipitation
dPson – change in autumn (September, October, November) precipitation

dTann – change in annual (January to December) temperature
dTdjf – change in winter (December, January, February) temperature
dTjja – change in summer (June, July, August) temperature
dTmam – change in spring (March, April, May) temperature
dTson – change in autumn (September, October, November) temperature

dswe – change in snowfall water amount, October to March
dFireCen – changes in numbers of fires per century
dVegCen – changes in vegetation per century
sno – snow index, the range between rain dominated and snow dominated
t1 – temperature at 1m ground depth

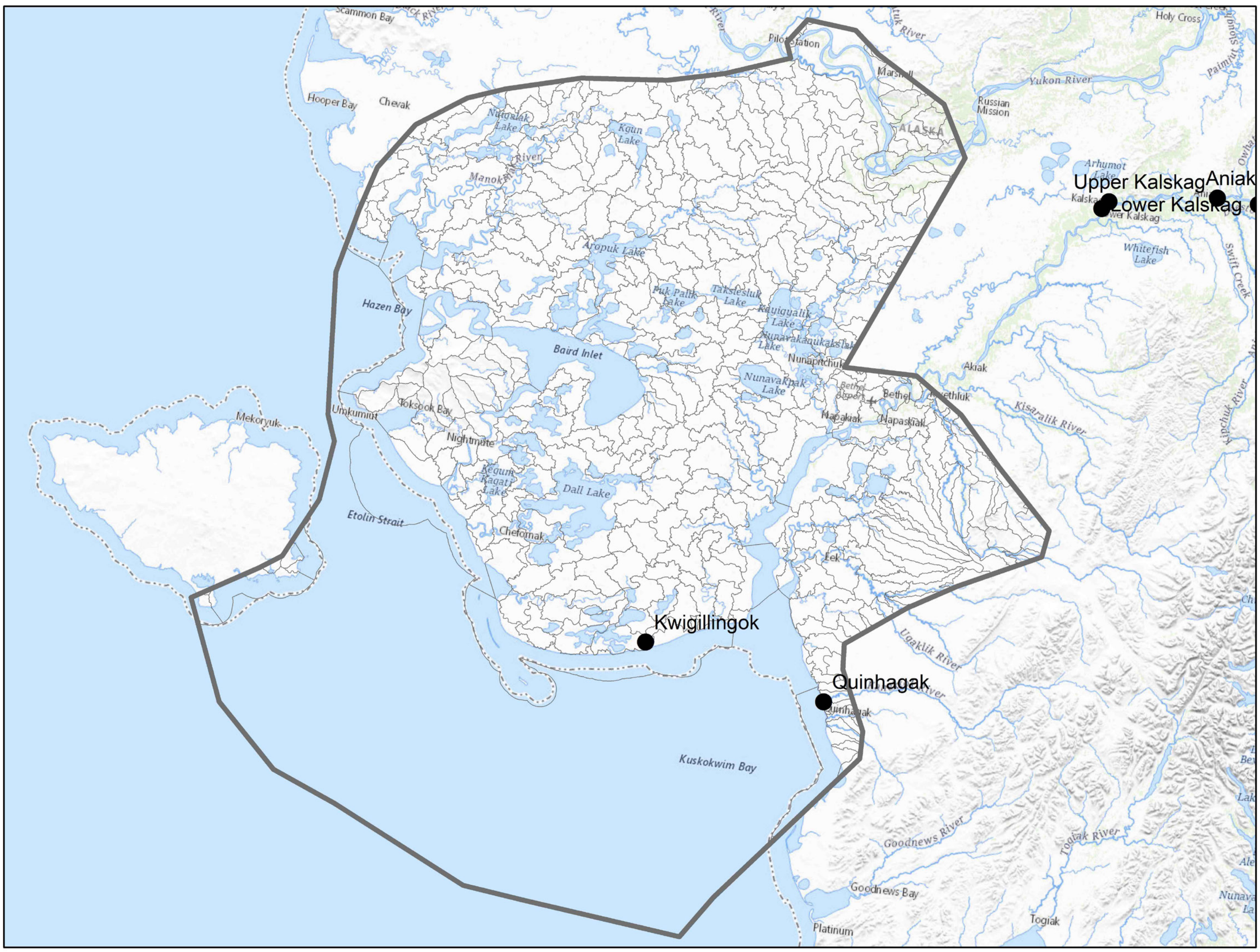
5045 – 2050s (2050-2069), RCP 4.5 (mid century, medium emissions)
5085 – 2050s (2040-2069), RCP 8.5 (mid century, higher emissions)
8045 – 2080s (2050-2069), RCP 4.5 (late century, medium emissions)
8085 – 2080s (2040-2069), RCP 8.5 (late century, higher emissions)

CCMA and ECHAM5 refer to climate models used in permafrost work. CGCM3, GFDL CM3, GISS E2R, IPSL CM5A LR, and CCSM4 refer to climate models used in the projections of temperature, precipitation, and snow. CGCM3 and CCSM4 are used in the vegetation and fire projections."

Kwigillingok region and watershed boundaries

Kwigillingok region outlined includes the areas defined by community workshop participants as important. The many lines within the region show watershed boundaries (called hydrologic units or HUC12s). Many of the following maps show average conditions for climate change and its effects within each watershed.

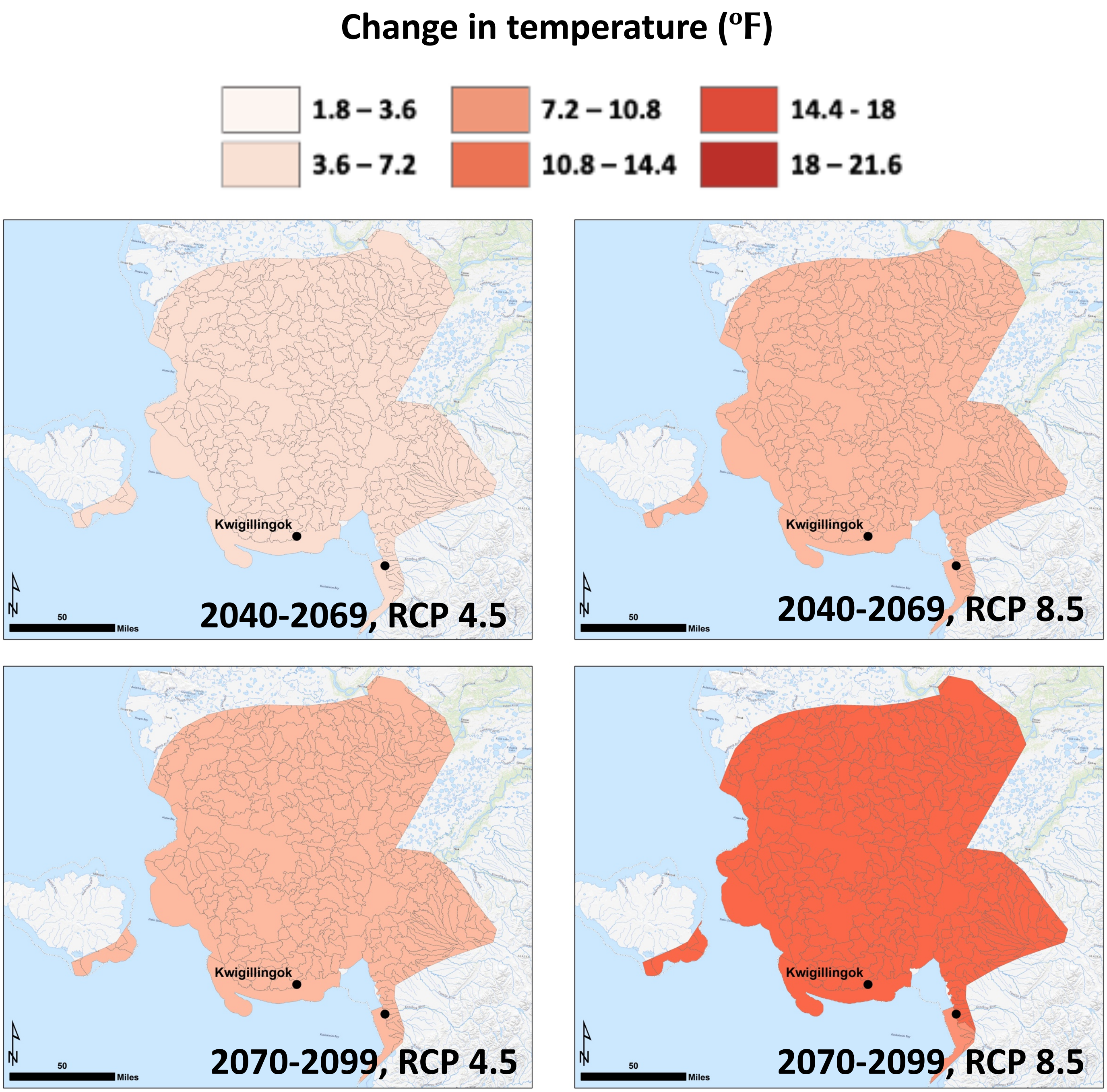
Background map: United States Geological Survey National Map



Annual temperature change, relative to 1970 - 1999

Annual temperature is projected to increase under all scenarios:

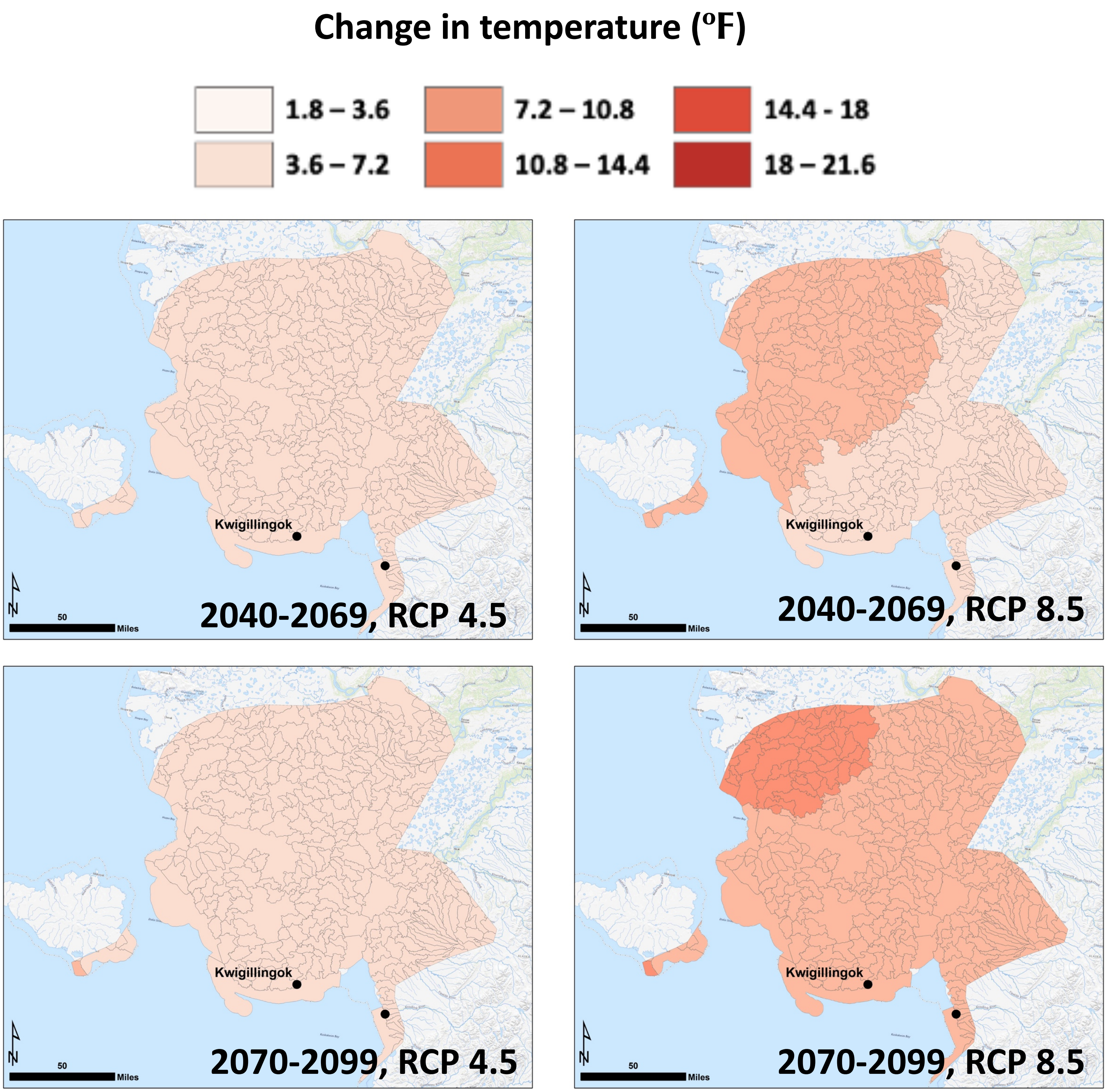
+ 5.9 °F (2050s, RCP 4.5)
+ 7.7 °F (2050s, RCP 8.5)
+ 7.6 °F (2080s, RCP 4.5)
+ 11.3 °F (2080s, RCP 8.5)



Spring (Mar - May) temperature change, relative to 1970 - 1999

Spring temperature is projected to increase under all scenarios:

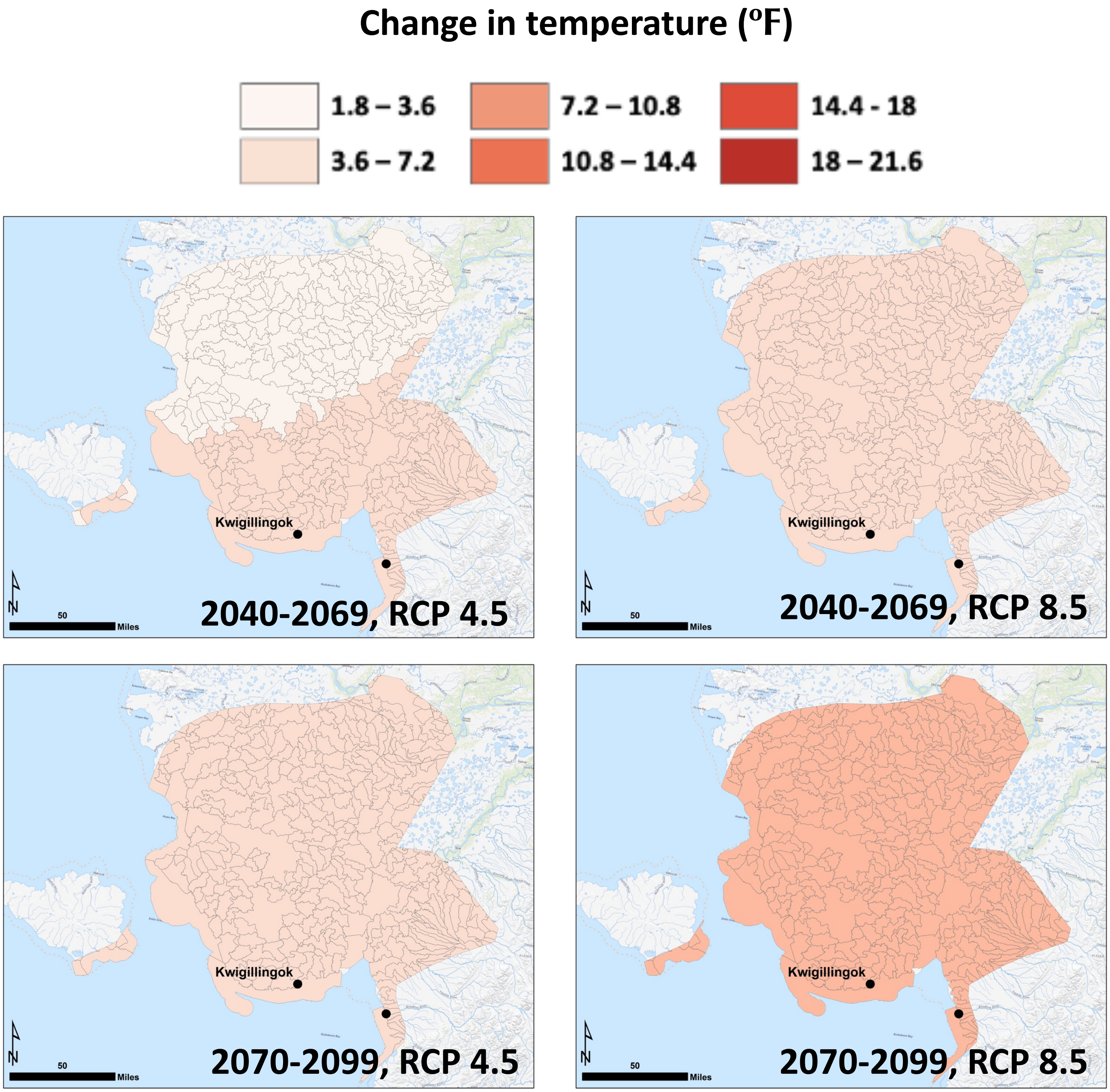
+ 5.6 °F (2050s, RCP 4.5)
+ 7.2 °F (2050s, RCP 8.5)
+ 6.9 °F (2080s, RCP 4.5)
+ 10.4 °F (2080s, RCP 8.5)



Summer (June - Aug) temperature change, relative to 1970 - 1999

Summer temperature is projected to increase under all scenarios:

+ 3.6 °F (2050s, RCP 4.5)
+ 4.9 °F (2050s, RCP 8.5)
+ 4.9 °F (2080s, RCP 4.5)
+ 7.8 °F (2080s, RCP 8.5)

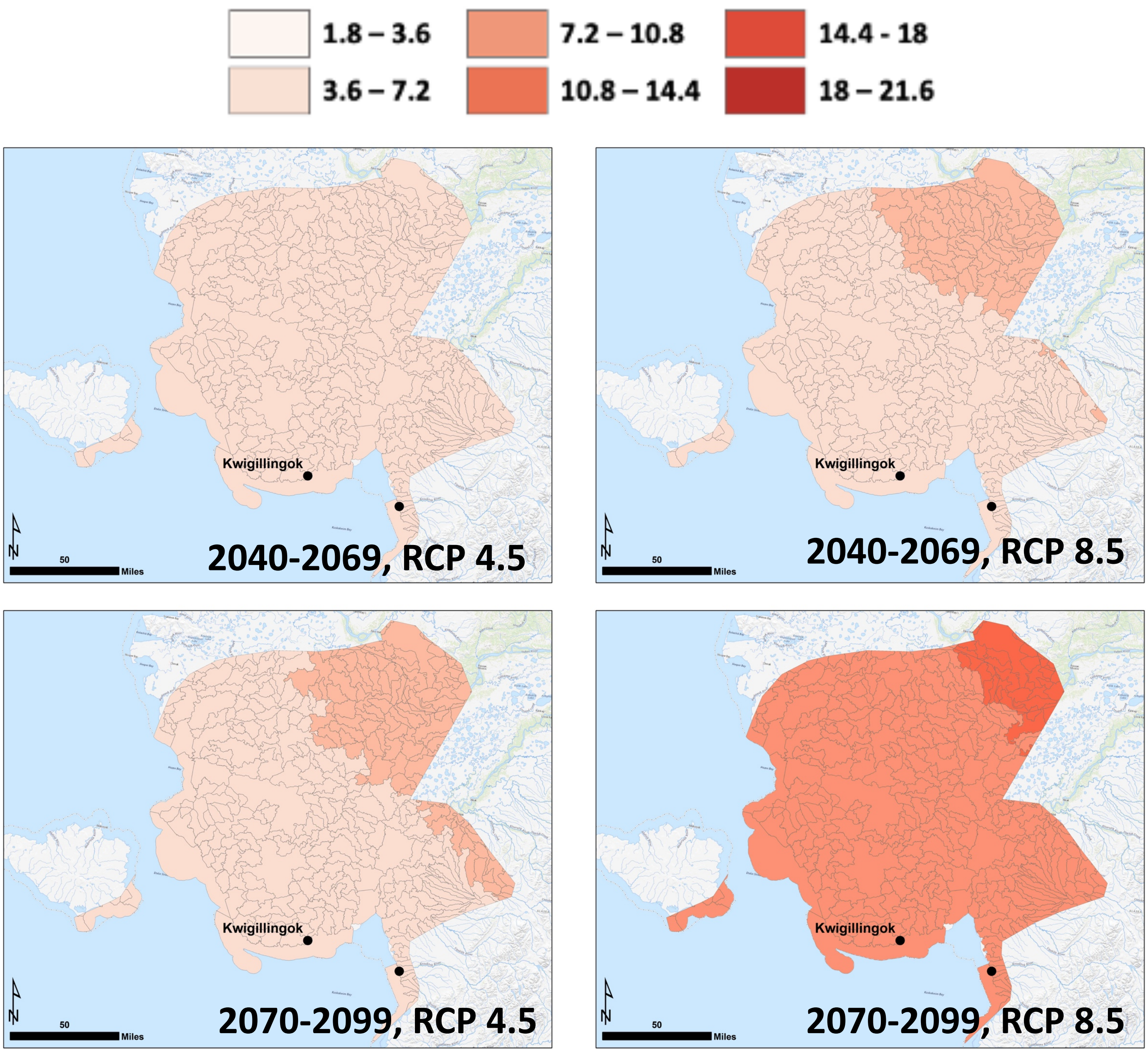


Autumn (Sep - Nov) temperature change, relative to 1970 - 1999

Autumn temperature is projected to increase under all scenarios:

+ 5.5 °F (2050s, RCP 4.5)
+ 7.0 °F (2050s, RCP 8.5)
+ 7.1 °F (2080s, RCP 4.5)
+ 10.4 °F (2080s, RCP 8.5)

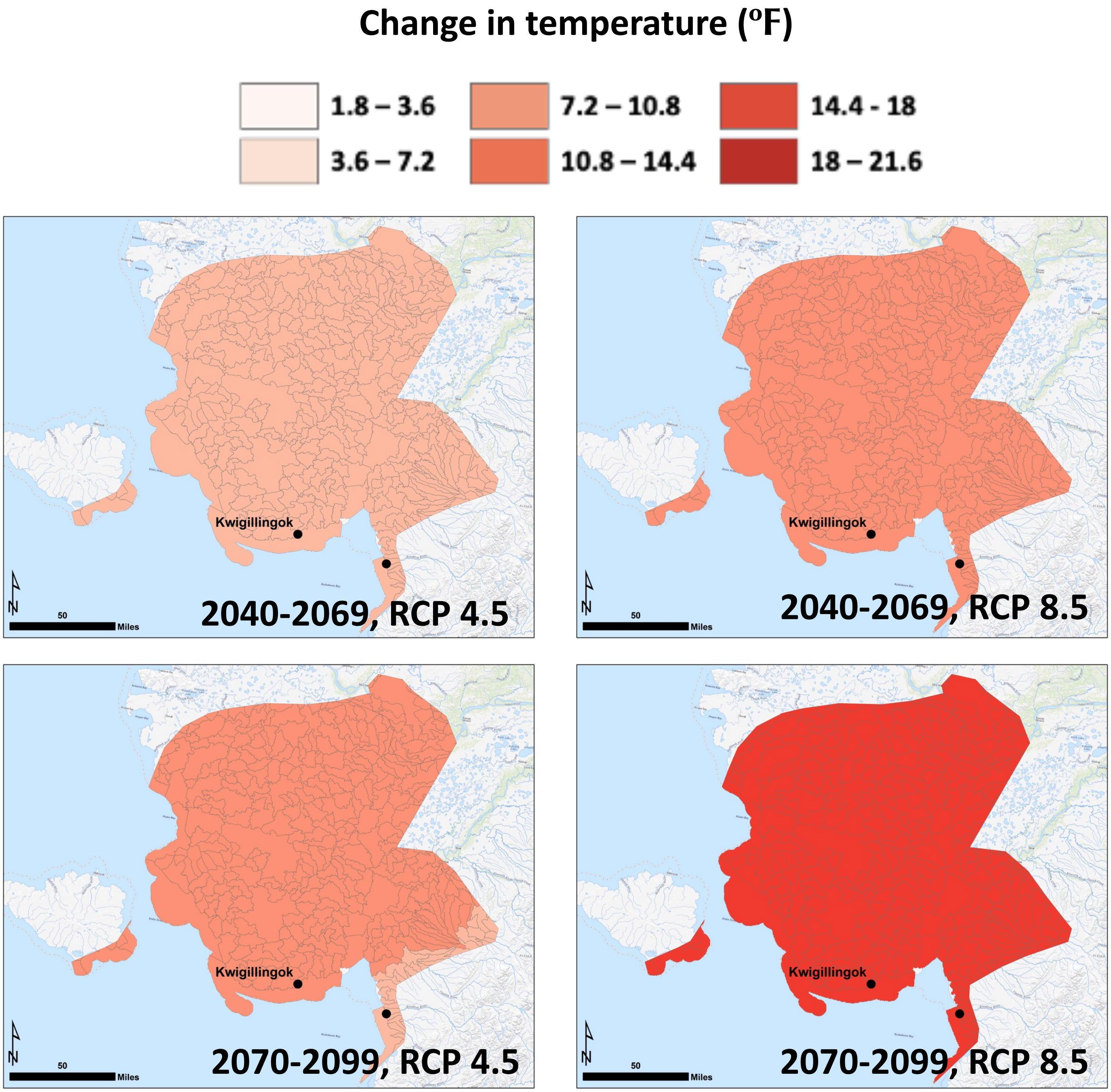
Change in temperature (°F)



Winter (Dec - Feb) temperature change, relative to 1970 - 1999

Winter temperature is projected to increase under all scenarios:

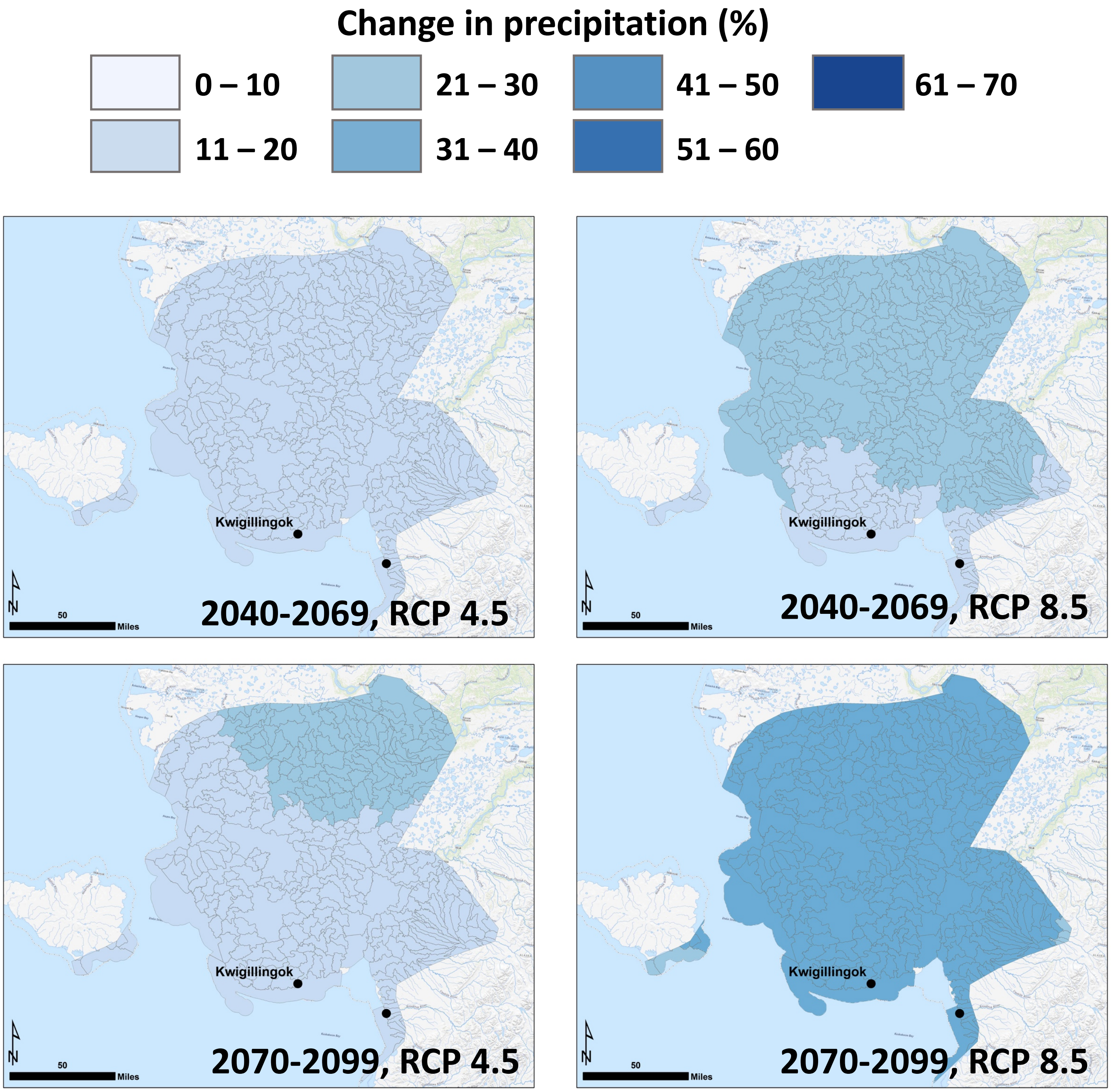
+ 8.5 °F (2050s, RCP 4.5)
+ 11.6 °F (2050s, RCP 8.5)
+ 11.3 °F (2080s, RCP 4.5)
+ 16.4 °F (2080s, RCP 8.5)



Annual precipitation change, relative to 1970 - 1999

Annual precipitation is projected to increase under all scenarios:

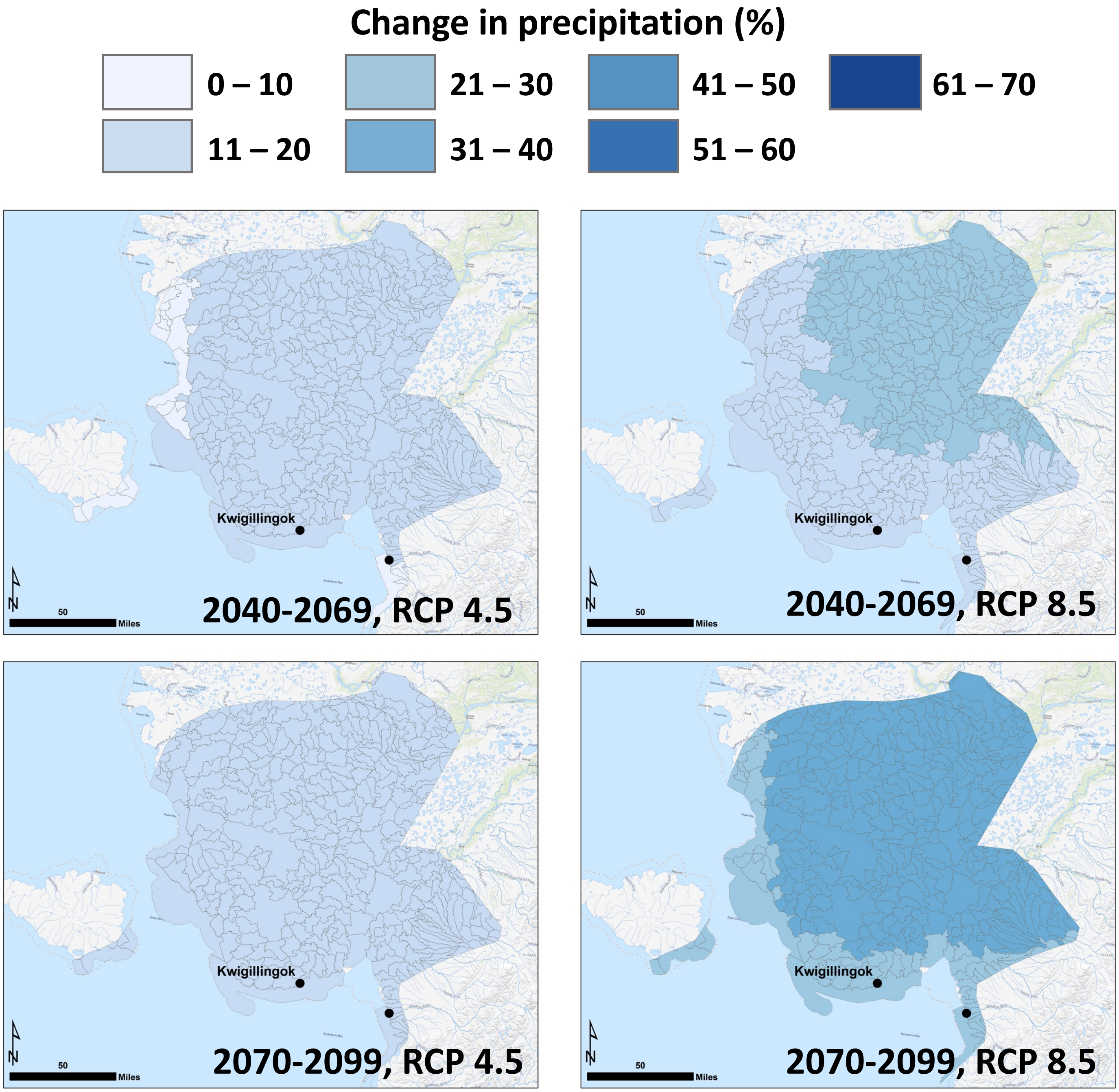
+ 17 % (2050s, RCP 4.5)
+ 21 % (2050s, RCP 8.5)
+ 19 % (2080s, RCP 4.5)
+ 33 % (2080s, RCP 8.5)



Spring (Mar - May) precipitation change, relative to 1970 - 1999

Spring precipitation is projected to increase under all scenarios, with slightly larger increases in the northern part of the region.

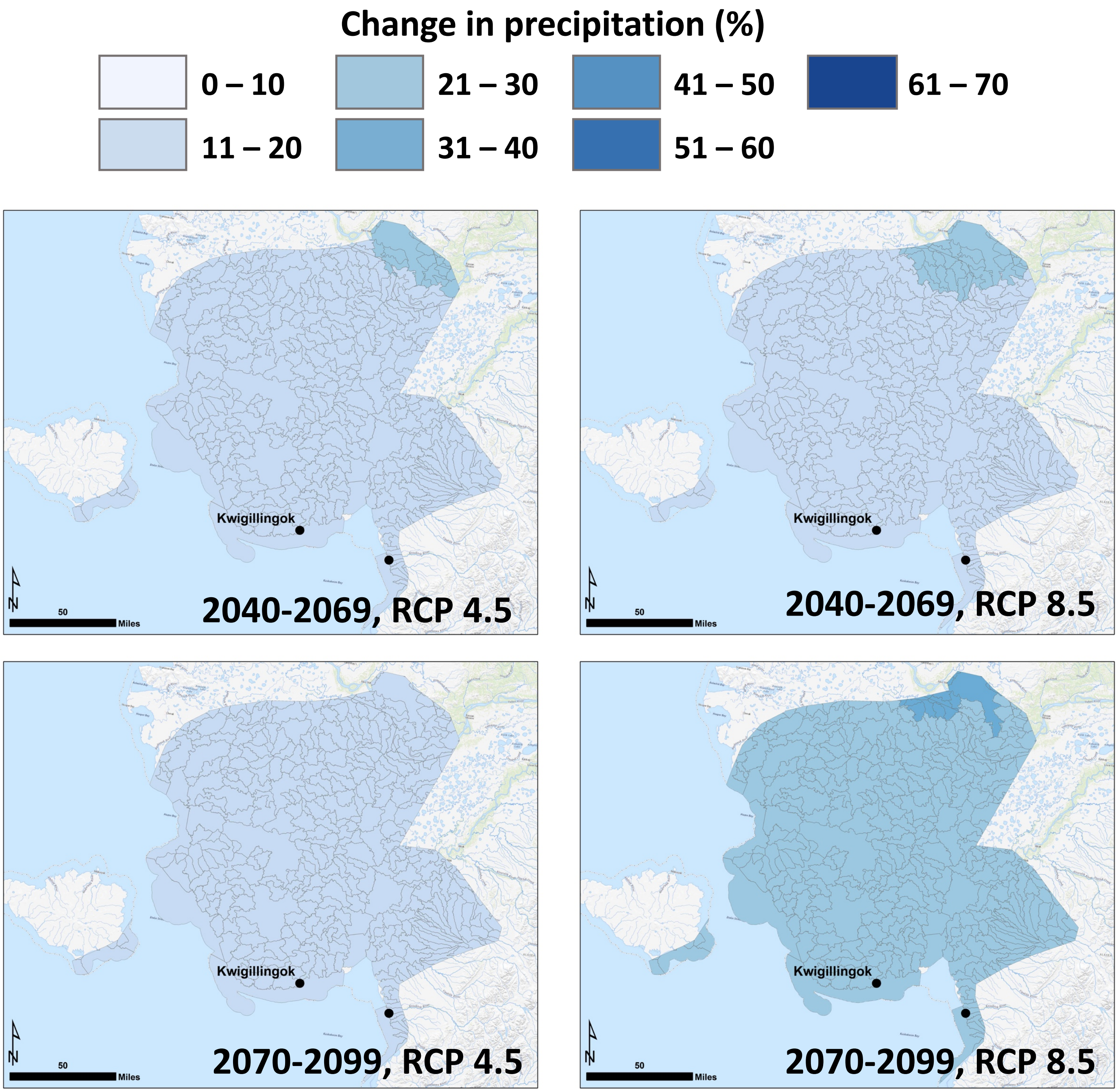
+ 12 % (2050s, RCP 4.5)
+ 19 % (2050s, RCP 8.5)
+ 17 % (2080s, RCP 4.5)
+ 32 % (2080s, RCP 8.5)



Summer (June - Aug) precipitation change, relative to 1970 - 1999

Spring precipitation is projected to increase under all scenarios, with slightly larger increases in the northern part of the region.

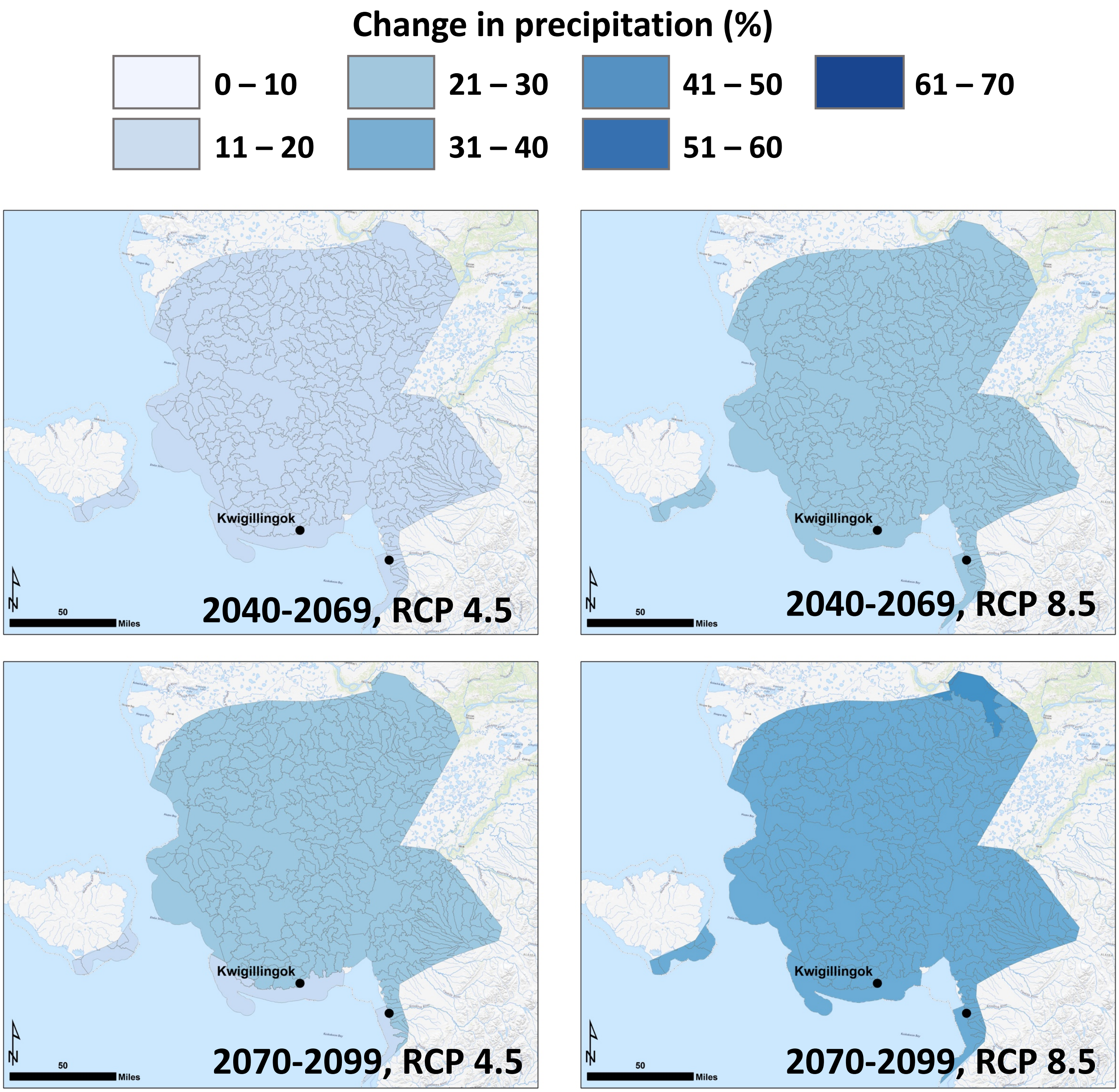
+ 17 % (2050s, RCP 4.5)
+ 18 % (2050s, RCP 8.5)
+ 15 % (2080s, RCP 4.5)
+ 26 % (2080s, RCP 8.5)



Autumn (Sep - Nov) precipitation change, relative to 1970 - 1999

Spring precipitation is projected to increase under all scenarios, with slightly larger increases in the northern part of the region.

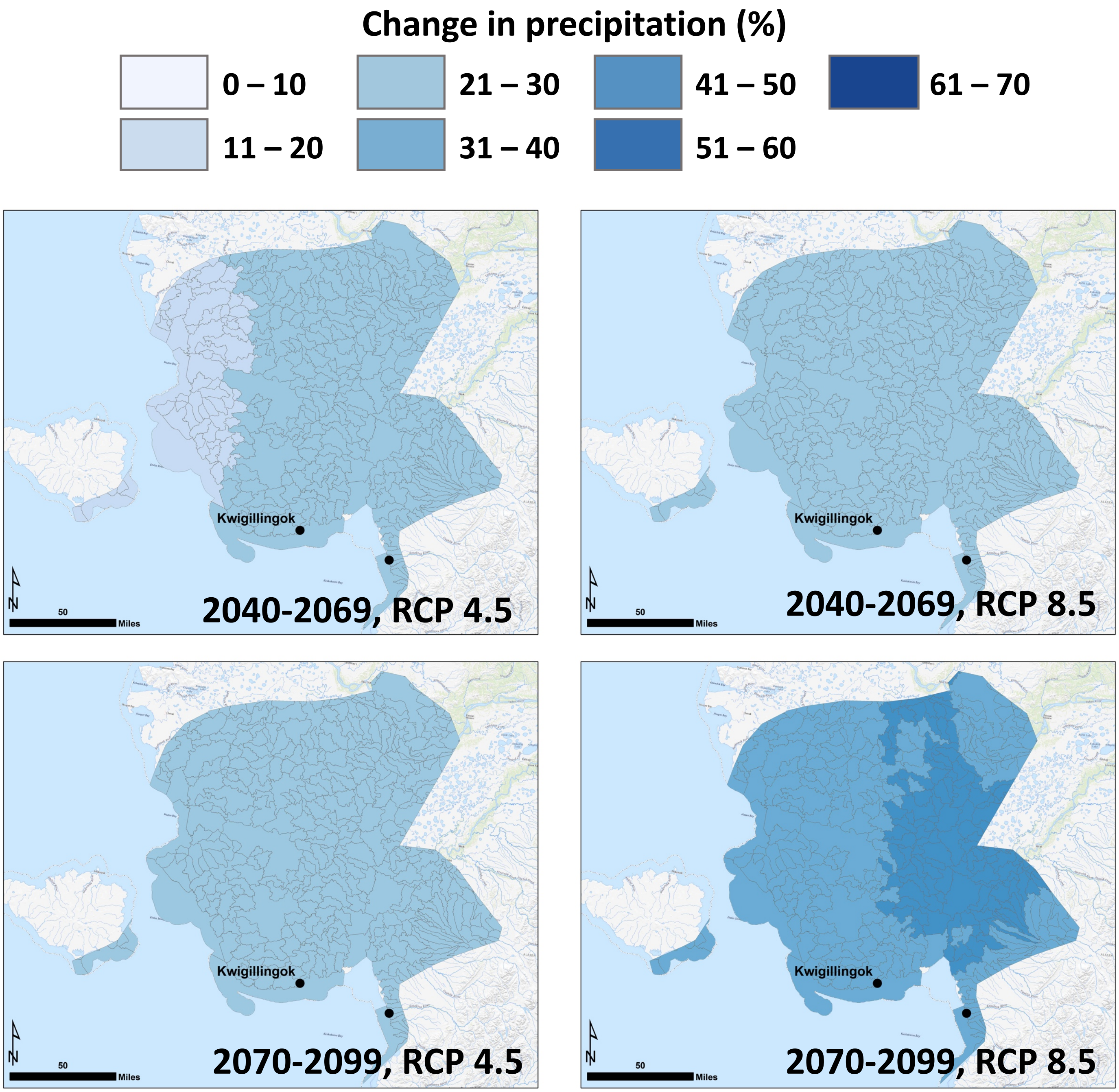
+ 17 % (2050s, RCP 4.5)
+ 24 % (2050s, RCP 8.5)
+ 22 % (2080s, RCP 4.5)
+ 36 % (2080s, RCP 8.5)



Winter (Dec - Feb) precipitation change, relative to 1970 - 1999

Winter precipitation is projected to increase under all scenarios, with slightly larger increases in the inland / eastern part of the region.

+ 21 % (2050s, RCP 4.5)
+ 24 % (2050s, RCP 8.5)
+ 28 % (2080s, RCP 4.5)
+ 39 % (2080s, RCP 8.5)

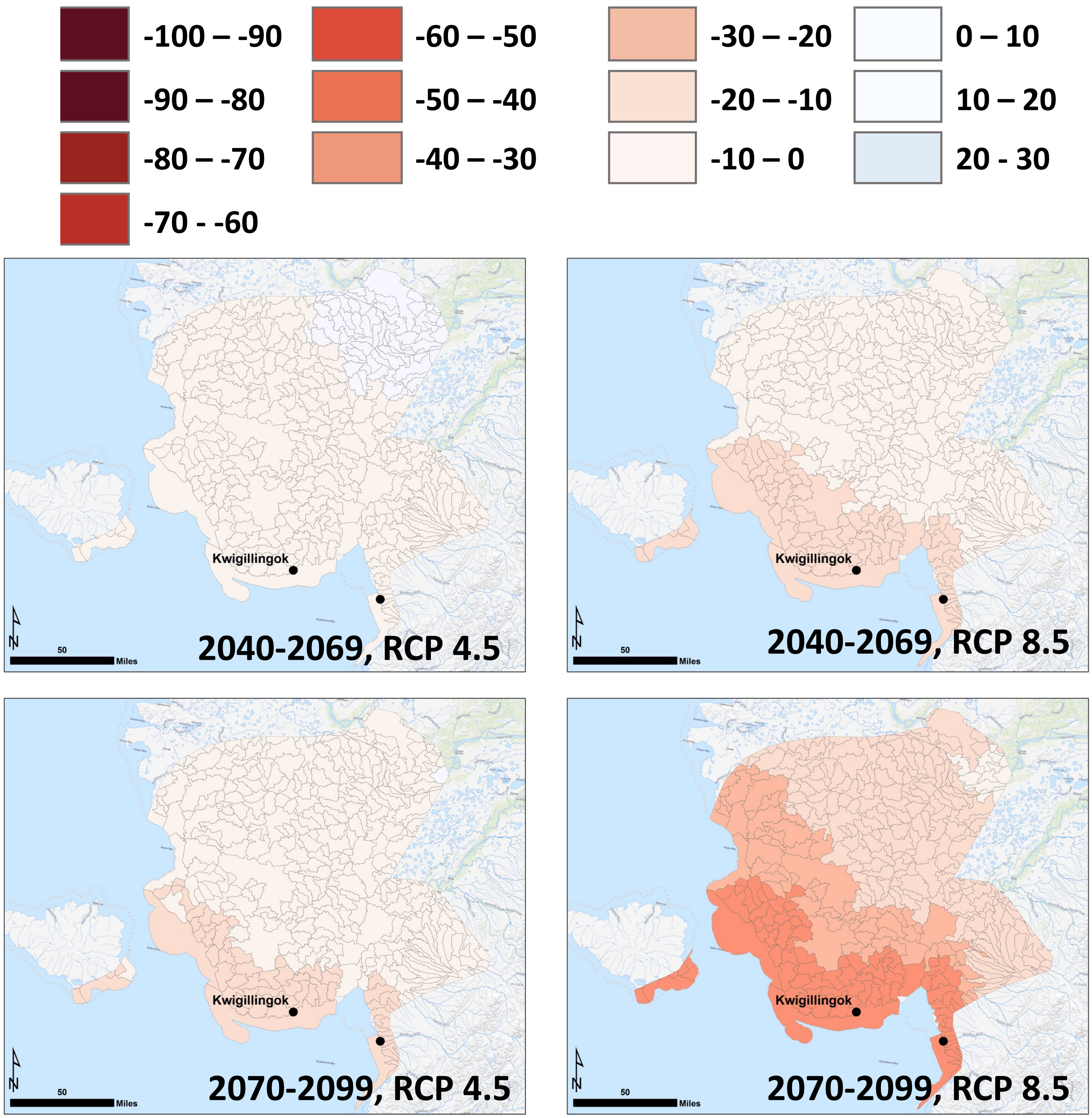


Snowfall water equivalent (snowfall) change in October to March, relative to 1970 - 1999

This is the change in the amount of snow that falls.

-5 % (2050s, RCP 4.5)
-14 % (2050s, RCP 8.5)
-11 % (2080s, RCP 4.5)
-31 % (2080s, RCP 8.5)

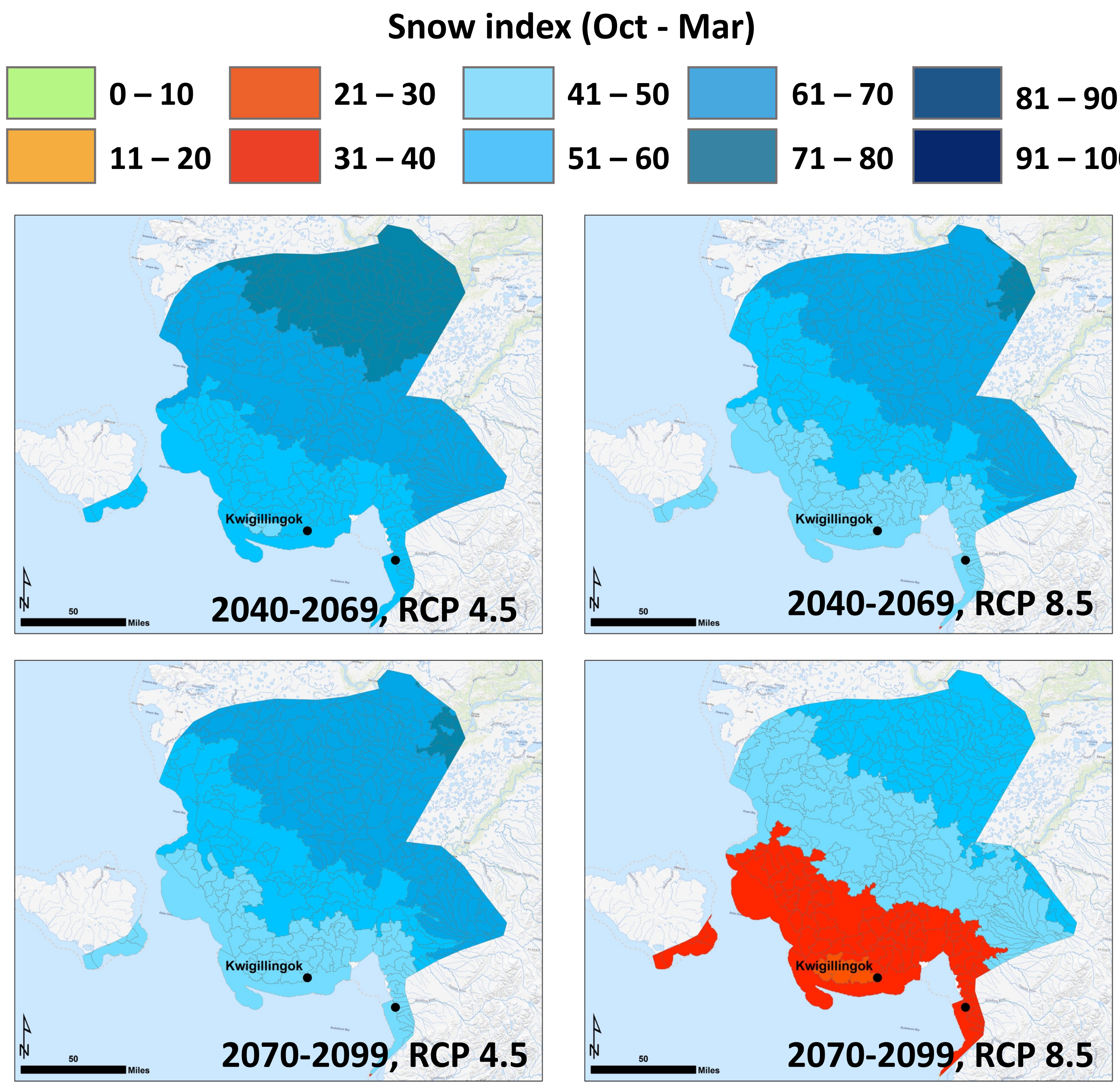
Change in snow (%)



Snow index, October to March % of precipitation in April 1 snow, relative to 1970 - 1999

This is a measure of how snow-dominated the climate is. Blues indicate snow dominated, reds and oranges are in between snow dominated and rain dominated. Greens represent rain dominated. Kwigillingok was historically snow dominated. Under all scenarios, the area that is snow dominated decreases, and the southern part of the region is projected to become transitional (between rain and snow) by the end of the 21st century.

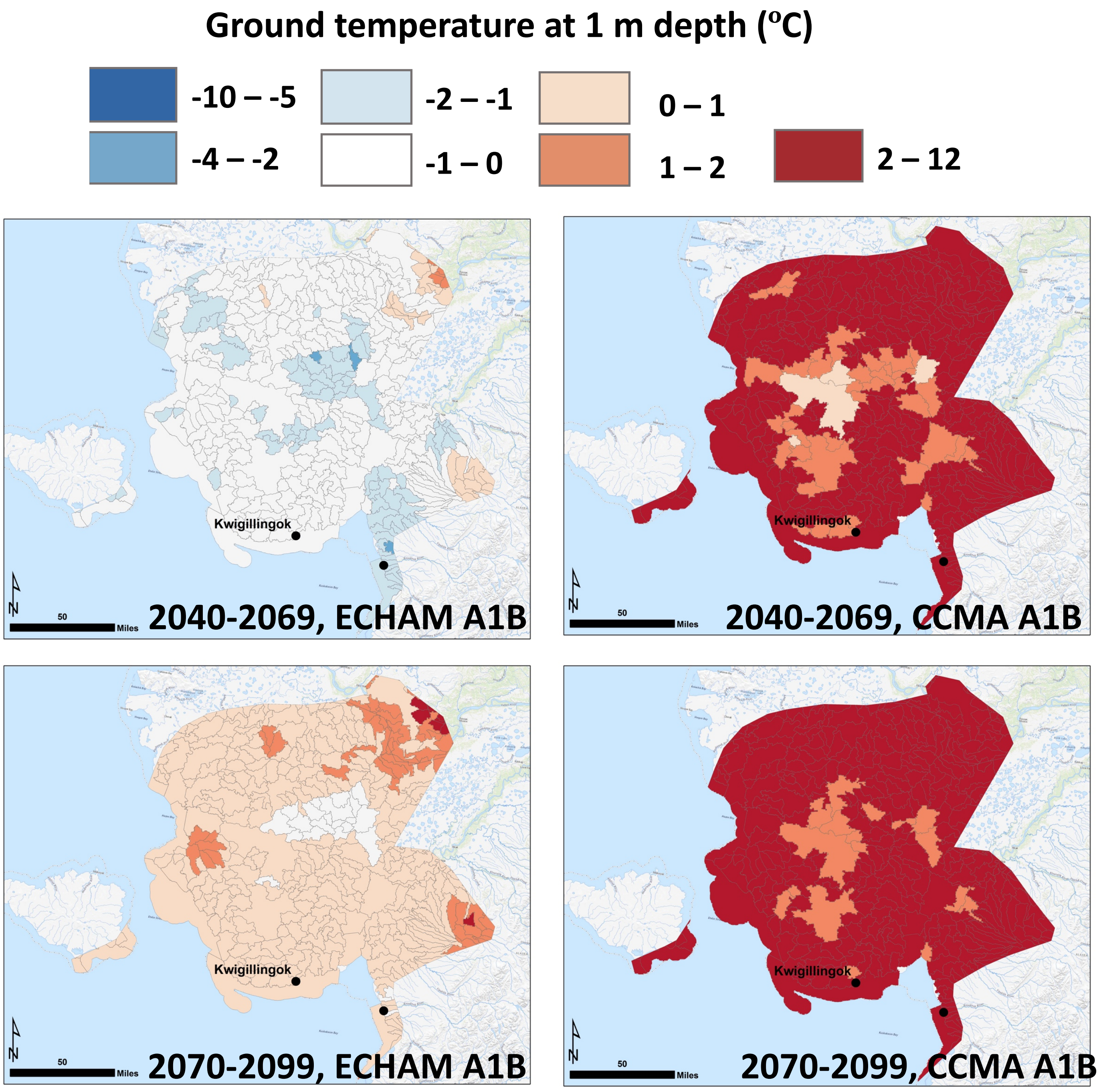
65% (2050s, RCP 4.5)
59% (2050s, RCP 8.5)
59% (2080s, RCP 4.5)
45% (2080s, RCP 8.5)



Annual average ground temperature at 1m (3.3ft) deep

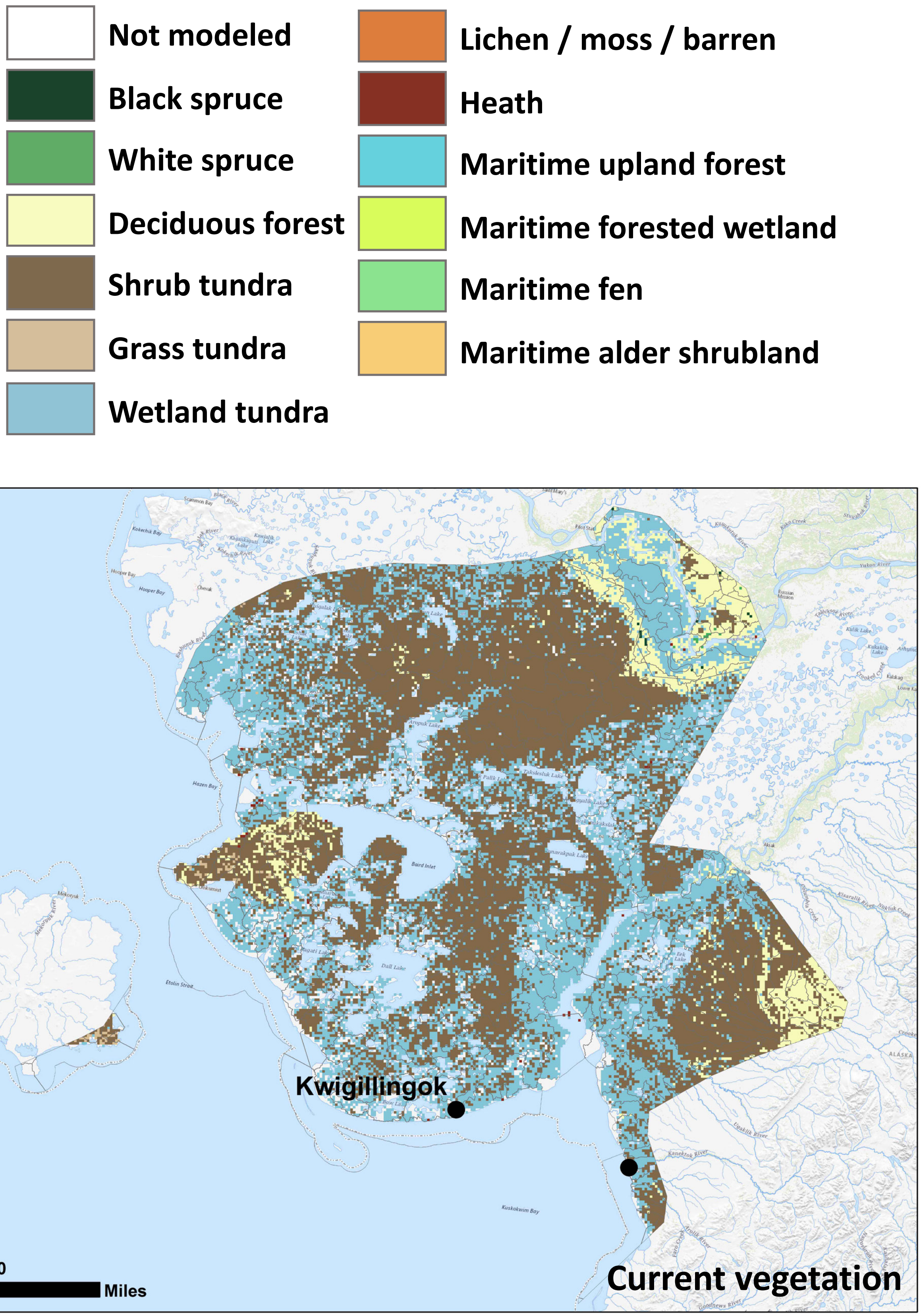
This is an index of how likely permafrost is to remain under climate change. Once annual average temperatures rise above freezing (0°C) permafrost thaw likely increases. Some areas of permafrost might persist until the 2050s under the ECHAM model, but decrease under all others.

- 1.7 ºC (2050s, ECHAM A1B)
- 0.9 ºC (2050s, CCMA A1B)
1.8 ºC (2080s, ECHAM A1B)
3.1 ºC (2080s, CCMA A1B)



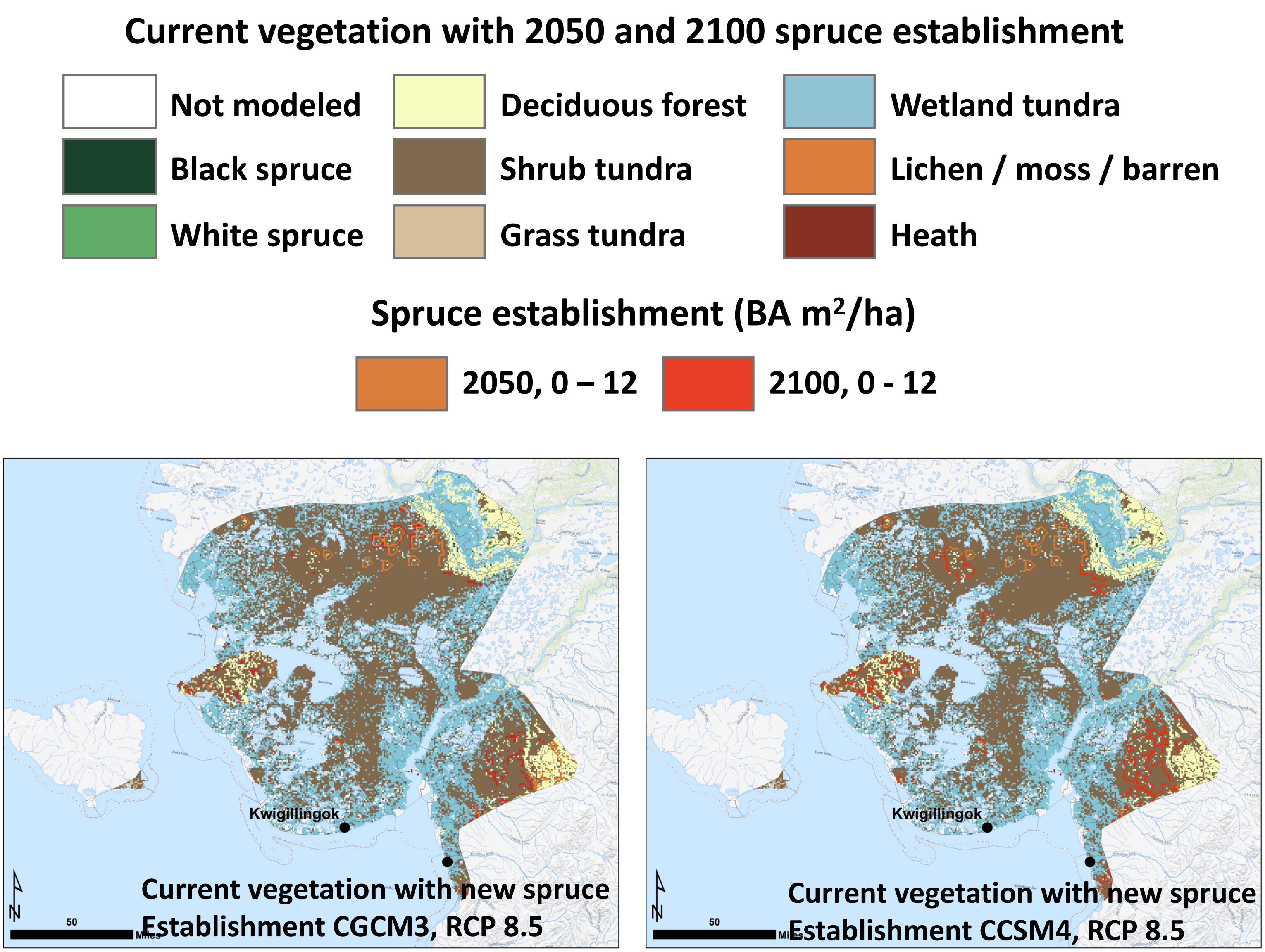
Current vegetation

Deciduous forest is birch, aspen, willow, cottonwood and/or alder.



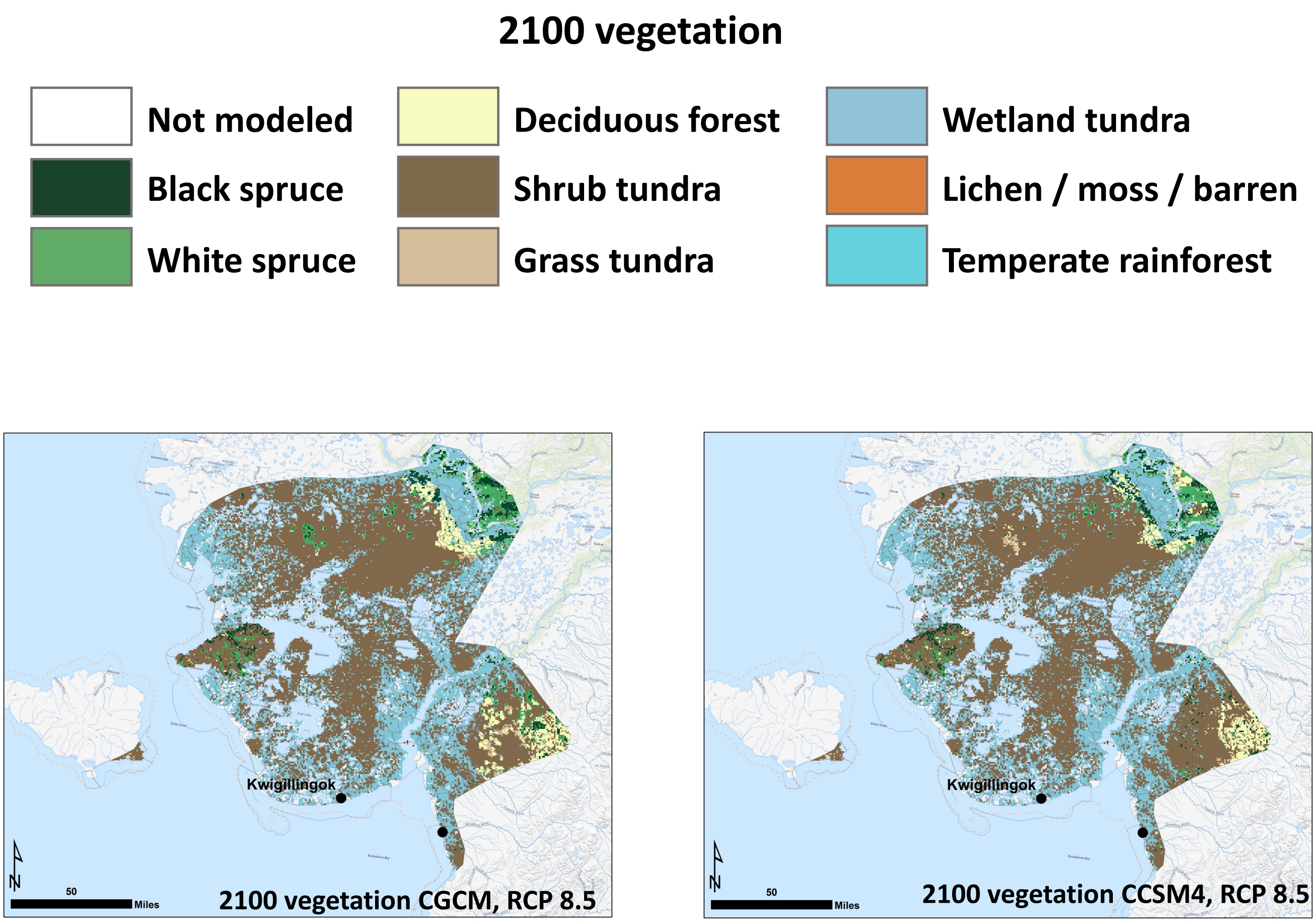
Current vegetation with 2050 and 2100 spruce establishment

Areas (in red) to the north and east of Kwigillingok become favorable for spruce establishment,generally in what was historically shrub tundra. More establishment is projected under the CGCM3 climate model than the CCSM4 climate model.



2100 vegetation

Future vegetation changes simulated by a vegetation model project spruce will establish to the north east of Kwigillingok. More establishment is projected under the CGCM3 climate model than the CCSM4 climate model. In the north central part of the region, some shrub tundra and deciduous forest transitions to grass tundra under the CCSM model.

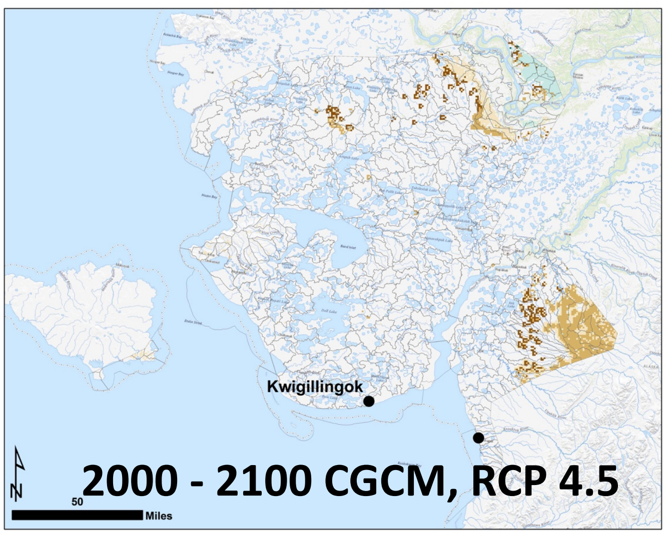


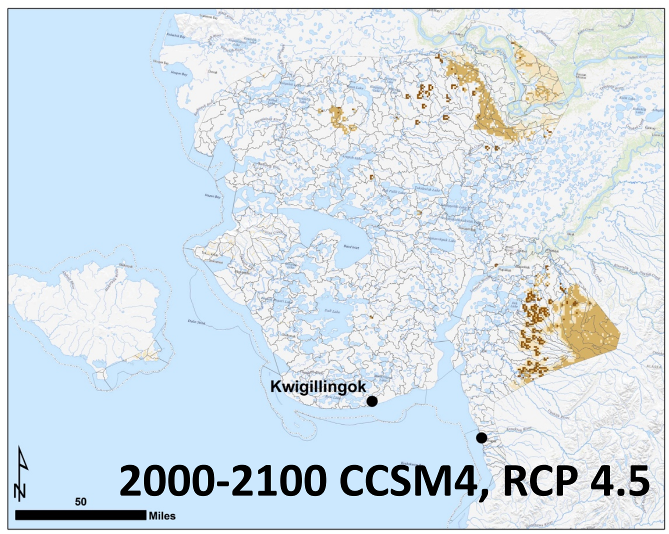
Change in vegetation per century, relative to 20th century

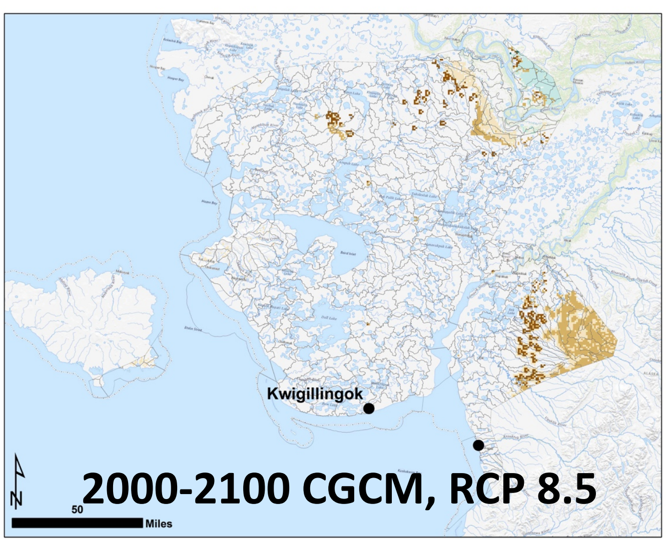
Changes in vegetation are new kinds of plants establishing where different plants used to be. These changes happen as new areas become favorable to plants, either due just to climate changes or after fire or other disturbance. Both models project significant landscape changes in some parts of the watershed (nearer to Quinhagak and the north / northeast parts of the region.

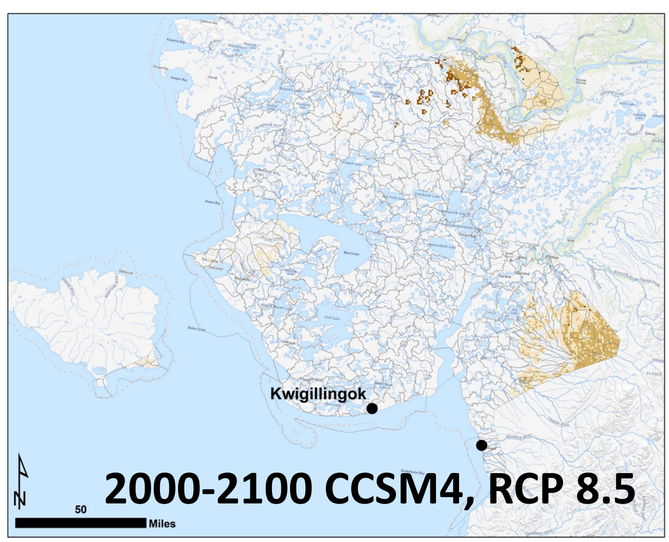
Change in vegetation per century

- -1.5 – -1
- -0.9 – -0.1
- 0 – 0.1
- 0.2 – 1
- 1.1 – 2
- 2.1 – 3
- 3.1 – 4
- 4.1 – 5





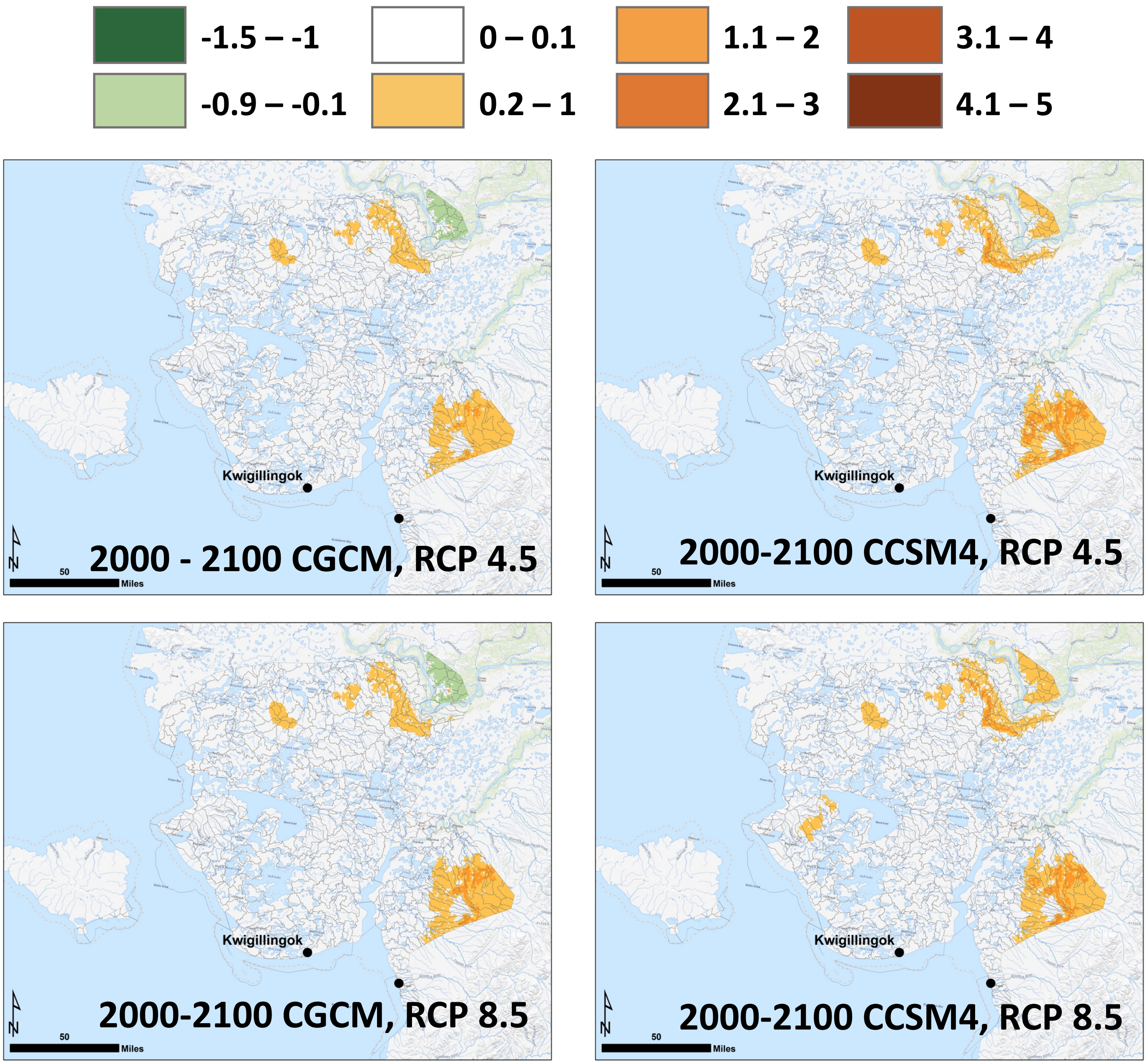




Change in fires per century, relative to 20th century

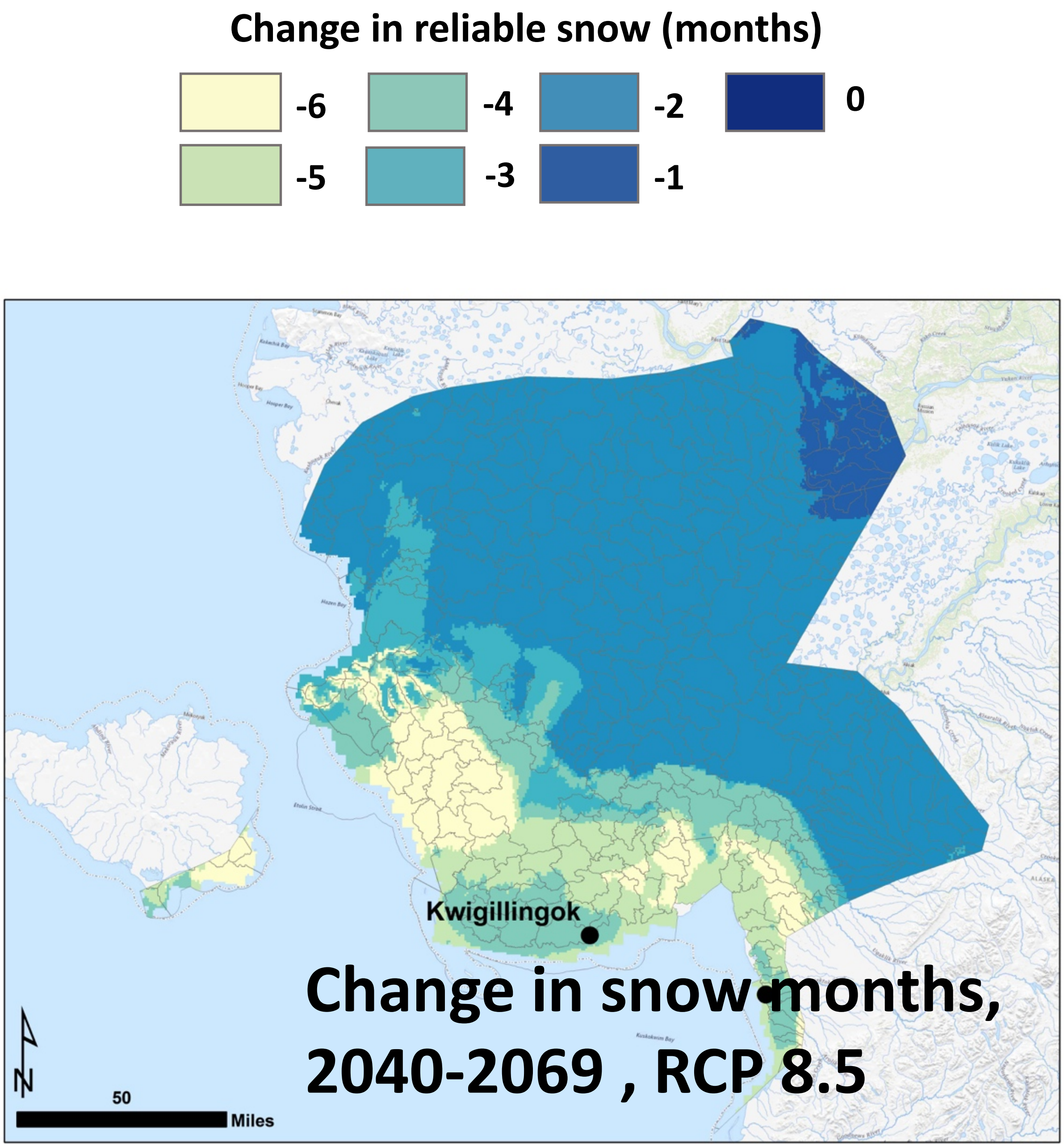
The number of fires per century is projected to increase by 1 (light orange) to 2 (darker orange) fires per century on average in the higher elevation arease northeast of Quinhagak and to the north and northeast of Kwigillingok. Some decrease in fire (green) is projected in the far northeast part of the region under both CGCM scenarios.

Change in fires per century



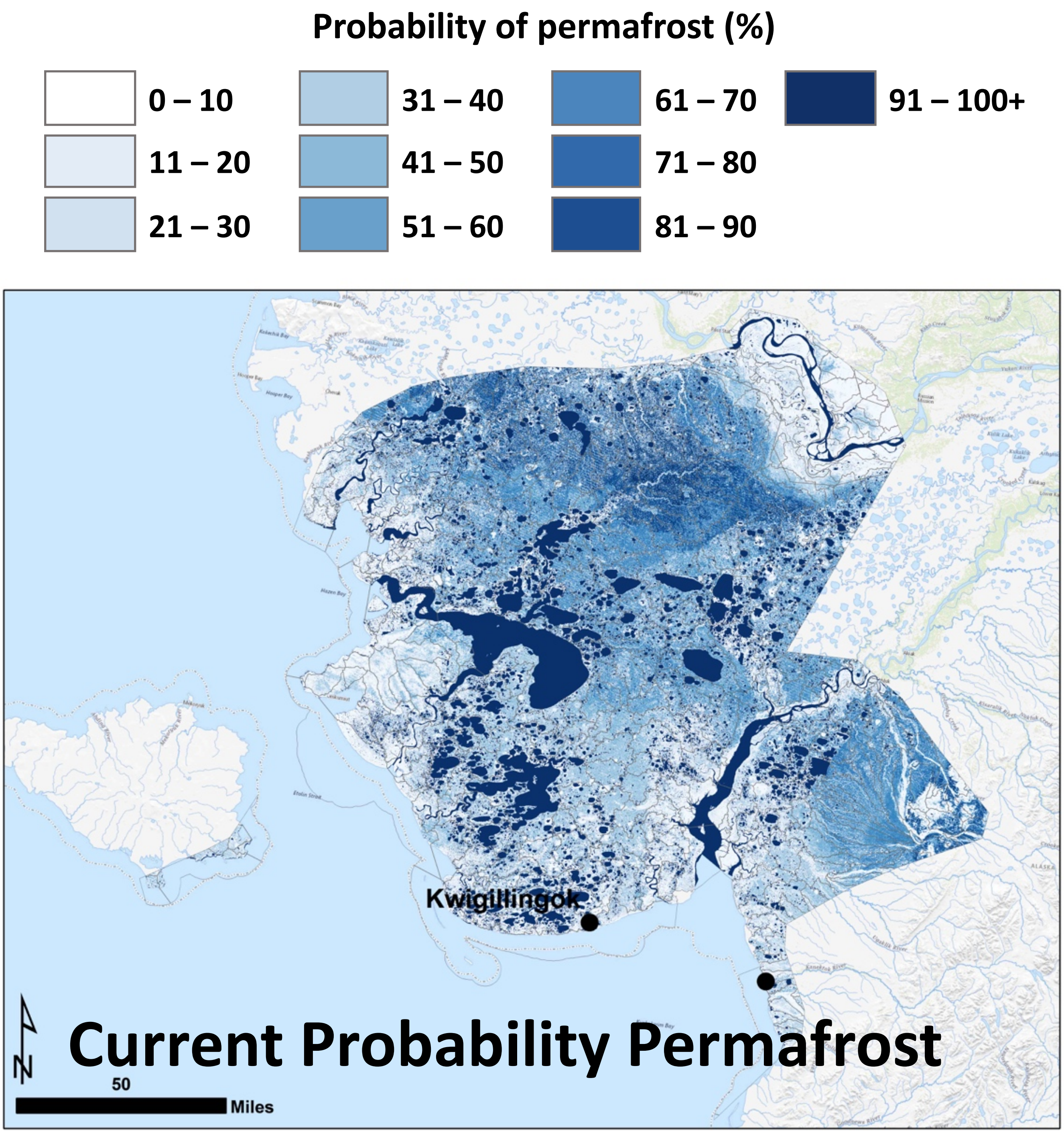
Change in reliable snow (months)

Snow months decrease by 1 to 2 months across much of the region, but larger decreases along the southern coast are projected – four to even six months to the northwest of Kwigllingok.



Probability of permafrost (%)

Currently, permafrost in the region is thought to be patchy but locally important.



Data tables

PRECIPITATION CHANGES – Percent (%) change averaged over the Kwigillingok region

	2040 - 2069				**2070 - 2099**			
	RCP 4.5		**RCP 8.5**		**RCP 4.5**		**RCP 8.5**	
	Average	Range	Average	Range	Average	Range	Average	Range
Annual	**17**	**15 - 19**	**21**	**19 - 24**	**19**	**17 - 21**	**33**	**29 - 36**
Spring	12	9 - 14	19	14 - 23	17	13 - 21	32	26 - 36
Summer	17	14 - 21	18	15 - 22	15	11 - 18	26	22 - 31
Autumn	17	16 - 18	24	21 - 27	22	19 - 31	36	31 - 40
Winter	21	18 - 23	24	22 - 25	28	25 - 30	39	37 - 42

TEMPERATURE – Change (in °F) averaged over the Kwigillingok region

	2040 - 2069				**2070 - 2099**			
	RCP 4.5		**RCP8.5**		**RCP 4.5**		**RCP 8.5**	
	Average	Range	Average	Range	Average	Range	Average	Range
Annual	**5.9**	**5.7 - 6.0**	**7.7**	**7.4 - 8.0**	**7.6**	**7.3 - 7.8**	**11.3**	**10.7 - 11.7**
Spring	5.6	5.4 - 5.9	7.2	6.9 - 7.5	6.9	6.6 - 7.2	10.4	9.9 - 10.9
Summer	3.6	3.3 - 3.8	4.9	4.6 - 5.2	4.9	4.6 - 5.3	7.8	7.4 - 8.1
Autumn	5.5	5.1 - 5.8	7.0	6.4 - 7.4	7.1	6.5 - 7.5	10.4	9.6 - 11.0
Winter	8.5	8.1 - 9.1	11.6	10.9 - 12.4	11.3	10.5 - 12.1	16.4	15.0 - 17.5

SNOWPACK - Percent (%) change (snowfall) and percent (%) (snow index) averaged over the Kwigillingok region

	2040-2069				**2070 - 2099**			
	RCP 4.5		**RCP 8.5**		**RCP 4.5**		**RCP 8.5**	
	Average	Range	Average	Range	Average	Range	Average	Range
Snowfall water	-5	-16 - +4	-14	-28 - -2	-11	-25 - +1	-31	-48 - -16
Snow index	65	49 - 78	59	42 - 73	59	42 - 72	45	29 - 60

*Averages are for five climate models. Ranges are across HUC 12 (12 digit Hydrological Unit Code) watersheds. See the PowerPoint with the regional maps file for descriptions of the variables.

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Resolution No. 07-589-20

WHEREAS, the Native Village of Kwigillingok participated in the recent *Looking Forward, Looking Back; Building Resilience Today Project,* referred to as the BRT Project, which resulted in three reports; *Kwigillingok Community Report, Training One Report* and *Training Two Report.*

NOW THEREFORE BE IT RESOLVED that the Native Village of Kwigillingok reviewed these reports and specifically approves the *BRT Kwigillingok Community Report.*

Certification

The Resolution was passed and approved at a duly convened meeting of the Kwigillingok I.R.A. Council at which required voting quorum was present and voted 4 Yes, 0 No, 0 Abstaining. This 9th day of August, 2020.

Tribal Council President

8/9/20

Date

Tribal Council Secretary

8/9/20

Date

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June 11, 2020

To;
Malinda Chase, AK CASC-APIA , LFLB BRT Project Co-Lead
Ryan Toohey, AK CASC-USGS, LFLB BRT Project Co-Lead
Alaska Climate Adaptation Science Center (AK CASC)
University of AK Fairbanks
PO Box 757245
Fairbanks, AK 99775

Regarding: Review of the BRT Kotlik Community Report, Training One and Training Two reports

This letter acknowledges that the Native Village of Kwigillingok received the BRT Kwigillingok Community Report, BRT Training One and BRT Training Two reports as submitted to us by the BRT Project Team. I have specifically reviewed the BRT Kwigillingok Community report with Gary Evon our BRT Team Leader for the project.

Like the rest of the world, responding to the COVID pandemic impacted conducting tribal business, and it's been a challenge for our full council to review these project documents.

In order to assist with routing and finalizing these documents, the Native Village of Kwigillingok Tribal Office has discussed this with our leadership. We support the following:

1) Approves the final drafts of these documents for general publication and to submit to the Bureau of Indian Affairs Tribal Resilience Program for reporting, to the US Geological Survey for review of the climate science, and to the Alaska Climate Adaptation Science Center to highlight as a partnership project with the Native Village of Kwigillingok

I recognize with our approval of the final drafts of these documents for general publication that all three reports will be submitted to the US Geological Survey for internal review of the science contained within these documents.

Sincerely Yours:
NATIVE VILLAGE OF KWIGILLINGOK
Fred K. Phillip, President